C-17 Type III Hydrant Refueling System and Ramp Expansion  
PN FJRP159073  
145th Airlift Wing  
Charlotte, NC  
North Carolina Air National Guard  

Type B.3 Final Submittal  
Technical Specifications (Vol 2 of 2)  

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)


ASTM INTERNATIONAL (ASTM)


ASTM D1535 (2014) Specifying Color by the Munsell System


INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)


NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1 (2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less

NEMA ICS 6 (1993; R 2011) Industrial Control and Systems: Enclosures
RELATD REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this Section, with the additions and modifications specified herein.

DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor QC approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Switchboard Drawings; G

SD-03 Product Data
Switchboard; G

SD-06 Test Reports
Switchboard Design Tests; G
Switchboard Production Tests; G
Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data
Switchboard Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals
Assembled Operation and Maintenance Manuals; G
Equipment Test Schedule; G
1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data.

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment,
materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this Section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Information on metering.

f. Design test reports.
g. Production test reports.

1.7 WARRANTY

Provide equipment items that are supported by service organizations reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.

b. Continuous current rating of the main bus: 1200 amperes as indicated.

c. Short-circuit current rating: 50k rms symmetrical amperes as indicated.

d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

a. Switchboard: Consisting of one vertical section and aligned as indicated.

b. All circuit breakers: Front accessible.

c. Rear aligned switchboards: Front accessible load connections.

d. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.

e. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type 1.
b. Enclosure: Bolted together with removable bolt-on side and rear covers.

c. Front doors: Provided with padlockable vault handles with a three point catch.

d. Base: Includes any part of enclosure that is within 3 inches of concrete pad.

e. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: Copper with silver-plated contact surfaces.
   (1) Phase bus bars: Uninsulated.
   (2) Neutral bus: Rated 100 percent of the main bus continuous current rating. Neutral bus for service entrance only.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): Rated at the full ampacity of the main throughout the switchboard.

d. Minimum 1/4 by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting of a combination section with molded-case circuit breakers for the main devices as indicated.

2.2.3 Protective Device

Provide main protective devices as indicated.

2.2.3.1 Molded-Case Circuit Breaker

Provide the following:

a. UL 489. UL listed and labeled, standard rated branch breakers, electrically operated, low voltage molded-case circuit breaker, with a short-circuit current rating of 50k rms symmetrical amperes.

b. Breaker frame size: 1200 amperes.

c. Series rated circuit breakers are unacceptable.

2.2.4 Electronic Trip Units

Equip main breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:
a. Current sensors ampere rating: The same as the breaker frame rating.

b. Trip unit ampere rating: As indicated.

c. Electronic trip units: Provide additional features:

(1) Breakers: Include long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.

(2) Main breakers: Include short delay pick-up and time settings, instantaneous settings, and ground fault settings.

2.2.5 Metering

2.2.5.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a sealed case with the following features.

a. Display capability:

(1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.

b. Design meters to accept input from standard 5A secondary instrument transformers and voltage monitoring range to 600 volts, phase to phase.

c. Provide programming via a front panel display and a communication interface accessible by a computer.

d. Provide password secured programming stored in non-volatile EEPROM memory.

e. Provide digital communications in a Modbus [RTU] protocol via a RS485 serial port.

f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.

g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

h. Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.

i. Provide event waveform recording triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms
for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.2.6 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.7 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lettering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

a. Provide a calibration program which assures that all applicable test
instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: Less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: Visible on all test equipment.

e. Calibrating standard: Higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this Specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this Project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.6 ARC FLASH WARNING LABEL

Provide warning label for switchboards. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.
2.7 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.2.1 Switchboard

ANSI/NEMA PB 2.1.

3.2.2 Meters and Instrument Transformers

ANSI C12.1.

3.2.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.2.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.2.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.3.1 Interior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

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c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4 FIELD QUALITY CONTROL

3.4.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.4.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection:

   (1) Compare equipment nameplate data with specifications and approved shop drawings.

   (2) Inspect physical, electrical, and mechanical condition.

   (3) Verify appropriate anchorage, required area clearances, and correct alignment.

   (4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

   (5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

   (6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker's address for microprocessor-communication packages.

   (7) Inspect all bolted electrical connections for high resistance using low-resistance ohmometer, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

   (8) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

   (9) Confirm correct application of manufacturer's recommended lubricants.

   (10) Inspect insulators for evidence of physical damage or
contaminated surfaces.

(11) Verify correct barrier installation and operation.

(12) Exercise all active components.

(13) Inspect all mechanical indicating devices for correct operation.

(14) Verify that filters are in place and vents are clear.

(15) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(16) Inspect control power transformers.

b. Electrical Tests:

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

3.4.1.2 Circuit Breakers

Low Voltage Molded Case with Solid State Trips.

a. Visual and Mechanical Inspection:

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests:

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform Breaker adjustments for final settings in accordance with Government provided settings.
(4) Perform long-time delay time-current characteristic tests
(5) Determine short-time pickup and delay by primary current injection.
(6) Determine ground-fault pickup and time delay by primary current injection.
(7) Determine instantaneous pickup current by primary injection.

3.4.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection:
   (1) Compare equipment nameplate data with specifications and approved shop drawings.
   (2) Inspect physical and mechanical condition.
   (3) Verify tightness of electrical connections.

b. Electrical Tests:
   (1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.
   (2) Calibrate watthour meters according to manufacturer's published data.
   (3) Verify all instrument multipliers.
   (4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.4.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --
PART 1   GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 242 (2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)


1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of:

a. New Type III Hydrant System, 12.47, 480/277 volt, pad-mounted transformer, generator, switch board, MCC, low-voltage transformer, and panelboards.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data
Fault Current Analysis
Protective Device Coordination Study
Equipment
System Coordinator
Installation
SD-06 Test Reports
Field Testing
SD-07 Certificates
Devices and Equipment

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a Registered Professional Electrical Power Engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Experience data shall include at least five references for work of a magnitude comparable to this Contract, including points of contact, addresses, and telephone numbers.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.6 PROJECT/SITE CONDITIONS

Submit certificates attesting that all devices or equipment meet the requirements of the Contract Documents. Devices and equipment furnished under this section shall be suitable for the following site conditions. Seismic details shall conform to UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

<table>
<thead>
<tr>
<th>Altitude</th>
<th>750 feet</th>
</tr>
</thead>
</table>
Ambient Temperature | 85 degrees F
---|---
Frequency | 60 Hz
Fungus Control | No
Hazardous Classification | Where indicated on drawings
Humidity Control | None
Ventilation | Interior: HVAC
Seismic Parameters | Refer to Seismic Protection specifications listed above
Other | 

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least 2 years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices. Protective devices are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with UL 489.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the Contract Requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, arc flash study, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall be performed by a registered Professional Engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses, and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

SECTION 26 28 01.00 10 Page 3
2.4.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: The source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses. The nearest upstream device in the existing source system and extend through the downstream devices at the load end.

2.4.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented.

2.4.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting fault rating.

2.4.4 Fault Current Analysis

2.4.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, IEEE 399, and IEEE 551.

2.4.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.4.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.4.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this Project. A written narrative shall be provided describing: Which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve
additions or modifications to the Contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.4.6 Arc Flash Study

Perform study in accordance with IEEE 1584.

2.4.7 Study Report

a. The report shall include a narrative describing: The analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturer's published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide calculated arc flash boundaries, incident energy levels, minimum clothing ratings, limited and restricted approach boundary distances.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and
tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 30 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

Visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, verify operating voltages on closing and tripping coils. Verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

-- End of Section --
SECTION 26 32 15.00 10

DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES

10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)


ASME INTERNATIONAL (ASME)

ASME B16.11 (2011) Forged Fittings, Socket-Welding and Threaded

ASME B16.3 (2011) Malleable Iron Threaded Fittings, Classes 150 and 300


ASME B31.1 (2016) Power Piping

ASME BPVC SEC IX (2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)


<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 43</td>
<td>(2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery</td>
</tr>
<tr>
<td>IEEE 519</td>
<td>(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems</td>
</tr>
<tr>
<td>MSS SP-80</td>
<td>(2013) Bronze Gate, Globe, Angle and Check Valves</td>
</tr>
<tr>
<td>NEMA ICS 6</td>
<td>(1993; R 2011) Industrial Control and Systems: Enclosures</td>
</tr>
</tbody>
</table>
Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Detailed Drawings; G
Acceptance; G

SD-03 Product Data
Harmonic Requirements
Engine-Generator Parameter Schedule
Heat Exchanger
Generator; G
Manufacturer's Catalog
Site Welding
Spare Parts
Onsite Training
Vibration-Isolation
Posted Data and Instructions; G
Instructions; G
Experience
Field Engineer
General Installation

SD-05 Design Data
Performance Criteria
Sound Limitations; G
Integral Main Fuel Storage Tank
Power Factor
Time-Delay on Alarms
Battery Charger

SD-06 Test Reports
Factory Inspection and Tests
Factory Tests
Onsite Inspection and Tests; G

SD-07 Certificates
Cooling System
Vibration Isolation
Prototype Test
Reliability and Durability
Emissions
Sound Limitations
Site Visit
Current Balance
Materials and Equipment
Inspections
Cooling System
SD-10 Operation and Maintenance Data
Operation and Maintenance Manuals; G
Maintenance Procedures; G
Special Tools
Filters

1.3 QUALITY ASSURANCE

1.3.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication, and installation shall also conform to the code.

1.3.2 Site Welding

For all welding, qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1. Submit a copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators. A letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests which shall be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record.

1.3.3 Vibration Limitation

The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, for all speeds through 110 percent of rated speed.

1.3.4 Seismic Requirements

Seismic requirements shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.
1.3.5 Experience

Each component manufacturer shall have experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler shall have a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets. Submit a statement showing that each component manufacturer has a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets. The engine-generator set manufacturer/assembler has a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

1.3.6 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer. The field engineer shall have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets.

1.3.7 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Complete starting system.

c. Complete fuel system.

d. Complete cooling system.

e. Complete exhaust system.

f. Layout of relays, breakers, programmable controllers, switchgear, and switches including applicable single line and wiring diagrams with written description of sequence of operation and the instrumentation provided.

g. The complete lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, together with a detailed description of how it is to work. Wiring schematics, safety devices with a listing of their normal ranges, alarm and shutdown values (to include operation parameters such as pressures, temperatures voltages, currents, and speeds) shall be included.
j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Layout of each panel.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set lifting points and rigging instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

Properly protect material and equipment, in accordance with the manufacturers recommended storage procedures, before, during, and after installation. Protect stored items from the weather and contamination. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 EXTRA MATERIALS

Submit a complete list of spare parts for each piece of equipment and a complete list of all material and supplies needed for continued operation. Lists shall include supply source and current prices. Separate each list into two parts, those elements recommended by the manufacturer to be replaced after 3 years of service, and the remaining elements.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: Air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set shall satisfy the requirements specified in the Engine-Generator Parameter Schedule.

b. Each set shall consist of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and other necessary ancillary equipment which may be mounted separately. Sets having a capacity of 750 kW or smaller shall be assembled and attached to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Each set component shall be environmentally suitable for the location shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Any nonstandard products or components and the reason for their use shall be specifically identified.

2.1.1 Engine-Generator Parameter Schedule

Submit description of the generator features which mitigate the effects of the non-linear loads listed.

<table>
<thead>
<tr>
<th>ENGINE-GENERATOR PARAMETER SCHEDULE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Rating</td>
</tr>
</tbody>
</table>

SECTION 26 32 15.00 10 Page 7
### ENGINE-GENERATOR PARAMETER SCHEDULE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Load</td>
<td>350 kVA (maximum)</td>
</tr>
<tr>
<td></td>
<td>50 kVA (continuous)</td>
</tr>
<tr>
<td>Motor Starting kVA (Max.)</td>
<td>720 kVA</td>
</tr>
<tr>
<td>Power Factor</td>
<td>0.8 lagging</td>
</tr>
<tr>
<td>Engine-Generator Applications</td>
<td>stand-alone</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>1800 rpm</td>
</tr>
<tr>
<td>Heat Exchanger Type</td>
<td>fin-tube (radiator)</td>
</tr>
<tr>
<td>Voltage Regulation (No Load to Full Load) (Stand alone applications)</td>
<td>± 2 percent (maximum)</td>
</tr>
<tr>
<td>Voltage Bandwidth (steady state)</td>
<td>± 2 percent</td>
</tr>
<tr>
<td>Frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Voltage</td>
<td>480 volts</td>
</tr>
<tr>
<td>Phases</td>
<td>3 Phase, Wye</td>
</tr>
<tr>
<td>Minimum Generator Subtransient Reactance</td>
<td>14 percent</td>
</tr>
<tr>
<td>Nonlinear Loads</td>
<td>10 kVA</td>
</tr>
<tr>
<td>Max Step Load Increase</td>
<td>75 percent of Service Load at 0.8 PF</td>
</tr>
<tr>
<td>Transient Recovery Time with Step Load Increase (Voltage)</td>
<td>3 seconds</td>
</tr>
<tr>
<td>Transient Recovery Time with Step Load Increase (Frequency)</td>
<td>3 seconds</td>
</tr>
<tr>
<td>Maximum Voltage Deviation with Step Load Increase</td>
<td>15 percent of rated voltage</td>
</tr>
<tr>
<td>Maximum Frequency Deviation with Step Load Increase</td>
<td>5 percent of rated frequency</td>
</tr>
<tr>
<td>Max Step Load Decrease (without shutdown)</td>
<td>100 percent of Service Load at 0.08 PF</td>
</tr>
<tr>
<td>Max Time to Start and be Ready to Assume Load</td>
<td>10 seconds</td>
</tr>
<tr>
<td>Max Summer Outdoor Temp (Ambient)</td>
<td>100 degrees F</td>
</tr>
</tbody>
</table>

SECTION 26 32 15.00 10 Page 8
2.1.2 Rated Output Capacity

Each engine-generator-set shall provide power equal to the sum of Service Load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

2.1.3 Power Ratings

Power ratings shall be in accordance with EGSA 101P.

2.1.4 Transient Response

The engine-generator set governor and voltage regulator shall cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set shall respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.5 Reliability and Durability

Each standby engine-generator set shall have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Two like engines and two like generators shall be cited that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Each like engine and generator shall have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Like engines shall be of the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Like generators shall be of the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e., engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.
2.1.6 Engine-Generator Set Enclosure

The engine-generator set enclosure shall be corrosion resistant and fully weather resistant. The enclosure shall contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Doors shall be provided for access to controls and equipment requiring periodic maintenance or adjustment. Removable panels shall be provided for access to components requiring periodic replacement. The enclosure shall be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.7 Vibration Isolation

The engine-generator set shall be provided with a vibration-isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, +10 percent. Vibration-isolation systems shall be designed and qualified (as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, seismic restraints shall be provided in accordance with the seismic parameters specified.

2.1.8 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA @ PF) when non-linear loads will also be in use is as indicated.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment. As a minimum, nameplates shall be provided for:

- Engines
- Generators
- Relays
- Transformers (CT & PT)
Regulators

Integral Main Fuel Storage Tank

Pumps and pump motors

Governors

Generator Breaker

Economizers

Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the diesel engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger

Heaters

Switchboards

Exhaust mufflers

Switchgear

Silencers

Battery

Exciters

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Filter Elements

Fuel-oil, lubricating-oil, and combustion-air filter elements shall be manufacturer's standard.

2.4.2 Instrument Transformers

NEMA/ANSI C12.11.

2.4.3 Revenue Metering

IEEE C57.13.

2.4.4 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53, or ASTM A106 steel pipe. Pipe smaller than 2 inches shall be Schedule 80. Pipe 2 inches and larger shall be Schedule 40.
2.4.4.1 Flanges and Flanged Fittings

ASTM A181, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.4.2 Pipe Welding Fittings

ASTM A234, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.4.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.4.4 Valves

MSS SP-80, Class 150.

2.4.4.5 Gaskets

Manufacturer's standard.

2.4.5 Pipe Hangers

MSS SP-58.

2.4.6 Electrical Enclosures

NEMA ICS 6.

2.5 ENGINE

Each engine shall operate on No. 2-D diesel fuel conforming to ASTM D975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine shall be naturally aspirated, supercharged, or turbocharged. The engine shall be 2- or 4-stroke-cycle and compression-ignition type. The engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine shall have a minimum of two cylinders. Opposed-piston type engines shall have not less than four cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.6 FUEL SYSTEM

The entire fuel system for each engine-generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.6.1 Pumps

2.6.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow rate shall be based on meeting the load requirements and all necessary recirculation.
2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump shall be driven by a dc electric motor powered by the starting/station batteries. The auxiliary pump shall be automatically actuated by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide the engine with an integral main fuel tank. The tank shall be factory installed and provided as an integral part of the diesel generator manufacturer's product and located beneath the generator, capable of supporting the generator and associated required equipment. The carbon steel fuel tank shall be a UL 142 listed double wall rectangular storage tank. Tank shall be provided with connections for fuel supply line, fuel return line, local fuel fill port, gauge, emergency vents, vent line, and float switch assembly. A fuel return line cooler shall be provided as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank shall be below the flash point of the fuel. The engine-generator set provided with weatherproof enclosures shall have its tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.6.4.1 Capacity

The tank shall have capacity to supply fuel to the engine for an uninterrupted 24-hour period at 100 percent rated load with an additional 10 percent spare fuel capacity.

2.6.4.2 Local Fuel Fill

Each local fuel fill port on the tank shall be provided with a screw-on cap.

2.6.4.3 Fuel Level Controls

The tank shall have a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.
2.6.4.4 Arrangement

Integral tank shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection shall be welded pipe.

2.7 LUBRICATION

The engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. The system shall be pressurized by an engine-driven pump. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase for closed systems. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. The system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for the pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.7.2 Lube-Oil Sensors

Equip engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. These filters shall be in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide the engine with its own cooling system to operate automatically while the engine is running. The cooling system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across the engine shall not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid.
b. The minimum allowable inlet temperature of the coolant fluid.
c. The maximum allowable temperature rise in the coolant fluid through the engine.
2.8.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers. Raw-water circulating pump shall be controlled by manual-off-automatic controllers and shall be engine driven.

2.8.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 7 psi and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes; one tapped hole shall be equipped with a drain cock, the rest shall be plugged.

2.8.3 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. The noise generated by the diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions.

<table>
<thead>
<tr>
<th>Frequency Band (Hz)</th>
<th>Maximum Acceptable Sound Level (Decibels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>88</td>
</tr>
</tbody>
</table>
2.10 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be rubber.

2.11 EXHAUST SYSTEM

Piping shall be supported to minimize vibration. Where a V-type engine is provided, a V-type connector, with necessary flexible sections and hardware, shall connect the engine exhaust outlets.

2.11.1 Flexible Sections and Expansion Joints

A flexible section shall be provided at each engine and an expansion joint at each muffler. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Expansion and flexible elements shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for outside vertical mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 1200 degrees F resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.
2.11.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.12 PYROMETER

A pyrometer, and thermocouple with calibrated leads shall be provided to show the temperature of the combined exhaust. For a supercharged engine, additional points, thermocouples and leads shall be provided to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length shall be not less than 6 inches. The selector switch shall be double pole, with an "off" position, one set of points for each thermocouple, and suitable indicating dial. The pyrometer, thermocouples, leads and compensating devices shall be calibrated to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.13 EMISSIONS

The finished installation shall comply with Federal, state, and local regulations and restrictions regarding the limits of emissions, as listed: Environmental Protection Agency Regulations. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HPAs).

2.14 STARTING SYSTEM

The starting system for engine generator sets used in non-emergency applications shall be as follows.

2.14.1 Controls

An engine control switch shall be provided with functions including: Run/start (manual), off/reset, and automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cooldown operation. The logic shall be arranged for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.14.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.14.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground.
2.14.3.1 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be lead-acid, with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.14.3.2 Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. Submit battery charger sizing calculations. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage. A timer shall be provided for the equalize-charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.14.4 Starting Aids

The manufacturer shall provide one or more of other following methods to assist engine starting as indicated.

2.14.4.1 Glow Plugs

Glow plugs shall be designed to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of –25 degrees F.

2.14.4.2 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 120 volts ac.

2.14.4.2.1 Standby Rated Sets

The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.14.4.3 Lubricating-Oil Heaters

A thermostatically controlled electric heater shall be mounted in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 120 volts ac.
2.14.5 Exerciser

The exerciser shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.15 GOVERNOR

The engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. The tools shall be supplied complete with a suitable tool box. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings. Isochronous governors shall maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity. Droop governors shall maintain the midpoint of the frequency bandwidth linearly for steady-state loads over the range of zero to 100 percent of rated output capacity, configured for safe, manual, external adjustment of the droop from zero to 100 percent.

2.16 GENERATOR

The generator shall be of the synchronous type, one or two bearing, conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Insulation shall be Class H.

a. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

b. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type.

c. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:
   (1) Direct-Axis subtransient reactance (per unit).
   (2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.16.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases shall not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and
dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.16.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases shall not exceed 1 percent of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases shall not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.16.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity shall not exceed 10 percent. The RMS of all harmonics shall be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Each engine-generator shall be designed and configured to meet the total harmonic distortion limits of IEEE 519.

2.17 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 10 percent generator output at 104 degrees F ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.18 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift shall not exceed plus or minus 0.5 percent for an ambient temperature change of 68 degrees F. Reactive droop compensation or reactive differential compensation shall load share the reactive load proportionally between sets during parallel operation. The voltage regulator shall have a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.19 GENERATOR ISOLATION AND PROTECTION

Devices necessary for electrical protection and isolation of each engine-generator set and its ancillary equipment shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit
withstand, and interrupting current ratings to match the generator capacity. The generator circuit breaker shall be electrically operated. A set of surge capacitors, to be mounted at the generator terminals shall be provided. Monitoring and control devices shall be as specified in paragraph GENERATOR PANEL.

2.20 SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgment and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

2.20.1 Audible Signal

The audible alarm signal shall sound at a frequency of 70 Hz at a volume of 100 dB at 10 feet. The sound shall be continuously activated upon alarm and silenced upon acknowledgment. Signal devices shall be located as shown.

2.20.2 Visual Signal

The visual alarm signal shall be a panel light. The light shall be normally off, activated to be blinking upon alarm. The light shall change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display shall maintain activated status to indicate the cause of failure and shall not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms shall be red; all other alarms shall be amber.

2.20.3 Alarms and Action Logic

2.20.3.1 Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.20.3.2 Problem

Activation of the visual signal shall be accomplished.

2.20.4 Local Alarm Panel

A local alarm panel shall be provided with the following shutdown and alarm functions in accordance with NFPA 110 level 2 and including the listed Corps of Engineer requirements mounted either on or adjacent to the engine generator set.

<table>
<thead>
<tr>
<th>Device/ Condition/ Function</th>
<th>What/Where/ Size</th>
<th>NFPA 110 Level 2</th>
<th>Corps of Engineers Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shutdowns w/Alarms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device/ Condition/ Function</td>
<td>What/Where/ Size</td>
<td>NFPA 110 Level 2</td>
<td>Corps of Engineers Required</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>High engine temperature</td>
<td>Automatic/ jacket/ water/ cylinder</td>
<td>SD/CP VA</td>
<td>SD VA</td>
</tr>
<tr>
<td>Low lube-oil pressure</td>
<td>Automatic/ pressure/ level</td>
<td>SD/CP VA</td>
<td>SD VA</td>
</tr>
<tr>
<td>Overspeed Shutdown &amp; Alarm</td>
<td>(110 percent (+ 2 percent of rated speed))</td>
<td>SD/CP VA</td>
<td>SD VA</td>
</tr>
<tr>
<td>Overcrank, Failure to start</td>
<td>Automatic/Failure to start</td>
<td>SD/CP VA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When used</td>
<td>SD/CP VA</td>
<td></td>
</tr>
<tr>
<td>Air shutdown damper (200-600kW)</td>
<td>When used</td>
<td>SD/CP VA</td>
<td></td>
</tr>
<tr>
<td>Red emergency stop switch</td>
<td>Manual Switch</td>
<td>SD/CP VA</td>
<td>SD VA</td>
</tr>
</tbody>
</table>

Alarms

<table>
<thead>
<tr>
<th>Integral main fuel storage tank (Low fuel Limit indication) (70 percent volume remaining)</th>
<th>Automatic/ Integral Tank Level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Integral Main Fuel Storage Tank High Fuel Level</td>
<td>95 percent volume</td>
<td></td>
</tr>
<tr>
<td>Pre-High Temperature</td>
<td>jacket water/ cylinder</td>
<td>CP VAO</td>
</tr>
<tr>
<td>Pre-Low Lube-oil Pressure</td>
<td></td>
<td>CP VA</td>
</tr>
<tr>
<td>High battery Voltage</td>
<td></td>
<td>CP VAO</td>
</tr>
</tbody>
</table>
### 2.20.5 Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device shall return its alarm to normal status after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.

### 2.21 ENGINE GENERATOR SET CONTROLS AND INSTRUMENTATION

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions.

#### 2.21.1 Controls

Provide a local control panel with controls in accordance with NFPA 110 level 2 mounted on the engine generator set.
<table>
<thead>
<tr>
<th>Device/ Condition/ Function</th>
<th>Corps of Engineers Requirements</th>
<th>NFPA 110 Level 2</th>
<th>Manufacturer Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch: Run/start - off/reset - auto</td>
<td>CP</td>
<td></td>
<td>CP/STD</td>
</tr>
<tr>
<td>Emergency stop switch &amp; alarm</td>
<td>CP</td>
<td></td>
<td>CP/STD</td>
</tr>
<tr>
<td>Lamp test/ indicator test</td>
<td>CP</td>
<td>CP VA</td>
<td>CP/STD</td>
</tr>
<tr>
<td>Common alarm contacts/ fault relay</td>
<td>X</td>
<td>CP/O</td>
<td></td>
</tr>
<tr>
<td>Panel lighting</td>
<td>CP</td>
<td></td>
<td>CP/STD</td>
</tr>
<tr>
<td>Audible alarm &amp; silencing/ reset switch</td>
<td>CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage adjust for voltage regulator</td>
<td>CP</td>
<td></td>
<td>CP/STD</td>
</tr>
<tr>
<td>Pyrometer display w/selector switch</td>
<td>CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote emergency stop switch</td>
<td>CP VA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote fuel shutoff switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote lube-oil shutoff switch</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X Required
STD Manufacturers Standard Offering
CP On Control Panel
VA Visual Alarm
O Optional
2.21.2 Engine Generator Set Metering and Status Indication

Provide a local panel with devices in accordance with NFPA 110 level 2 mounted on the engine generator set.

<table>
<thead>
<tr>
<th>Device/ Condition/ Function</th>
<th>Corps of Engineers Requirements</th>
<th>NFPA 110 Level 2</th>
<th>Manufacturer Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genset Status &amp; Metering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genset supplying load</td>
<td>CP VAO</td>
<td>CP VAO</td>
<td></td>
</tr>
<tr>
<td>System ready</td>
<td></td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Engine oil pressure</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Engine coolant temperature</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Engine RPM (tachometer)</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Engine run hours</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Pyrometer display w/selector switch</td>
<td>CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC volts (generator), 3-phase</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>AC amps (generator), 3-phase</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Generator Frequency</td>
<td>CP</td>
<td>CP/STD</td>
<td></td>
</tr>
<tr>
<td>Phase selector switches (amps &amp; volts)</td>
<td>CP</td>
<td>CP/STD</td>
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<tr>
<td>Watts/kW</td>
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<td>CP/VA-O</td>
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<tr>
<td>Voltage Regulator Adjustment</td>
<td>CP</td>
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**X Required**  
**STD** Manufacturers Standard Offering  
**CP** On Control Panel
### 2.22 PANELS

Each panel shall be of the type and kind necessary to provide specified functions. Panels shall be mounted on the engine-generator set base by vibration/shock absorbing type mountings. Instruments shall be mounted flush or semiflush. Convenient access to the back of panels shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Switch plates shall clearly identify the switch-position function.

#### 2.22.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6. Locking mechanisms shall be keyed alike.

#### 2.22.2 Analog

Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Switchboard, switchgear, and control-room panel-mounted instruments shall have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments shall be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range shall be minus 4 to plus 158 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy for phase voltages, hertz and amps.

#### 2.22.3 Electronic

Electronic indicating instruments shall be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F. Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be 0.5 inch minimum.
2.22.4 Parameter Display

Indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters shall be provided. A momentary switch shall be specified for other panels.

2.23 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: Engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of engine-generator set after cool-down. Devices shall automatically reset after termination of their function.

2.23.1 Automatic Transfer Switch

Automatic transfer switches shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.23.2 Monitoring and Transfer

Devices shall be provided to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Functions, actuation, and time delays shall be as described in Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Complete facilities shall be provided for manual starting and testing of each set without load and loading and unloading of each set.

2.25 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall withstand and mitigate the affects of synchronous vibration of the engine and generator. The base shall be provided with suitable holes for anchor bolts and jacking screws for leveling.

2.26 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance with the manufacturer's standard color and practice.

2.27 FACTORY INSPECTION AND TESTS

Submit six complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Each engine-generator set shall be run not less than 1 hour at rated output capacity prior to inspections. Inspections shall be completed and all necessary repairs made, prior to testing. Engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package shall be used.
for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.27.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Inspectors shall look for leaks, looseness, defects in components, proper assembly, etc., and note any item found to be in need of correction as a necessary repair. The following checklist shall be used for the inspection:

<table>
<thead>
<tr>
<th>INSPECTION ITEM</th>
<th>GOOD</th>
<th>BAD</th>
<th>NOTES</th>
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<tbody>
<tr>
<td>Drive belts</td>
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<td>Governor and adjustments</td>
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<td>Engine timing mark</td>
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<td>Coolant type and concentration</td>
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<td>Radiator drains</td>
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<td>Block coolant drains</td>
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<td>Lube oil type</td>
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<td>Lube oil sump drain</td>
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<td>Coupling and shaft alignment</td>
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<td>Voltage regulators</td>
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<td>All wiring connections</td>
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<td>Switchgear</td>
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2.27.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests, including:

a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

b. Six copies of the Factory Test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (8-1/2 by 11 inch minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.
(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor shall be the power factor specified in the engine generator set parameter schedule. For engine-generator set with dual-fuel operating capability the following tests shall be performed using the primary fuel type. Electrical measurements shall be performed in accordance with IEEE 120. Definitions of terms are in accordance with IEEE Stds Dictionary. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.

d. Overspeed Vibration Test, in accordance with IEEE 115 to the performance criteria in NEMA MG 1. The vibration shall be measured at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Vibration amplitude and speed shall be recorded at one minute intervals.

e. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.
(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

f. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: To the performance criteria specified in paragraph GENERATOR.

g. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. High-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion shall be used. Representation of results shall include appropriate scales to provide a means to measure and interpret results.

h. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

\[
\text{Voltage droop percent} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity Volts})}{(\text{Service-Load Volts})} \times 100
\]

\[
\text{Frequency droop percent} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity Hertz})}{(\text{Service-Load Hertz})} \times 100
\]

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

i. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).
(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations shall include the actual instrument trace of voltage and frequency showing: Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended prestarting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L1-L2, L2-L0, and L3-L0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the
PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Installation shall provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Installation of pipe, duct, conduit, and ancillary equipment shall be configured to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturers standard connection is threaded. Except where otherwise specified, welded flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to equipment shall be made with vibration-isolation-type flexible connectors. Piping and tubing shall be supported and aligned to prevent stressing of flexible hoses and connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and shall be installed with a 1/2 inch drain valve with cap at each low point.

3.3.1 Support

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58. Supports shall be spaced not more than 7 feet on center for pipes 2 inches in diameter or less, not more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Supports shall be provided at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Exhaust piping shall be supported with appropriately sized Type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized Type 1 clevis and threaded rods.
3.3.2 Flanged Joints

Flanges shall be Class 125 type, drilled, and of the proper size and configuration to match the equipment and diesel engine connections. Flanged joints shall be gasketed and made up square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of debris.

3.4 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, flexible fittings shall be provided for conduit, cable trays, and raceways attached to engine-generator sets; metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor; and terminations of conductors on the engine generator set shall be crimp-type terminals or lugs.

3.5 FIELD PAINTING

Field painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 10 days prior to beginning tests.

b. Submit six copies of the onsite test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (8-1/2 by 11 inch minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for onsite tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.
3.6.1 Test Conditions

3.6.1.1 Data

Measurements shall be made and recorded of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments, replacements, or repairs shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be recorded in 15 minute intervals during engine-generator set operation and shall include: Readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Electrical measurements shall be performed in accordance with IEEE 120. Definitions of terms are in accordance with IEEE Stds Dictionary. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations shall be in accordance with IEEE 1.

3.6.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor shall be the power factor specified in the engine-generator set parameter schedule.

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and load banks at the specified power factors.

3.6.1.4 Instruments

Readings of panel gauges, meters, displays, and instruments provided as permanent equipment shall be verified during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy shall be within the following: Current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Test instruments shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however, the following general order of testing shall be followed: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior
to connection to the engine-generator set.

3.6.2.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine-generator set shall be pressure tested with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 150 psi, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the downstream distribution equipment. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

(1) \( R \text{ in megohms} = \frac{(\text{rated voltage in kV} + 1)}{304.8}(\text{length of cable in meters}). \)

(2) \( R \text{ in megohms} = \frac{(\text{rated voltage in kV} + 1)}{1000}(\text{length of cable in feet}). \)

(3) Each cable failing this test shall be repaired or replaced. The repair cable shall be retested until failures have been eliminated.

b. Ground-Resistance Tests. The resistance of each grounding electrode shall be measured using the fall-of-potential method defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the requirements resistance, but the specified number of electrodes must still be provided as follows:

(1) Single rod electrode - 25 ohms.

c. Circuit breakers and switchgear shall be examined and tested in accordance with the manufacturer's published instructions for functional testing.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set.
and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented and submitted in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

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<th>Drive belts</th>
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<td>Governor type and features</td>
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<td>Fuel-line connections</td>
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</tr>
<tr>
<td>Fuel lines</td>
<td>I</td>
</tr>
<tr>
<td>Fuel filter</td>
<td>I</td>
</tr>
<tr>
<td>Access for maintenance</td>
<td>I</td>
</tr>
<tr>
<td>Voltage regulator</td>
<td>I</td>
</tr>
<tr>
<td>Battery-charger connections</td>
<td>I</td>
</tr>
<tr>
<td>Wiring and terminations</td>
<td>I</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>I</td>
</tr>
<tr>
<td>Hazards to personnel</td>
<td>I</td>
</tr>
<tr>
<td>Base</td>
<td>I</td>
</tr>
<tr>
<td>Nameplates</td>
<td>I</td>
</tr>
<tr>
<td>Paint</td>
<td>I</td>
</tr>
<tr>
<td>Exhaust-heat system</td>
<td>I</td>
</tr>
<tr>
<td>Exhaust muffler</td>
<td>I</td>
</tr>
<tr>
<td>Switchboard</td>
<td>I</td>
</tr>
<tr>
<td>Switchgear</td>
<td>I</td>
</tr>
<tr>
<td>Access provided to controls</td>
<td>I</td>
</tr>
<tr>
<td>Enclosure is weather resistant</td>
<td>I</td>
</tr>
<tr>
<td>Engine and generator mounting bolts (application)</td>
<td>I</td>
</tr>
</tbody>
</table>

#### 3.6.4 Pre-operational Tests

##### 3.6.4.1 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the installation coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.1.
3.6.4.2 Insulation Test

Generator and exciter circuits insulation resistance shall be tested in accordance with IEEE 43. Stator readings shall be taken at the circuit breaker, to include generator leads to downstream distribution equipment. Results of insulation resistance tests shall be recorded. Readings shall be within limits specified by the manufacturer. Mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of downstream distribution equipment shall be verified. Precautions shall be taken to preclude damaging generator components during test.

3.6.4.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, the engine-generator connection coupling shall be inspected and checked by dial indicator to prove that no misalignment has occurred. The dial indicator shall measure variation in radial positioning and axial clearance between the coupling halves. Readings shall be taken at four points, spaced 90 degrees apart. Solid couplings and pin-type flexible couplings shall be aligned within a total indicator reading of 0.0005 to 0.001 inch for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.002 inch will be acceptable.

3.6.5 Safety Run Test

For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated safety tests shall be repeated.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on
the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.

l. Verify proper operation and setpoints of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the overspeed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

r. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold. The manifold shutoff valve shall be open and bleed valve closed.

s. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

t. Close the manifold shutoff valve. Slowly allow the pressure in the
manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

u. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 75 feet from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is provided, the enclosure, the muffler, and intake silencer shall be modified or replaced as required to meet the sound requirements contained within this specification.

v. Manually drain off fuel slowly from the tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the tank to fill it above low level alarm limits.

3.6.6 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated tests shall be repeated.

3.6.6.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. The engine load run test shall be accomplished principally during daylight hours, with an average ambient temperature of 80 degrees F. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Data taken at 15 minute intervals shall include the following:

   Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

   Pressure: Lube-oil.

   Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting
checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.

d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.

e. Decrease load to 100 percent of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

f. Remove load from the engine-generator set.

3.6.6.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

\[
\text{Voltage droop percent} = \frac{\text{No-load volts} - \text{rated output capacity volts}}{\text{Rated output capacity volts}} \times 100
\]

\[
\text{Frequency droop percent} = \frac{\text{No load hertz} - \text{rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100
\]

d. Repeat steps a. through c. two additional times without making any adjustments.

3.6.6.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.6.6.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.6.6.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of
blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

a. Ambient temperature (at 15 minute intervals).

b. Generator output current (before and after load changes).

c. Generator output voltage (before and after load changes).

d. Frequency (before and after load changes).

e. Generator output power (before and after load changes).

f. Graphic representations shall include the actual instrument trace of voltage and frequency showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.6.7 Fuel Consumption Tests

Perform fuel consumption tests to confirm the manufacturer's certified rates on engine generator set and tabulate and average the results. Fuel consumption tests shall be conducted under the direct supervision of the engine manufacturer's representative. Fuel consumption readings shall be taken at 15 minute intervals, over a minimum period of 1 hour at 50 percent
Service Load, 1 hour at 75 percent Service Load, and 4 hours at 100 percent Service Load. Fuel consumption data may be taken during the 75 percent load test and 100 percent load tests. Fuel consumption readings at site conditions shall be correlated to the guarantee-baseline conditions. Test report shall contain: Readings of the output frequency, voltage, current, power factor, and power; barometric pressure; ambient temperature; intake-air temperature; fuel temperature; the site fuel consumption readings, adjustment calculations, factors, and source references for correlation of actual consumption rate of the guaranteed rate.

a. Start and operate the generator set and allow it to stabilize at rated load, rated voltage and rated frequency. During this period, readings of all instruments including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet. Unless otherwise specified in the procurement document, stabilization will be consideration to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or frequency has been made.

b. Perform one of the following procedures:

BALANCE SCALE PROCEDURE.

(1) Supply fuel from auxiliary container mounted on a balance scale.

(2) After stabilization has occurred, set the balance weights at any convenient value slightly less than the total weight of the fuel and container.

(3) Start the stopwatch when the balance weights fall and record the total weight.

(4) Reduce the balance weight a convenient amount and record the amount of the weights removed.

(5) Stop the stopwatch when the balance weights fall and record the total weight and the elapsed time.

(6) Repeat steps (1) thru (2) above until the timed portion of the test exceeds the 2 hours.

(7) From the total elapsed time and total of the weights removed calculate the fuel consumption in terms of pounds per hour.

(8) Using the value obtained in step (7) above, compute the rate of fuel consumption per kilowatt hour, as follows:
Pounds per kWH = \frac{\text{Fuel Consumption in Pounds per Hour}}{\text{kW Load}}

(9) Repeat the test for each load condition specified.

(10) Determine the capacity of the generator set fuel tank in pounds of fuel.

(11) For each specified load, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used.

\text{Operating hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per hour)}}

ALTERNATE PROCEDURE FOR WEIGHING FUEL

(1) Supply fuel from the auxiliary fuel container, mounted on a platform balance, or other weighing device.

(2) After stabilization has occurred, record weight readings every one-half hour for a period of 2 hours.

(3) Calculate the average hourly fuel consumption rate in pounds per hour.

(4) Using the average hourly fuel consumption rate obtained above, compute the rate of fuel consumption per kilowatt hour, as follows:

\text{Pounds per kWH} = \frac{\text{Fuel Consumption}}{\text{kW Load}}

(5) Repeat test for each load condition specified.

(6) Determine the capacity of the generator set fuel tank in pounds of fuel.

(7) For each specified load test, compute the number of continuous ours the generator set will operate on a full tank of fuel. The following formula shall be used:

\text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}}

ALTERNATE PROCEDURE USING FLOWMETER

Flowmeters may be used to determine the fuel rate. They usually are calibrated in either gallons per hour, or pounds per hour, for a fuel of a definite specific gravity and temperature.

(1) After stabilization has occurred record the fuel consumption rate, and continue to record the fuel consumption rate at one-half hour intervals for 2 hours.

(2) Determine the average of the readings (correct for fuel specific gravity and temperature). This is the fuel consumption rate and should be converted, if necessary, to pounds per hour.

(3) Using the average value obtained above, calculate the rate of fuel
consumption per kilowatt hour.

(4) Repeat the test for each load condition specified.

(5) Determine the capacity of the generator set fuel tank in pounds of fuel.

(6) For each specified load test, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used:

\[ \text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}} \]

c. Results. Compare the operating hours or the fuel consumption rate per kWh.

3.7 ONSITE TRAINING

Conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the video taping service to be provided, and the kind and quality of the tape to be left with the Contracting Officer at the end of the instructional period.

b. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate routine maintenance procedures as described in the operation and maintenance manuals. Two copies of a video tape of the entire training session manufacturers operating and maintenance training course shall be submitted.

c. Submit six copies of the operation manual (approved prior to commencing onsite tests) in 8-1/2 by 11 inch binders, having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each system or subsystem. Sections shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be folded blue lines, with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes.

d. One full size reproducible mylar of each drawing shall accompany the booklets. Mylars shall be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual shall include: Step by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions shall include procedures for interface and interaction with related systems to include automatic transfer switches. Each booklet shall include a CD containing an ASCII file of the procedures.
e. All operation and maintenance manuals shall be approved and made available for the training course. All posted instructions shall be approved and posted prior to the beginning date of the training course. The training course schedule shall be coordinated with the Using Service's work schedule, and submitted for approval 14 days prior to beginning date of proposed beginning date of training.

f. Submit six copies of the maintenance manual containing the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each item listed. Each section shall be separated by a heavy plastic divider with tabs. Drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes.

(1) Procedures for each routine maintenance item.

(2) Procedures for troubleshooting.

(3) Factory-service, take-down overhaul, and repair service manuals, with parts lists.

(4) A copy of the posted instructions.

(5) A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components specified for nameplates.

(6) Submit six complete reproducible copies of the final relay and protective device settings. The settings shall be recorded with the name of the company and individual responsible for their accuracy.

3.8 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 8 hours at Service Load, then re-examining the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.
3.9 POSTED DATA AND INSTRUCTIONS

Posted Data and Instructions shall be posted prior to field acceptance testing of the engine generator set. Two sets of instructions/data shall be typed and framed under weatherproof laminated plastic, and posted side-by-side where directed. First set shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set of shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Submit posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

a. Instructions shall include procedures for interrelated equipment (such as automatic transfer switches). Two sets of instructions/data shall be typed in 8-1/2 by 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. The binders shall be placed as directed by the Contracting Officer. The instructions shall be in place prior to acceptance of the engine generator set installation.

b. First set shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as automatic transfer switches).

c. Submit instructions including: The manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as automatic transfer switches). Instructions shall be weatherproof, laminated in plastic, and posted where directed.

3.10 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)


NEMA ICS 2 (2000; R 2005; Errata 2008)  Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V


NEMA ICS 6 (1993; R 2011)  Industrial Control and Systems: Enclosures
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)


NFPA 70 (2017) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1008 (2014) Transfer Switch Equipment

UL 1066 (2012; Reprint Aug 2016) UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
  Detail Drawings
  Equipment
  Installation

SD-03 Product Data
  Equipment

SD-06 Test Reports
  Testing; G

SD-07 Certificates
  Equipment
  Switching Equipment

SD-10 Operation and Maintenance Data
  Switching Equipment; G
  Instructions; G
1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Submit schematic, external connection, one-line schematic and wiring diagram of each ATS assembly. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

1.3.2 Switching Equipment

Upon request, manufacturer shall provide notarized letter certifying compliance with requirements of this specification, including withstand current rating (WCR). Submit evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008. Submit an operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply source and current cost of recommended spare parts. Manual shall include simplified wiring and control diagrams for system as installed.

1.4 SITE CONDITIONS

Seismic requirements shall be as specified in UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT. ATS shall be suitable for prolonged performance under following service conditions:

<table>
<thead>
<tr>
<th>Altitude</th>
<th>750 feet above mean sea level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Humidity</td>
<td>90 percent maximum, continuous</td>
</tr>
<tr>
<td>Temperature</td>
<td>30 to 90 degrees F</td>
</tr>
<tr>
<td>Seismic Parameters</td>
<td>Refer to Section 33 71 02</td>
</tr>
</tbody>
</table>

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are standard products of a manufacturer regularly engaged in manufacturing the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit list of proposed equipment and material, containing a description of each separate item, and certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards. The experience use shall include applications in similar circumstances and of same design and rating...
as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

2.2 NAMEPLATE

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 1/8 inch tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

2.3 AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in standby systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13, IEEE C62.41.1, IEEE C62.41.2, IEEE 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10 Part 2, UL 1008, and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall have following characteristics:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>480 volts ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Phases</td>
<td>Three</td>
</tr>
<tr>
<td>Number of Wires</td>
<td>Three</td>
</tr>
<tr>
<td>Frequency</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Poles</td>
<td>Three switched</td>
</tr>
<tr>
<td>ATS WCR</td>
<td>Rated to withstand short-circuit current of 50k amperes, RMS symmetrical.</td>
</tr>
<tr>
<td>Nonwelding Contacts</td>
<td>Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.</td>
</tr>
<tr>
<td>Main and Neutral Contacts</td>
<td>Contacts shall have silver alloy composition. Neutral contacts shall have same continuous current rating as main or phase contacts.</td>
</tr>
</tbody>
</table>

2.3.1 Override Time Delay

Provide adjustable time delay to override monitored source deviation from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase
conductors to detect and respond to sustained voltage drop of 25 percent of nominal between any two normal source conductors and initiate transfer action to alternate source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 85 percent of nominal.

2.3.2 Transfer Time Delay

Time delay before transfer to alternate power source shall be adjustable from 0 to 5 minutes and factory set at 0 minutes. ATS shall monitor frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.3.3 Return Time Delay

Time delay before return transfer to normal power source shall be adjustable from 0 to 30 minutes and factory set at 30 minutes. Time delay shall be automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal supply has been restored.

2.3.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.3.5 Exerciser

Provide a generator exerciser timer. Run times shall be user programmable. The generator exerciser shall be selectable between load transfer and engine run only, and shall have a fail-safe feature that will retransfer the ATS to normal during the exercise period.

2.3.6 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 10 amperes at 120 volts shall operate when ATS is connected to normal power source, and two normally open and two normally closed contacts shall operate when ATS is connected to alternate source.

2.3.7 Supplemental Features

ATS shall be furnished with the following:

a. Engine start contact.
b. Alternate source monitor.
c. Test switch to simulate normal power outage.
d. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.
e. Time delay bypass switch to override return time delay to normal.
2.4.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal or alternate power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with Paragraph "Automatic Transfer Switch (ATS)" and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.
b. Indication shall be provided of ATS isolation. The ATS controls shall remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.4.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.5 ENCLOSURE

ATS and accessories shall be installed in free-standing, floor-mounted, ventilated NEMA ICS 6, Type 1R, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Intake vent shall be screened and filtered. Exhaust vent shall be screened. Door shall have suitable hinges, locking handle latch, and gasketed jamb. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system using No. 10 AWG copper conductors. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors from bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.5.1 Construction

Enclosure shall be constructed for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.5.2 Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Finish shall be manufacturer's standard material, process,
and color and shall be free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4, or 12 shall be acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.5.3 Pullbox

Provide when necessary to allow for bottom entry of conductors from generator. Conductors from MDS and MCC shall be top entry. Pullbox shall be of same material and gauge as ATS and mounted to the side of the ATS. Pullbox shall be a maximum of 20 inches wide and the same depth and height of the ATS.

2.6 TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 2 weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

2.6.1 Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system.

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.6.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

2.7 FACTORY TESTING (MEDICAL FACILITIES)

2.7.1 Viewing Ports

ATS and BP/IS switches shall be of draw-out construction. Viewing ports to inspect the contacts without requiring disassembly shall be provided.

2.7.2 Operating Handles

The operating handles shall be externally operated, and designed and constructed not to stop in an intermediate or neutral position during operation, but shall permit load by-pass and transfer switch isolation in
no more than two manual operations which can be performed by one person in 5 seconds or less. The transfer speed will be independent of the operational speed of the switch handle or handles.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions. Submit dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door. Submit 6 copies of operating and 6 copies of maintenance manuals listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

3.3.1 Insulation Resistance

Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

3.3.2 Power Failure of Normal Source

Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

3.3.3 Power Failure of Emergency Source

Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

3.3.4 Low Phase-to-Ground Voltage

Simulate low phase-to-ground voltage for each phase of normal source.

3.3.5 Operation and Settings

Verify operation and settings for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.
3.3.6 ATS and BP/IS Functions

Verify manual and automatic ATS and BP/IS functions.

-- End of Section --
PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code

NFPA 780 (2014) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)


UNDERWRITERS LABORATORIES (UL)

UL 467 (2013) Grounding and Bonding Equipment


1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.
1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
- Overall lightning protection system; G
- Each major component; G

SD-06 Test Reports
- Lightning Protection and Grounding System Test Plan; G
- Lightning Protection and Grounding System Test; G

SD-07 Certificates
- Lightning Protection System Installers Documentation; G
- Component UL Listed and Labeled; G
- Lightning protection system inspection certificate; G
- Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.
1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Constructn, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780 and AFI 32-1065. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780 and AFI 32-1065. In either case, AFI 32-1065 takes precedence over NFPA 780, whether or not it is more stringent.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100 percent system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture
unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors. All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

2.1.2 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel conforming to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps. Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end," "Tee," or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, and grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves or as otherwise indicated on drawings. Bond secondary conductors with grounded
metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals and Roof Conductors

Coordinate air terminal and roof conductor mounting with manufacturer of structure. Design of air terminal layout and support shall confirm to NFPA 780. Avoid mounting penetrations in roof and sharp bends or turns in conductors. Adhesive shoes shall be used for mounting air terminals and roof conductors to EPDM type roofs.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by NFPA 780. Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Contractor may submit, for approval, alternative method for concealing exposed down conductors.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by compression. All connections to ground rods below ground level must be by high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 10 feet. Set ground rods not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 1/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 3 feet nor more than 8 feet from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 30 inches. Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.
3.2 INTERFACE WITH OTHER STRUCTURES

3.2.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 6 feet of any part of the lightning protection system in accordance with ANSI C2.

3.3 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.4 FIELD QUALITY CONTROL

3.4.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: Locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B31.4 (2012) Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquid

ASME INTERNATIONAL (ASME)

ASME B31.4 (2012) Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquid

ASTM INTERNATIONAL (ASTM)


INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


NACE INTERNATIONAL (NACE)


NACE SP0169 (2013) Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0169 (2013) External Cathodic Protection of Underground or Submerged Metallic Piping System

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6 (1993; R 2011) Industrial Control and Systems: Enclosures

NEMA ST 1 (1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)


UNDERWRITERS LABORATORIES (UL)

UL 467 (2013) Grounding and Bonding Equipment


UL 506 (2008; Reprint Oct 2013) Specialty Transformers

UL 510 (2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

UL 514A (2013) Metallic Outlet Boxes

UL 514B (2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings

UL 6 (2007; reprint Nov 2014) Electrical Rigid Metal Conduit-Steel

UL 83 (2014) Thermoplastic-Insulated Wires and Cables

1.2 Related Requirements

Sections 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and, 26 20 00 INTERIOR DISTRIBUTION SYSTEM, 01 78 23 OPERATION AND MAINTENANCE DATA, 03 30 00.00.10 CAST-IN-PLACE CONCRETE apply to this section except as modified herein.
1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Rectifier Installation; G
- Anode installation; G
- Test stations; G
- Anode junction boxes; G

SD-03 Product Data

- Rectifiers; G
- Cable and wire; G
- Anodes; G
- Anode junction boxes; G
- Reference electrodes; G
- Shunt Resistors
- Anode backfill; G
- Anode vent pipe
- Surge Arresters; G

SD-07 Certificates

- Qualifications of Corrosion Engineer; G

SD-10 Operation and Maintenance Data

- Cathodic protection system, Data Package; G
- Rectifier replacement/spare parts list, Data Package; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

- Initial Cathodic Protection System Field Test Report; G
- Final Cathodic Protection System Field Test Report; G
1.4 SERVICES OF CORROSION ENGINEER

The Contractor shall obtain the services of a cathodic protection specialty firm (CP firm) with a "Corrosion Engineer" to supervise, inspect and test the installation of the cathodic protection system(s). Corrosion Engineer refers to a registered professional engineer with certification or licensing that includes education and experience in cathodic protection of buried or submerged metal structures and on-grade above ground fuel storage tanks, or a person certified by NACE International at the level Cathodic Protection Specialist. Such a person shall have not less than five years experience in the cathodic protection of buried or submerged metal structures and on-grade above ground fuel storage tanks. The Corrosion Engineer can perform all the onsite tasks themselves or may have a certified "CP Technologist" perform some of the tasks. The contractor shall submit evidence of the qualifications of Corrosion Engineer and the CP Technologist to the Contracting Officer for review and approval.

a. The "Corrosion Engineer" must be accredited or certified by NACE International as a NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification or licensing that includes education and experience in corrosion control of buried or submerged metallic piping and tank systems, if such certification or licensing includes 5 years experience in corrosion control on underground metallic surfaces of the type under this Contract. The CP Technologist must be a NACE certified CP Technologist and have documented experience in installation, inspection, and testing of fuel facility corrosion control systems. The CP Technologist shall work under the supervision of the Corrosion Engineer.

b. The Corrosion Engineer is not required to personally visit the project site. The approved and qualified CP Technologist can perform the required visits. Once the submittals are approved and the materials delivered, the Corrosion Engineer or CP Technologist shall visit the site to ensure the Contractor understands installation practices and laying out the components. The CP firm shall be on site during the tank floor installation to ensure the anode is protected during the floor installation and remains electrically isolated. Subsequent site visits shall involve testing the installed cathodic protection systems and training applicable personnel on proper maintenance techniques. The Corrosion Engineer or the CP Technologist shall supervise installation and perform testing of all the cathodic protection components.

c. Submit evidence of Qualifications of "Corrosion Engineer" and "CP Technologist" including names and qualifications certified in writing to the Contracting Officer prior to the start of construction. Certification shall be submitted giving the name of the firm, the number of years of experience, and a list of not less than five (5) of the firm's installations, three (3) or more years old, that have been tested and found satisfactory.

PART 2 PRODUCTS

2.1 UNDERTANK ICCP SYSTEM ANODES

Anodes shall be one of two type depending on the Contractor's expertise. Anode shall be MMO ribbon grid type. Refer to the project drawings for the type and dimensions of the anode spacing.
2.1.1 Conductive Material

ASTM B265 Grade 1 Titanium Anode substrate coated with an inert, dimensionally stable, electrically conductive coating with a mixture of iridium and titanium oxides with a small amount of tantalum and ruthenium, 0.002 ohm-centimeter maximum resistivity, 50 MPa minimum adhesion or bond strength, and capable of sustaining a current density of 100 ampere per square meter in an oxygen generating electrolyte at 150 degrees F for 25 years. Sinter the mixed metal oxide coating to the titanium surface as to remain tightly bound to the surface when bent 180 degrees onto itself.

2.1.2 Anode Lead Wires

Dual jacket wire. No. 8 AWG stranded copper conductor with 110 mils thick ASTM D1248, an inner jacket of 40 mils of ethylene chlorotrifluoroethylene (Halar common brand name) insulation covered by an outer jacket of 65 mils of ASTM D1248, high molecular weight polyethylene (HMWPE) of sufficient length to extend to junction box without splicing.

2.1.3 Anode Lead Wire Connections

Anode lead wires shall be connected to the anodes or conductor bars during installation. Solidly crimp and solder the connection between the anode conductor bar and the copper lead wire. Seal the connection with a three layer system of half lapped mastic tape covered with a heat shrinkable sleeve and in cast epoxy. Alternate splice may be used if they are factory connected and of a proven design from the manufacturer with a product history of a minimum 10 years successful application. Cable to anode contact resistance shall be 0.02 ohms maximum.

2.1.4 Mixed Metal Oxide Anode Ribbons

Mixed metal oxide anode ribbons shall be provided by a firm that is regularly engaged in and has a minimum 5 years experience in manufacturing and applying mixed metal oxide coatings to titanium anode substrates. The mixed metal oxide anode ribbons conform to the following requirements.

<table>
<thead>
<tr>
<th>Width</th>
<th>0.5 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>0.025 inches</td>
</tr>
<tr>
<td>Weight</td>
<td>6 pounds/500 feet</td>
</tr>
<tr>
<td>Resistance</td>
<td>0.042 ohms/foot</td>
</tr>
</tbody>
</table>

2.1.4.1 Conductor Bars

Titanium conductor bars are used to form a grid pattern and thereby reduce the voltage drop along the ribbon anode. The conductor bars shall be:

<table>
<thead>
<tr>
<th>Composition: ASTM B265; Titanium, Grade 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
</tr>
<tr>
<td>Thickness</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Resistance</td>
</tr>
</tbody>
</table>

2.2 UNDERGROUND PIPING ICCP SYSTEM

2.2.1 Mixed Metal Oxide Anodes

Mixed metal oxide anodes shall be of the size indicated in the project drawings and shall conform to the following requirements. Mixed metal oxide anodes shall be provided by a firm that is regularly engaged in and has a
minimum 5 years experience in manufacturing and applying mixed metal oxide coatings to titanium anode substrates. The mixed metal oxide anodes shall be of the size indicated and shall conform to the following requirements

2.2.1.1 Conductive Material

The electrically conductive coating shall contain a mixture consisting primarily of iridium, tantalum, and titanium oxides. The average composition is generally a 50/50 atomic percent mixture of iridium and titanium oxides, with a small amount of tantalum. The resistivity, as tested by the manufacturer, shall be no more than 0.002 ohm-centimeter, and the bond strength shall be greater than 7.25 ksi to guarantee the current capacity life and the quality of the conductive ceramic coating. The adhesion or bond strength shall be determined by epoxy bonding a 0.1 inch diameter stud to the ceramic coating and measuring the load to failure (about 10.15 ksi) of either the epoxy or the interface between the coating and the substrate. The anode must be inert and the electrically conductive ceramic coating dimensionally stable. The ceramic coated anode shall be capable of sustaining a current density of 100 ampere per 10.764 square feet in an oxygen generating electrolyte at 150 degrees F for 20 years, to ensure the current capacity life. An accelerated current capacity life test shall be performed by the manufacturer on every lot of anode wire used to construct the anode as described. The mixed metal oxide coating shall be applied to the wire anode by a firm that is regularly engaged in and has a minimum 5 years experience in manufacturing and applying mixed metal oxide coatings to titanium anode substrates. The mixed metal oxide must be sintered to the titanium surface as to remain tightly bound to the surface when bent 180 degrees onto itself.

2.2.1.2 Anode Life Test

The anode wire material shall sustain current densities of 100 ampere per 10.764 square feet in an oxygen generating electrolyte for 20 years. The manufacturer shall certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria. The test cell sustains a current density of 10,000 ampere per 10.764 square feet in a 15 weight percent sulfuric acid electrolyte at 150 degrees F without an increase in anode to cathode potential of more than 1 volt. The cell containing the anode shall be powered with a constant current power supply for the 30 day test period. The representative sample shall be 5 inch in length taken from the lot of wire that is to be used for the anode.

2.2.1.3 Anode Connecting Cables

Anodes shall have connecting cables installed at the factory. The connection between the anode rod or ribbon and the lead wire shall be made with a solid crimp couple with solder. The connection shall be sealed in cast epoxy.

2.2.2 Anode Backfill

Provided Loresco Type SWS Earth Contact Backfill, or approved equal, with the following analysis:

a. Chemical composition
### Fixed carbon
- 99.35 percent (minimum)

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>0.60 percent</td>
</tr>
<tr>
<td>Moisture content</td>
<td>0.05 percent</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.00 percent (maximum)</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>0.01 percent (maximum)</td>
</tr>
</tbody>
</table>

b. Weight: 68 lbs per cubic foot

c. Size: 90 percent between 1 mm and 5 mm.

2.2.3 Anode Vent Pipe

NEMA TC 2, Type EPC-80-PVC, 1 inches in diameter and having vertical slits parallel to the pipe longitudinal centerline, 1 inches long, 0.006 inch wide, spaced 6 inches apart longitudinally and one inch apart circumferentially around the vent pipe along the length of vent tube which is in the coke breeze backfill

2.3 RECTIFIERS

2.3.1 Transformer

UL 506 and NEMA ST 1, as applicable. The rectifier unit shall consist of an air cooled non-explosion proof cabinet, a transformer, rectifying elements, transformer tap adjuster, terminal block, one DC output voltmeter, one DC output ammeter, an AC power-supply circuit breaker, lightning arresters for both input and output terminals, filter chock, calibrated shunt, DC ratings as required, all wired and assembled in a weatherproof cabinet. The overall efficiency of the rectifier shall be not less than 65 percent when operated at nameplate rating and shall be capable of supplying continuous full rated output at an ambient temperature of 112 degrees F in full sunlight with the expected life in excess of 10 years.

2.3.2 Electrical Ratings

Electrical ratings as follows:

a. Input voltage at 60 Hz: 115/230 volts single phase.

b. Output voltage, dc: 30 Volt for Tank; 40 Volt for Piping.

c. Output current, dc: 6 Amp for Tank; 10 Amp for Piping.

The rectifiers shall be capable of supplying continuous full rated output at an ambient temperature of 112 degrees F in full sunlight with expected life of 15 years minimum.

2.3.3 Rectifier Stacks

Silicon connected in such a manner as to provide full wave rectification. Silicon diodes shall be protected by selenium cells or varistors against overvoltage surges and by current limiting devices against overcurrent surges.
2.3.4 Enclosure

NEMA ICS 6, Type 3R, suitable for wall mounting. Enclosure shall include hinged door with padlock hasp. Fit enclosure with screened openings to provide for cooling by natural convection. Provide holes, conduit knockouts and threaded hubs of sufficient size and location. The cabinet and mounting support shall be hot-dipped galvanized steel, stainless steel, or aluminum.

2.3.5 Overload and Short Circuit Protection

UL 489, Molded case circuit breaker, magnetic type.

2.3.6 D.C. Output Control

D.C. output voltage shall be adjustable. Transformer taps, 6 coarse, 6 fine.

2.3.7 Output Voltage and Current Metering

Provide separate panel voltmeter and ammeter, not less than 2-1/2 inch rectangular or round, two percent full scale accuracy at 80 degrees F, temperature stability above and below 80 degrees F of at least one percent per 10 degrees F. Provide additional output terminals for a Remote Monitoring Unit.

2.3.8 Surge Protection

Protect silicon diodes by use of AC and DC lightning arresters or metal oxide varistors against overvoltage surges and by current-limiting device against overcurrent surges.

2.3.9 Efficiency

Overall efficiency of 65 percent minimum when operated at full output.

2.3.10 Grounding Provisions

NFPA 70 and UL 467 including a grounding terminal in the cabinet. Grounding conductor from terminal to earth grounding system shall be solid or stranded copper not smaller than No. 6 AWG. Earth grounding system shall consist of one or more copper clad steel rods. Ground rods shall be a minimum of 8 feet long.

2.3.11 Shunt Resistor

MIL-I-1361. Resistors shall be located on the rectifier front panel and clearly marked with current and voltage for verification of panel ammeter.

2.3.12 Wiring Diagram

Provide complete wiring diagram of the power unit showing both A.C. supply and D.C. connections to anodes on the inside of the cabinet door. Show and label components.

2.3.13 Rectifier Replacement/Spare Parts List

Provide identification and coverage for all parts of each component, assembly, and accessory of the items subject to replacement in accordance.
2.4 CONDUIT AND CABLE FOR POWER SERVICE AT 600 VOLTS OR LESS

2.4.1 Conduit


2.4.2 Cable and Wire Other Than Anode Lead Wires

Copper conductors conforming to ASTM B3 and ASTM B8. Wires terminating at a rectifier, junction box, or test station shall have cable identification tags. Refer to the Paragraph entitled "Anode Lead Wires" for anode lead wires.

2.4.2.1 AC Power Supply Wiring

UL 83, Type THWN with stranded copper conductors, gage (AWG) as indicated.

2.4.2.2 AC Disconnect

UL 489, AC breaker wall mounted adjacent to rectifier.

2.4.2.3 Rectifier DC Negative (Structure) Cable(s)

ASTM D1248, High Molecular Weight Polyethylene (HMWPE) insulation, Black color insulation, stranded copper conductors, gage (AWG) as indicated in the project drawings.

2.4.2.4 Rectifier DC Positive (Anode) Header Cable(s)

ASTM D1248, High Molecular Weight Polyethylene (HMWPE) insulation, Red color insulation, stranded copper conductors, gage (AWG) as indicated in the project drawings. Refer to the paragraph entitled "Anode Lead Wires" for anode lead wires. Black cable with red tape or other identification is not acceptable. The DC Positive Header Cable must be red for the entire length between the rectifier and the anode junction box.

2.4.3 Cable and Wire Identification Tags

Brass or Stainless steel material with stamped or engraved letters. Print letters and numbers a minimum of 3/16 inch in size. Provide identifier legend in accordance with the drawings.

2.4.4 Wire Connectors to Tank or Fuel Pipe

For above grade connections, solderless copper crimp or heavy duty screw type lugs, capable of a 50 amp load, or exothermic weld. For below grade connections, exothermic weld only.

2.4.5 Insulating Tape

UL 510.

2.4.6 Underground Splices

Splices are not permitted in buried sections of cable.
2.4.7 Buried Cable Warning and Identification Tape

Polyethylene tape, manufactured for warning and identification of buried cable and conduit. Tape shall be 3 inches wide, Yellow in color and read "Caution Buried Cable Below" or similar. Color and lettering shall be permanent and unaffected by moisture or other substances in backfilling.

2.5 ANODE JUNCTION BOXES AND TEST STATIONS

2.5.1 Pull Box-Post Mounted Type

NEMA ICS 6, Type 4X enclosure rated for Class 1, DIV 1 hazardous locations (explosion proof) with bolted cover. Mount enclosures as indicated. The box shall have threaded hubs for conduit or seal fitting with minimum sizes as follows:

a. 2 inch for the anode lead wires and reference electrodes from under the tank.

b. 2 inch for the anode lead wires and reference electrode wires to anode junction box.

c. 3/4 inch for the Tank Test Lead wire from the tank exterior.

d. 3/4 inch for the Tank DC Negative wire from the tank exterior.

2.5.2 Anode Junction Box Wall Mounted Type

NEMA Type 4X fiberglass enclosure for non hazardous locations with stainless steel hinges. Enclosure shall include terminal board and labeled with name plate.

2.5.3 Test Stations

Test stations shall be H2O traffic rated and FAA runway tested. Provide test stations complete with an insulated terminal block having the indicated number of terminals; provided with a lockable cover and have a cast-in legend, "C.P. Test" (One terminal required for each conductor). Provide sufficient test stations to monitor underground isolation points. Test station terminal connections and the terminal conductor shall be permanently tagged to identify each termination of the conductors (e.g. identify the conductors connected to the protected structures). Conductors shall be permanently identified in the station by means of plastic or metal tags, or plastic sleeves to indicate termination. Each conductor shall be color coded in accordance with the drawings. The station test facility, including permanent Cu-Cu SO4 reference cells and test returns shall be installed as indicated. Pavement inserts shall be nonmetallic and shall allow Cu-Cu SO4 reference electrode to contact the electrolyte beneath the pavement surface. Welding of electrical connections shall be as follows: Exothermic welds shall be "CADweld", "Thermo-weld", or approved equal. Use and selection of these materials and welding equipment shall be in accordance with the manufacturer's recommendations.

2.5.4 Terminal Boards

Provide terminal boards for anode junction boxes, bonding boxes, and test stations made of phenolic plastic 1/8 inch thick with dimensions as to accommodate the cable terminations, shunts and wire identification labels.
Insulated terminal boards shall have the required number of terminals (one terminal required for each conductor). There shall be one current shunt for each anode power feed cable. Install solderless copper lugs and copper bus bars, shunts, and variable resistors on the terminal board as indicated. Test station terminal connections shall be permanently tagged to identify each termination of conductors (e.g. identify the conductors connected to the protected structure, anodes, and reference electrodes). Conductors shall be permanently identified by means of metal tags to indicate termination. Each conductor shall be color coded as follows:

<table>
<thead>
<tr>
<th>Conductors</th>
<th>Colors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anode lead wire</td>
<td>Red</td>
</tr>
<tr>
<td>Structure lead wire</td>
<td>Black</td>
</tr>
<tr>
<td>DC Positive Rectifier</td>
<td>Red</td>
</tr>
<tr>
<td>Zinc Reference</td>
<td>Blue</td>
</tr>
<tr>
<td>Copper:Copper Sulfate</td>
<td>Yellow</td>
</tr>
<tr>
<td>DC Negative Rectifier</td>
<td>Black</td>
</tr>
</tbody>
</table>

2.5.5 Shunt Resistors

MIL-I-1361. One current shunt for each power feed cable. Calibrated resistance 0.001 ohm, 10 ampere capacity, accuracy plus or minus one percent, manganin wire type. Holloway Type SO or Holloway Type SS or Holloway Type SW or approved equal.

2.6 BONDING AND GROUNDING EQUIPMENT

UL 467.

2.7 ELECTRICAL INSULATING COATINGS

Conformable water tight sealant having dielectric strength not less than 15 kV for a 1/8 inch thick layer.

2.8 CONCRETE RECTIFIER PAD

Dimensions, conduit locations, and anchor bolt location as indicated and in accordance with the manufacturer's drawings for the equipment furnished.

2.8.1 Concrete

4000 psi concrete conforming to ASTM C94/C94M or Section 03 30 00.00.10 CAST-IN-PLACE CONCRETE.

2.9 PERMANENT REFERENCE ELECTRODES

Permanent reference electrodes shall be dual element zinc and copper copper-sulfate specifically manufactured for underground use with a minimum manufacturer design life of 30 years. Provide cells, in quantities indicated on the project drawings, with two No. 14 AWG, neoprene jacket cable of sufficient length to extend to the junction box without splicing. Dual element reference electrode shall be Model UD-CUG-LW050 by
Electrochemical Devices or approved equal.

2.9.1 Zinc Element

Zinc shall conform to ASTM B418, Type II. 1.4 inch by 1.4 inch by 9 inch electrodes, prepackaged in quick wetting backfill.

2.9.2 Copper Copper Sulfate Electrode

1-5/8 inch diameter, by 21 inches long, plastic schedule 80 PVC tube with an ion trap to minimize contamination of the cell. The CSE electrodes shall have a minimum stability of plus or minus 5 millivolts under 3 microamp load, and an initial accuracy of plus or minus 10 millivolts referenced to a calibrated portable reference electrode. The cell shall be prepackaged by the manufacturer with a backfill material as recommended by the manufacturer.

2.10 EXOTHERMIC WELD KITS

ASME B31.4 Exothermic welds shall be "Cadweld", "Burndy", or "Thermoweld". Use of this material shall be in strict accordance with the manufacturer's recommendations. Exothermic weld kits, charges and molds shall be specifically designed by the manufacturer for welding the types of materials and shapes provided.

2.10.1 SURGE ARRESTORS

Provide surge arrestors across all aboveground insulated flanges connected to belowground cathodically protected piping. Require surge arrestors to be designed for use with insulated flanges and for use in Class I, Division 1 areas. Provide covers over flanges to preclude dirt from degrading surge arrestors; refer to DoD Standard Design AW 78-24-28.

PART 3 EXECUTION

3.1 General

IEEE C2 NFPA 70

The cathodic protection system for the aboveground fuel storage tank shall be installed after the tank construction contractor has constructed the ring wall and placed the secondary containment liner and compacted a single 2 inch thick lift of sand.

3.2 Anode Installation

3.2.1 Lifting Anodes

Do not lift or support anode by the lead wire. Exercise care to preclude damaging the anode and the lead wire insulation.

3.2.2 Mixed Metal Oxide Anodes - Piping

Installing anodes: Place 12 inches of coke breeze in the hole. Connect the anodes and vent pipe to "ventralizer" as shown in the project drawings and lower the assembly into anode well. Fill anode well with additional coke breeze until 12 inches above the top anode. Cut the pipe to sufficient length to extend from 3 inches within the coke breeze to 3 inches below finish grade. Place gravel around the vent pipe to a level 6 inches
below finish grade. Fill the remaining excavation with soil and tamp.

3.2.2.1 Anode Requirements

Anode sizes, spacing, number of anodes, installation depth, and other details shall be as shown on the project drawings.

3.2.2.2 Anode Lead Wire

Each anode shall have a separate, continuous wire extending from the anode to the junction box at the well head. Each anode wire shall be the color and size as indicated on the project drawings.

3.2.2.3 Anode Cables

Anode cables shall terminate in a nearby junction box, equipped with individual anode current shunts.

3.2.3 Anode Grid Placement

Unroll the anode in a flat clear area near the tanks. Place the ribbon anode mesh on top of the first compacted lift as per the project drawings. Lay the conductor bars perpendicular to the anode ribbon mesh as per the project drawings. At each intersection, clean the ribbons and make a resistance weld connection. Lay power feed cables in the center of the conductor bars as indicated on the project drawings. Clean the ribbons and make several resistance weld connections to each bar. Test each weld as it is made to make sure it is sound. The Corrosion Engineer must inspect each field weld. Pull the power feed cables through the ringwall penetration. Place next lift of sand and compact. Repeat sequence until remaining sand is compacted. Arrange the anodes and lead wires as per the drawings. A minimum of 1 inch sand shall be placed between the anode ribbon and any power feed cables where they overlap.

3.2.4 Isolation from Tank

Anode ribbon must not electrically contact any structural steel of the tank floor, sump pit or any part of the tank. Electrical shorts are not acceptable. Maintain a minimum separation of 8-inch between the anode wire and the tank bottom and sump pit as indicated.

3.2.5 Tank Floor Installation

During the tank floor installation care shall be taken to ensure the anode does not become electrically shorted to the tank. During the floor installation, the CP Engineer or CP Technologist shall monitor the electrical isolation of the anodes from the tank using electrical instruments and a DC power source.

3.2.6 Anode Wire Protection

Maintain anode lead wire and reference electrode lead wire identification throughout the project. After the anode leads are routed through the concrete ring wall penetration there will be several weeks before wires can be routed to the anode junction box. Dig a pit outside the ring wall foundation at the cathodic protection ring wall penetration large enough to contain the anode lead wires and the reference electrode lead wires. Cover the wires with 3/8 inch plywood. Cover the plywood with a 6 to 12 inch layer of sand as a heat barrier from welding slag. Lead wires with
damaged insulation shall be removed along with the anode or reference electrode it is connected to. This will require removing the sand pad and installation of a replacement lead wires and the anode or reference electrode it is connected to. Provide access to the wires to facilitate construction phase anode isolation testing and reference electrode isolation testing during the tank bottom installation.

3.3 Cable-To-Structure Connections

Connect cable to tank structure by use of an exothermic weld kit. Bolted connections are not permitted. Clean the structure surface by scraping, filing or wire brushing to produce a clean, bright surface. Weld connections using the exothermic weld kits in accordance with the kit manufacturer's instructions. Test the integrity of the weld, prior to coating, by striking with a two pound hammer. Cover connections and exposed structures with an electrically insulating coating, compatible with existing coating.

3.3.1 Safety Precautions Around Fuel Facilities

Contractor shall take proper safety precautions prior to and during welding to live fuel pipelines or tanks. Contractor shall notify the activity Fuel Office via the Contracting Office a minimum of three days before performing exothermic welding to live fuel lines. Exothermic welding shall be conducted with fuel flowing through the pipeline to eliminate vapor spaces within the pipe and to dissipate the heat on the pipe. Exothermic weld charges for connections to fuel lines shall be limited to a maximum 15 gram charge to prevent burning through the pipe wall. Exothermic weld connections shall be spaced a minimum of 6 inches apart. In the event of an unsuccessful weld, the new weld location shall be located a minimum of 6 inches from the unsuccessful weld and any other existing welds.

3.4 Rectifiers

Provide Rectifier Installation shop drawing(s). Location and mounting as indicated. Assemble and attach equipment enclosures to wall in accordance with the manufacturer's instructions. Ensure that the enclosure doors can be fully opened without interference from other objects or structures. Handle wires to prevent stretching or kinking the conductors or damaging the insulation. Use lubricants when pulling wires into conduits. Bond the equipment enclosures to a grounding electrode.

3.5 Permanent Reference Electrodes

3.5.1 Lead Wires

Wires for permanent reference electrodes are terminated on isolated terminals in the anode junction box located at the rectifier.

3.5.2 Permanent Reference Electrode Calibration and Installation

Prior to installation, soak the prepackaged reference electrode in a container of potable water for 1 hour. Do not use seawater. Calibrate the permanent reference electrode in the presence of the contracting officer or his approved representative by measuring the potential difference between the permanent reference electrode and an independent (portable) calibrated reference electrode placed in the water adjacent to the permanent reference electrode. Potential differences between the two electrodes of the same generic type should not exceed 10 millivolts when
3.6 FIELD QUALITY CONTROL

Field tests shall be witnessed by the Contracting Officer or his designated representative. Advise the Contracting Officer 5 days prior to performing each field test. Quality control for the cathodic protection system shall consist of the following:

a. Tank Floor Isolation Testing.

b. Wire for Power Service.

c. Initial field testing by the contractor upon construction.

d. Government Field Testing after Contractor initial field test report submission.

e. Warranty period field testing by the Contractor.

3.6.1 Testing

3.6.1.1 Tank Floor Isolation Testing

After the tank bottom and all associated structures and conduits are installed, perform Tank Floor Isolation testing to assure that the anodes and the reference electrodes are not electrically shorted to any steel structures. The resultant resistance shall be greater than 10 ohms per anode header cable. The reference electrodes shall be tested by measuring the DC voltage between tank and electrode. Apply a small DC current source between the anodes and the tank floor as it is being installed. Measure the electrical resistance between the two structures. If the anode becomes shorted to the tank floor, stop the floor installation and reposition the anode to maintain the minimum 8 inch clearance.

3.6.1.2 Wire for Power Service

Test wire for power service at 600 volts or less to determine that the wiring system and equipment are free from short circuits and grounds by a minimum of two megohms. Perform the test with a megohm meter having a 500-volt rating.

3.6.1.3 Initial Cathodic Protection System Field Testing

The systems shall be tested and inspected by the Contractor's Corrosion Engineer or CP Technologist in the presence of the Contracting Officer's corrosion protection engineer or an approved representative. Record test data, including date, time, and locations of testing and submit report to
the Contracting Officer. Contractor shall correct, at his expense, all
deficiencies in the materials and installation observed by these tests and
inspections. Contractor shall pay for retests made necessary by the
corrections. Testing shall include the following measurements:

a. Base Line Potential test: At least one week after initial operation of
structures containing fluids, but before energizing of the cathodic
protection system, measure the base (native) structure-to-electrolyte
potentials of the structure. Use the same measuring equipment that is
specified for measuring protected potential measurements.

b. Initial ICCP Checkout Test: Perform all the rectifier checkout tests as
recommended by the manufacturer. Verify correct electrical polarity
for the system by tracing the wires and perform a wire continuity
test. Check the settings for AC input power and the status of the
breakers. Turn the ICCP system on at the lowermost tap setting. Check
the polarity of the system by observing a normal IR shift in all of the
permanent reference electrodes. Check the transformer windings are at
the expected AC voltages. Adjust the rectifier one step at a time and
aim for a 100 mV cathodic polarization level of cathodic protection.
Do not attempt to achieve -850 mV. Wait 30 minutes between tap bar
adjustment to allow the tank to polarize. Measure and record the
ON/Instant Off Potentials after allowing the system to operate for 30
minutes at each output level. Record the level of the fuel in the
tank, the date and time of each set of test data. Measure and record
the output of each anode circuit. Adjust, wait, and test until the 100
mV cathodic polarization criterion is achieved. Formation of cathodic
polarization may take longer than 24 hours. Measure and record the
anode currents when the ICCP system is set to the final tap setting.
Prepare a full report of the tests, giving all details including
remedial actions taken or recommendations to correct noted problems.

c. Rectifier System Test: Upon completion of the installation, "Baseline
Potential Tests", energize and adjust each rectifier. Measure D.C.
outputs of the rectifier and current outputs of each anode at different
rectifier settings. Measure the current outputs across the installed
shunts. Verify these readings using portable, calibrated meters and
shunts. This testing shall demonstrate if the rectifier system is
capable of functioning properly as required to provide effective
cathodic protection.

d. Energized Potential Test: With the entire cathodic protection system
put into operation for at least 30 days, measure ON and Instant OFF
potentials at and all permanent reference electrode(s) and a voltmeter
having an input impedance of not less than 10 megohms. The locations
of these measurements shall be identical to the locations used for the
base potential measurements. The rectifier cycle shall be 2 seconds off
maximum and 10 seconds on minimum. Adjust the system to achieve a level
of CP that satisfies the 100 mV cathodic polarization criterion.

3.6.1.4 Initial Cathodic Protection System Field Test Report

The contractor shall submit a field test report of the cathodic protection
system. All structure-to-electrolyte measurements, including initial
potentials and anode outputs, shall be recorded on applicable forms.
Identification of test locations, test station and anode test stations
shall coordinate with the as-built drawings and be provided on system
drawings included in the report. The contractor shall locate, correct, and
report to the Contracting Officer any short circuits encountered during the
checkout of the installed cathodic protection system.

3.6.1.5 Government Field Testing

The government corrosion engineer shall review the Contractor's initial field testing report. Approximately four weeks after receipt of the Contractor's initial test report, the system will be tested and inspected in the Contractor's presence by the government corrosion engineer. The Contractor shall correct, at his expense, materials and installations observed by these tests and inspections to not be in conformance with the plans and specifications. The Contractor shall pay for all retesting done by the government engineer made necessary by the correction of deficiencies.

3.6.1.6 Final Field Testing

Conduct final field testing of the cathodic protection system utilizing the same procedures specified under, "Initial Field Testing of the Galvanic Cathodic Protection Systems". The Contractor shall inspect, test, and adjust the cathodic protection system 60 days after the Government Field Testing. The performance period for these tests shall commence upon the completion of all cathodic protection work, including changes required to correct deficiencies identified during initial testing, and preliminary acceptance of the cathodic protection system by the Contracting Officer.

Copies of the Final Cathodic Protection System Field Test Report, certified by the Contractor's Corrosion Engineer shall be submitted to the Contracting Officer and the geographic Engineering Field Division corrosion engineer for approval, and as an attachment to the operation and maintenance manual in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. The Final Cathodic Protection System Field Test Report shall also be submitted on a CD-ROM with the various files provided in the native format (Excel, WORD, PFD, AutoCAD, etc.) and sent to the DOR Corrosion Engineer.

3.6.2 Criteria for Cathodic Protection

Conduct in accordance with NACE RP0193 for the tank, and NACE SP0169 for the underground piping. Criteria for determining the adequacy of protection shall be 100 mV cathodic polarization for tank and a negative polarized potential of at least 850 mV as selected by the design corrosion engineer as applicable:

a. A minimum polarization voltage shift of 100 mV measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the electrolyte. This voltage shift shall be determined by interrupting the protective current and measuring the formation or polarization decay. At the instant the protective current is interrupted ("instant off"), an immediate voltage shift will occur. The voltage reading just after the immediate shift shall be used as the base reading from which to measure the polarization decay. The polarization decay shall be the difference between the base reading and a voltage measurement made prior to application of CP or after the interruption of protective current.

b. A negative voltage of at least 0.85 volt (850 millivolts) as measured between the structure surface and a saturated copper-copper sulfate reference electrode contacting the earth [electrolyte]. Determination of this voltage is to be made with the protective current applied to the pipeline for a minimum of 24 hours. Voltage drops must be considered for valid interpretation of this voltage measurement. The
method of voltage drop consideration shall be identified by the Contractor's corrosion engineer and approved by the Government corrosion engineer.

3.7 DEMONSTRATION

3.7.1 Instructing Government Personnel

During the warranty testing and at a time designated by the Contracting Officer, make available the services of a CP expert regularly employed or authorized by the manufacturer of the Cathodic Protection System for instructing Government personnel in the proper operation, maintenance, safety, and emergency procedures of the Cathodic Protection System. The period of instruction shall be not less than one but not more than two 8-hour working days. Conduct the training at the jobsite or at another location mutually satisfactory to the Government and the Contractor. The field instructions shall cover all of the items contained in the operation and maintenance manual.

-- End of Section --
PART 1  GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)


ASTM INTERNATIONAL (ASTM)


ASTM A653 (2015; E 2016) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process


ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10 (2011; Errata 2015) IES Lighting Handbook


<table>
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<tr>
<th>Reference</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>IES RP-16</td>
<td>(2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering</td>
</tr>
<tr>
<td>IES TM-21</td>
<td>(2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources</td>
</tr>
</tbody>
</table>

**INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
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**NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
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<tbody>
<tr>
<td>NEMA 250</td>
<td>(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)</td>
</tr>
<tr>
<td>NEMA C82.77</td>
<td>(2002) Harmonic Emission Limits – Related Power Quality Requirements for Lighting Equipment</td>
</tr>
<tr>
<td>NEMA SSL 1</td>
<td>(2010) Electronic Drivers for Led Devices, Arrays, or Systems</td>
</tr>
<tr>
<td>NEMA SSL 3</td>
<td>(2011) High-Power White LED Binning for General Illumination</td>
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**NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>(2017) National Electrical Code</td>
</tr>
</tbody>
</table>

**UNDERWRITERS LABORATORIES (UL)**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1598</td>
<td>(2008; Reprint Oct 2012) Luminaires</td>
</tr>
<tr>
<td>UL 844</td>
<td>(2012; Reprint Mar 2016) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations</td>
</tr>
<tr>
<td>UL 924</td>
<td>(2016) UL Standard for Safety Emergency Lighting and Power Equipment</td>
</tr>
</tbody>
</table>
1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires or luminaire accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories mounted on exterior surfaces of buildings are specified in Section 26 56 00 EXTERIOR LIGHTING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these Specifications, and on the Drawings, must be as defined in IEEE 100 and IES RP-16.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES HB-10 as applicable, for the lighting system specified. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
  Luminaire Drawings; G

SD-03 Product Data
  Luminaires; G
  Light Sources; G
  Drivers; G
  LED Luminaire Warranty; G
  Luminaire Design Data; G
  Lighting Contactor; G
  Exit Signs; G
  LED Emergency Drivers; G
1.5 QUALITY CONTROL

1.5.1 Luminaire Drawings

Include dimensions, accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified per the NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections must be obtained from testing in accordance with IES LM-80.

1.5.3 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in IES LM-79.

1.5.4 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module). Include all applicable and required data as outlined under "8.0 Test Report" in IES LM-80.

1.5.5 LED Light Source - IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module). Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in IES TM-21.

1.5.6 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports must be one
of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List at for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.7 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated.

1.5.8 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design, and workmanship. Products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this Section.

1.5.8.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.8.2 Material and Equipment Manufacturing Date

Products manufactured more than six months prior to date of delivery to site must not be used, unless specified otherwise.

1.5.8.3 Energy Efficiency

Submit data indicating lumens per watt efficacy and color rendering index of light source.

1.6 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the
warranty period of the Contract.

1.6.1 LED Luminaire Warranty

a. Provide a written 10 year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

(1) Include finish warranty to include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

(2) Material warranty must include:

(a) All drivers.

(b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Provide the Contracting Officer with signed warranty certificates prior to final payment.

1.6.1.1 Provide Luminaire Useful Life Certificate

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life must be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions must be taken into consideration.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, luminaire controls, or associated equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires, luminaire controls, and associated equipment for exterior applications are specified in Section 26 56 00 EXTERIOR LIGHTING.

2.2 LUMINAIRES

UL 1598, NEMA C82.77, and UL 8750. Provide luminaires as indicated in luminaire schedule and NL plates or details on Project Plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. Provide all luminaires of the same type by the same manufacturer. Luminaires must be specifically designed for use with the driver, ballast, or generator and light source provided.

2.2.1 LED Luminaires

Provide luminaires complete with power supplies (drivers) and light sources. Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires. LED luminaires must meet the minimum requirements in the following table:

LED luminaires must also meet the following minimum requirements:
a. Luminaires must have a minimum 10 year manufacturer's warranty.

b. Luminaires must have a minimum L70 lumen maintenance value of 50,000 hours as calculated by IES TM-21, with data obtained per IES LM-80 requirements.

c. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Luminaires must be tested to IES LM-79 and IES LM-80 standards, with the results provided as required in the Submittals Paragraph of this Specification.

e. Luminaires must be listed with the DesignLights Consortium 'Qualified Products List' when falling into category of "General Application" luminaires, i.e., Interior Directional, Display Case, Troffer, Linear Ambient, or Low/High Bay. Requirements are shown in the DesignLights Consortium "Technical Requirements Table" at Technical Requirements.

f. Provide Department of Energy 'Lighting Facts' label for each luminaire.

2.2.2 Luminaires for Hazardous Locations

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.3 DRIVERS

2.3.1 LED Drivers

NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

a. Output power (watts) and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.

b. Power Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.

c. Current draw Total Harmonic Distortion (THD) of less than 20 percent.

d. Class A sound rating.

e. Operable at input voltage of 120-277 volts at 60 hertz.

f. Minimum 10 year manufacturer's warranty.

g. RoHS compliant.

h. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.

i. UL listed for dry or damp locations typical of interior installations.

j. Non-dimmable.
2.4 LIGHT SOURCES

NEMA ANSI C78.377, NEMA SSL 3. Provide type and wattage as indicated in luminaire schedule on Project Plans.

2.4.1 LED Light Sources

a. Correlated Color Temperature (CCT) as indicated, no greater than 4100 degrees K.

b. Minimum Color Rendering Index (CRI) R9 value of 80.

c. High power, white light output utilizing phosphor conversion (PC) process or mixed system of colored LEDs, typically red, green, and blue (RGB).

d. RoHS compliant.

e. Provide light source color consistency by utilizing a binning tolerance within a 4 step McAdam ellipse.

2.5 EXIT AND EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 101, and NFPA 70 compliant.

2.5.1 Exit Signs

Provide exit signs consuming a maximum of five watts total and operable on 120 VAC.

2.5.1.1 LED Self-Powered Exit Signs

Provide in UV-stable, thermo-plastic housing with UL damp label, configured for wall mounting. Provide 6 inch high, 3/4 inch stroke red lettering on face of sign. Provide chevrons on either side of lettering to indicate direction. Provide single face. Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years.

2.5.2 LED Emergency Drivers

Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Integral nickel-cadmium battery is required to supply a minimum of 90 minutes of emergency power at 14 watts, 10-50 VDC, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.6 LUMINAIRE SUPPORT HARDWARE

2.6.1 Wire

ASTM A641. Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.
2.6.2 Wire for Humid Spaces

ASTM A580. Composition 302 or 304, annealed stainless steel, minimum 0.11 inches in diameter.

ASTM B164. UNS NO4400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

2.6.3 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.6.4 Straps

Galvanized steel, 1 by 3/16 inch, conforming to ASTM A653, with a light commercial zinc coating or ASTM A1008 with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires must be clearly marked for operation of specific light sources and ballasts, generators or drivers. Note the following light source characteristics in the format "Use Only _____":

a. Light source type, wattage, and coating (clear or coated) for LED luminaires.

b. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. Ballasts, generators, or drivers must have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.8 FACTORY APPLIED FINISH

Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of NEMA 250 corrosion-resistance test.

2.9 RECESS- AND FLUSH-MOUNTED LUMINAIRES

Provide access to lamp and ballast from bottom of luminaire. Provide trim for the exposed surface of flush-mounted luminaires as indicated on Project Drawings and Specifications.
PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein. Install luminaires and lighting controls to meet the requirements of ASHRAE 90.1 - IP and ASHRAE 189.1. To encourage consistency and uniformity, install luminaires of the same manufacture and model number when residing in the same facility or building.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature, color rendering index, and voltage rating indicated to the project site and install just prior to Project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Installation must meet requirements of NFPA 70. Mounting heights specified or indicated must be to the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed luminaires must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire and located near each corner of the luminaire. Ceiling grid clips are not allowed as an alternative to independently supported luminaires. Round luminaires or luminaires smaller in size than the ceiling grid must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around. Do not support luminaires by acoustical tile ceiling panels. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire. Provide wires, straps, or rods for luminaire support in this Section.

3.1.3 Suspended Luminaires

Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level. Locate so that there are no obstructions within the 45 degree range in all directions. The stem, canopy and luminaire must be capable of 45 degree swing. Pendants, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints. Support steel luminaires to prevent "oil-canning" effects. Luminaire finishes must be free of scratches, nicks, dents, and warps, and must match the color and gloss specified. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel. Canopies must be finished to match the ceiling and must
be low profile unless otherwise shown. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts, Generators and Power Supplies

Typically, provide ballasts, generators, and power supplies (drivers) integral to luminaire as constructed by the manufacturer.

3.1.5 Exit Signs and Emergency Lighting Units

Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.2 FIELD APPLIED PAINTING

Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


ASTM INTERNATIONAL (ASTM)


ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10  (2011; Errata 2015) IES Lighting Handbook


IES RP-16  (2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering


IES TM-15  (2011) Luminaire Classification System for Outdoor Luminaires

IES TM-21  (2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)


NEMA 250 (2014) Enclosures for Electrical Equipment (1000 Volts Maximum)


NEMA C82.77 (2002) Harmonic Emission Limits – Related Power Quality Requirements for Lighting Equipment

NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 6 (1993; R 2011) Industrial Control and Systems: Enclosures


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1310 (2011; Reprint Dec 2014) UL Standard for
Safety Class 2 Power Units

UL 1598  (2008; Reprint Oct 2012) Luminaires

UL 773  (1995; Reprint Jul 2015) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting

UL 773A  (2016) Standard for Nonindustrial Photoelectric Switches for Lighting Control

UL 844  (2012; Reprint Mar 2016) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations


1.2 RELATED REQUIREMENTS

a. Section 01 33 29 SUSTAINABILITY REPORTING for sustainability requirements, documentation, and reporting.

b. Section 01 74 19 CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT for waste diversion goals and reporting requirements.

c. Materials not considered to be luminaires or lighting equipment are specified in Section(s) 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Luminaires and accessories installed in interior of buildings are specified in Section 26 51 00 INTERIOR LIGHTING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings shall be as defined in IEEE 100 and IES RP-16.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Photometric Plan; G

LED Luminaire Warranty; G

SD-02 Shop Drawings
Submit manufacturer's catalog data for the following items:

- Enclosed, Gasketed, and Explosion-proof Vapor-Tight Fixtures; G
- Luminaire Light Sources; G
- Luminaire Power Supply Units (Drivers); G
- Lighting contactor; G
- Photocell; G
- Steel poles; G
- Brackets

Design Data for luminaires; G

LED Luminaire - IES LM-79 Test Report; G
LED Light Source - IES LM-80 Test Report; G

Submit operating test results as stated in Paragraph entitled "Field Quality Control."

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life shall be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions shall be taken into consideration.

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the Project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.
1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and candlepower distribution data shall accompany shop drawings.

1.5.1.2 Poles

Include dimensions, wind load determined in accordance with AASHTO LTS, pole deflection, pole class, and other applicable information.

1.5.2 Photometric Plan

For LED luminaires, include computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.8. For LED and all other types of luminaires, the submittal shall include the following:

a. Horizontal illuminance measurements at finished grade, taken at a maximum of every 10 feet.

b. Vertical illuminance measurements at 5 feet above finished grade.

c. Minimum and maximum footcandle levels.

d. Average maintained footcandle level.

e. Maximum to minimum ratio for horizontal illuminance only.

1.5.3 Design Data for Luminaires

a. Provide distribution data according to IES classification type as defined in IES HB-10.

b. Shielding as defined by IES RP-8 or B.U.G. rating for the installed position as defined by IES TM-15.

c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification per NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

d. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections shall be obtained from testing in accordance with IES LM-80.

e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets shall not exceed maximum rating of pole as installed in particular wind zone area.
1.5.4 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Submittal shall include all photometric and electrical measurements, as well as all other pertinent data outlined under "14.0 Test Report" in IES LM-79.

1.5.5 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED package, array, or module. Submittal shall include:

a. Testing agency, report number, date, type of equipment, and LED light source being tested.

b. All data required by IES LM-80.

1.5.5.1 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports shall be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.


c. A manufacturer's in-house lab that meets the following criteria:

(1) Manufacturer has been regularly engaged in the design and production of LED roadway and area luminaires and the manufacturer's lab has been successfully certifying these fixtures for a minimum of 15 years.

(2) Annual equipment calibration including photometer calibration in accordance with National Institute of Standards and Technology.

1.5.6 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.7 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or
brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this Section.

1.5.7.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of LED roadway and area luminaires for a minimum of 5 years. Products shall have been in satisfactory commercial or industrial use for 5 years prior to bid opening. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period.

1.5.7.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.6.1 Steel Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the Contract.

1.7.1 LED Luminaire Warranty

Provide Luminaire Useful Life Certificate.

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the Contract.

a. Provide a written five year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

(1) Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

(2) Material warranty shall include:

(a) All power supply units (drivers).

(b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.
b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

1.8 OPERATIONAL SERVICE

Coordinate with manufacturer for maintenance agreement. Collect information from the manufacturer about maintenance agreement options, and submit to Contracting Officer. Services shall reclaim materials for recycling and/or reuse. Services shall not deposit materials in landfills or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, equipment or accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and associated equipment and accessories for interior applications are specified in Section 26 51 00 INTERIOR LIGHTING.

2.2 LED LUMINAIRES

UL 1598, NEMA C82.77, and UL 8750. Provide luminaires as indicated in luminaire schedule and XL plates or details on Project Plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. All luminaires of the same type shall be provided by the same manufacturer.

2.2.1 General Requirements

a. LED luminaire housings shall be die cast or extruded aluminum.

b. LED luminaires shall be rated for operation within an ambient temperature range of minus 22 degrees F to 122 degrees F.

c. Luminaires shall be UL listed for wet locations per UL 1598 including hazardous area fixtures where applicable. Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.

d. LED luminaires shall produce a minimum efficacy as indicated on design drawings, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.

(1) See design drawings for quantities of luminaires (pole mounted, canopy, exterior mounted).

e. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on Project Plans per IES HB-10.

f. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving ASTM B117 salt fog environment testing for 2,500 hours minimum without blistering or peeling.
g. Luminaires shall not exceed the following IES TM-15 Backlight, Uplight, and Glare (B.U.G.) ratings:

(1) Maximum Backlight (B) rating shall be determined by lighting zone in which luminaire is placed.

(2) Maximum Uplight (U) rating shall be U0.

(3) Maximum Glare (G) rating shall be determined by lighting zone in which luminaire is placed.

h. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.

i. The finish color shall be as indicated in the luminaire schedule or detail on the Project Plans.

j. Luminaire arm bolts shall be 304 stainless steel or zinc-plated steel.

k. Luminaire lenses shall be constructed of clear tempered glass or UV-resistant acrylic.

l. The wiring compartment on pole-mounted, street and area luminaires must be accessible without the use of hand tools to manipulate small screws, bolts, or hardware.

m. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

n. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.

o. Roadway and area luminaires shall have an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled in accordance with ANSI C136.3.

p. Luminaire must pass 3G vibration testing in accordance with NEMA C136.31.

q. All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

2.2.2 Enclosed, Gasketed, and Explosion-Proof Vapor-Tight Fixtures

Provide enclosed, gasketed, and explosion-proof vapor-tight fixtures suitable for wet or damp locations consisting of a cast-aluminum body, cap or matching outlet box, porcelain lampholder, impact resistant lens, cork gaskets, and cast-aluminum guards for wall, ceiling, or pendant mounting in accordance with UL 844, UL 1598, and NFPA 70. Fixtures shall be suitable for use in classified (i.e., Class I Division 1/2) environments as indicated and required in design drawings.

Furnish exposed cast aluminum outlet boxes for wall- and ceiling-mounted fixtures with four tapped hubs 90 degrees apart circumferentially, with
three cast-aluminum threaded pipe plugs to fit the tapped holes. Provide boxes with ears or lugs for surface mounting to wall or ceiling. Provide body with mounting screws and gasket to ensure a vapor-tight joint between the body and outlet box. Outlet boxes and all required mounting accessories shall be rated for use in classified (i.e., Class I Division 1/2) environments as indicated and required in design drawings.

Concealed outlet boxes for wall- and ceiling-mounted fixtures shall be cast-aluminum. Provide fixture body with mounting screws and gasket to ensure a vapor-tight joint between the body and outlet box.

Seal body and cap for pendant-mounted fixtures with a gasket at the joint. Provide cast aluminum cap with top hub tapped for 1/2 inch tapered iron pipe threads.

Furnish cast aluminum exposed outlet boxes for pendant-mounted fixtures with the fixtures with four tapped hubs 90 degrees apart circumferentially, with three cast-aluminum threaded pipe plugs to fit the tapped holes. Supply boxes with ears or lugs for surface mounting to the ceiling. Provide cast aluminum outlet-box covers for concealed and exposed outlet boxes with the center hub tapped for 1/2 inch tapered iron pipe threads. Provide cover and outlet box with mounting screws and gasket to ensure a vapor-tight joint between the cover and outlet box. Also provide 1/2 inch galvanized rigid steel conduit stem.

2.2.3 Luminaire Light Sources

2.2.3.1 LED Light Sources

a. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

   (1) Nominal CCT: 4000 degrees K: No greater than 4100 degrees K.

b. Color Rendering Index (CRI) shall be:

   (1) Greater than or equal to 70 for 4000 degrees K light sources.

c. Color Consistency:

   (1) Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

2.2.4 Luminaire Power Supply Units (Drivers)

2.2.4.1 LED Power Supply Units (Drivers)

UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements:

a. Minimum efficiency shall be 85 percent.

b. Drive current to each individual LED shall not exceed 700 mA, plus or minus 10 percent.

c. Shall be rated to operate between ambient temperatures of minus 22 degrees F and 104 degrees F.

d. Shall be designed to operate on the voltage system to which they are connected.
connected, typically ranging from 120 volts to 480 volts nominal. Refer to design drawings for voltage requirements.

e. Operating frequency shall be: 60 Hz.

f. Power Factor (PF) shall be greater than or equal to 0.90.

g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.

h. Shall meet requirements of 47 CFR 15, Class B.

i. Shall be RoHS-compliant.

j. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

2.2.5 LED Luminaire Surge Protection

Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

2.3 EXTERIOR LUMINAIRE CONTROLS

2.3.1 Photocell

UL 773 or UL 773A. Photocells shall be hermetically sealed, silicon diode light sensor type, rated at 2.4 watts, 120 volts, 50/60 Hz with single-pole, single-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of UV stabilized polypropylene, rated to operate within a temperature range of minus 40 to 158 degrees F. Photocell shall have a 1/2 inch threaded base for mounting to a junction box or conduit. Provide swivel base type housing. Photocell shall turn on at 1-3 footcandles and turn off at 3 to 15 footcandles. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition. Provide photocell with metal oxide varistor (MOV) type surge protection.

2.3.2 Lighting Contactor

NEMA ICS 2. Provide an electrically-held lighting contactor housed in a NEMA 1 enclosure conforming to NEMA ICS 6. Contactor shall have 12 poles, configured as normally open (NO). Contacts shall be rated 600 volts, 30 amperes for a resistive load. Coil operating voltage shall be 120 volts. Contactor shall have silver cadmium oxide double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic selector switch.

2.4 POLES

Provide poles designed for wind loading of 100 miles per hour determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be direct-embedded type designed for use with underground supply conductors. Poles shall have handhole having a minimum clear opening of 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Poles shall have an
internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

2.4.1 Steel Poles

AASHTO LTS. Provide steel poles having minimum 11-gauge steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized in accordance with ASTM A123 factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be direct set anchor bolt mounted type. Poles shall have tapered tubuler members, either round in cross section or polygonal. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.

2.5 BRACKETS AND SUPPORTS

ANSI C136.3 and ANSI C136.21, as applicable. Pole brackets shall be not less than 1-1/4 inch aluminum secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

2.6 POLE FOUNDATIONS

Anchor bolts shall be steel rod having a minimum yield strength of 50,000 psi; at a minimum, the top 12 inches of the rod shall be galvanized in accordance with ASTM A153. Concrete shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Foundation Requirements are indicated on Drawings.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.7.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. Luminaires shall be clearly marked for operation of specific light sources and ballasts according to proper light source type. The following light source characteristics shall be noted in the format "Use Only _____:"

a. Light source type, wattage, voltage.

b. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.
Markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place.

2.8 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Aluminum Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end, with anchor plate and nut at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Polyvinyl chloride (PVC) conduit ells and ground rods shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. After installation, paint exposed surfaces of steel poles with two finish coats of aluminum paint. Install according to pole manufacturer's instructions. Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed.

3.1.2 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations. Mount switch on enclosure or building, as indicated, when switch is provided in cast aluminum or stainless steel NEMA 4X enclosure with swivel arm.

3.1.3 Grounding

Ground noncurrent-carrying parts of equipment including luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.1.4 Field Applied Painting

Coordinate painting requirements with AAFB personnel, including base Architect. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test in presence of Contracting Officer after 100 hours of burn-in time to show that the
equipment operates in accordance with the requirements of this Section.

-- End of Section --
PART 1 GENERAL

1.1 SUMMARY

1.1.1 SCOPE

a. This work includes completion of design and providing a new, complete, fire alarm system in accordance with UFC 3-600-01, ANGETL 15-01-03, and NFPA 72, as described herein and on the Contract Drawings for the C-17 Type III Hydrant Refueling System/Ramp Expansion. Include in the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, supervising station fire alarm system transmitter, and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation.

b. Provide equipment, materials, installation, workmanship, inspection and testing in strict accordance with the required provisions of UFC 3-600-01, ANGETL 15-01-03, and NFPA 72, except as modified herein. The Drawings indicate the intent of coverage. Submit plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, wire counts, circuit identification in each conduit, and circuit layouts for all floors. Drawings shall comply with the requirements of NFPA 170. Final quantity, system layout, and coordination are the responsibility of the Contractor.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR NATIONAL GUARD (ANG)

ANGETL 15-01-03 Fire Protection Design Guidance

ACOUSTICAL SOCIETY OF AMERICA (ASA)


U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01 (2016; with Change 1) Fire Protection Engineering for Facilities

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1221 (2016) Standard for the Installation,
C-17 Type III Fuel System & Ramp Expansion
145th Airlift Wing, North Carolina Air National Guard

Maintenance and Use of Emergency Services Communications Systems

NFPA 70  (2017) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15  Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1283  (2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449  (2014; Reprint Mar 2016) UL Standard for Safety Surge Protective Devices
UL 1971  (2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 268A  (2008; Reprint Oct 2014) Smoke Detectors for Duct Application
UL 464  (2016) Standard for Audible Signal Appliances

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Nameplates; G, AE
Instructions; G, AE
Wiring Diagram; G, AE
System Layout; G, AE
System Operation; G, AE
Notification Appliances; G, AE

SD-03 Product Data
Technical Data and Computer Software; G, AE
Fire Alarm Control Unit (FACU); G, AE
Terminal Cabinets; G, AE
Manual Stations; G, AE
Transmitters (including housings); G, AE
Batteries; G, AE
Battery Charger; G, AE
Heat Detectors; G, AE
Smoke Detectors; G, AE
Notification Appliances; G, AE
Addressable Interface Devices; G, AE
Radio Transmitter and Interface Panels; G, AE

SD-05 Design Data
Battery Power; G, AE
Battery Charger; G, AE

SD-06 Test Reports
Field Quality Control
Testing Procedures; G, AE
Smoke Detector Testing Procedures; G, AE

SD-07 Certificates
Installer; G, AE
Formal Inspection and Tests; G, AE
Final Testing; G, AE
1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Submit proof of qualifications for required personnel. The installer shall submit proof of experience for the Professional Engineer, fire alarm technician, and the installing company.

1.4.1.1 Installer

The installing Contractor shall provide the following: NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level 3 Fire Alarm Technician shall supervise the installation of the fire alarm system. NICET Level 2 or higher Fire Alarm Technician shall install and terminate fire alarm devices, cabinets and panels. An electrician or NICET Level 1 Fire Alarm Technician shall install conduit for the fire alarm system.

1.4.1.2 Qualified Fire Protection Engineer

A qualified Fire Protection Engineer (QFPE) is defined as an individual who is a registered Professional Engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection experience.

1.4.2 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, annotated catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical audible appliances. Check the layout based on the actual audible devices to be installed and make any necessary revisions in the detail drawings. The detail drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Detail drawings and detailed point-to-point wiring diagrams shall be prepared by an individual that has obtained National Institute for Certification in Engineering Technologies, Fire Alarm Systems, Level III certification, at a minimum. Diagram shall include connections between system devices, appliances, control panels, supervised devices, and equipment that is activated or controlled by the panel. The QFPE must review review the shop drawings, calculations, and material submittals. The shop drawings must bear the review stamp of the QFPE prior to submittal of the fire alarm
system shop drawings.

1.5 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data which relates to computer software) which is specifically identified in this project, and which may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this Contract. The data package shall also include the following:

  a. Identification of programmable portions of system equipment and capabilities.
  
  b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
  
  c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.
  
  d. Description of Fire Alarm Control Panel equipment operation.
  
  e. Description of auxiliary and remote equipment operations.
  
  f. Library of application software.
  
  g. Operation and maintenance manuals as specified in SD-10 of the Submittals paragraph.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt, dust, and any other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The fire detection and alarm system and the central reporting system shall be a complete, supervised fire alarm reporting system configured in accordance with NFPA 72; exceptions are acceptable as directed by the Contracting Officer. Furnish equipment compatible and UL listed, FM approved, or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards. Locks shall be keyed alike. Provide four keys for the system. Furnish tags with stamped identification number for keys and locks.

2.1.1 Operation

Activate the system into the alarm mode by actuation of any alarm initiating device. The system will remain in the alarm mode until the initiating device is reset and the fire alarm control panel is reset and restored to normal. Alarm and supervisory initiating devices shall be individually addressable. Alarm initiating devices shall be connected to signal line circuits (SLC), Class B, in accordance with NFPA 72. Connect
alarm notification appliances to notification appliance circuits (NAC), Class B in accordance with NFPA 72. Audible and visual appliances and systems shall comply with NFPA 72. Fire alarm system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc. Addressable system shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits and shall provide the following features:

a. Sufficient memory to perform as specified and as shown for addressable system.

b. Individual identity of each addressable device for the following conditions: Alarm; trouble; open; short; and appliances missing/failed remote detector - sensitivity adjustment from the panel for smoke detectors.

c. Capability of each addressable device being individually disabled or enabled from the panel.

d. Size each SLC to provide 40 percent addressable expansion without hardware modifications to the panel.

2.1.2 Operational Features

The system shall have the following operating features:

a. Monitor electrical supervision of SLC and NAC.

b. Monitor electrical supervision of the primary power (ac) supply, battery voltage, placement of alarm zone module (card, PC board) within the control panel, and transmitter tripping circuit integrity.

c. A trouble buzzer and trouble LED/LCD (light emitting diode/liquid crystal diode) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. Submit Voltage drop calculations for notification appliance circuits to indicate that sufficient voltage is available for proper appliance operation. A trouble alarm silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator LED/LCD. Subsequent trouble and supervisory alarms shall sound the trouble signal until silenced. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.

d. A one person test mode. Activating an initiating device in this mode will activate an alarm for a short period of time, then automatically reset the alarm, without activating the transmitter during the entire process.

e. A transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but providing a trouble signal when disconnected and a restoration signal when reconnected.

f. Evacuation alarm silencing switch which, when activated, will silence alarm devices, but will not affect the zone indicating LED/LCD displays
on the control panel nor the operation of the transmitter. This switch shall be over-ridden upon activation of a subsequent alarm from an unalarmed device and the NAC devices will be activated.

g. Electrical supervision for circuits used for supervisory signal services. Supervision shall detect any open, short, or ground.

h. Confirmation or verification of all smoke detectors. The control panel shall interrupt the transmission of an alarm signal to the system control panel for a factory preset period. This interruption period shall be adjustable from 1 to 60 seconds and be factory set at 20 seconds. Immediately following the interruption period, a confirmation period shall be in effect during which time an alarm signal, if present, will be sent immediately to the control panel. Fire alarm devices other than smoke detectors shall be programmed without confirmation or verification.

i. The control panel and field panels shall be software reprogrammable to enable expansion or modification of the system without replacement of hardware or firmware. Examples of required changes are: Adding or deleting devices or zones; changing system responses to particular input signals; programming certain input signals to activate auxiliary devices.

2.1.3 Alarm Functions

An alarm condition on a circuit shall automatically initiate the following functions:

a. Transmission of a signal over the station radio fire reporting system. The signal shall be common for any device.

b. Visual indications of the alarmed devices on the fire alarm control panel display.

c. Continuous sounding or operation of alarm notification appliances throughout the building as required by ASA S3.41.

2.1.4 Primary Power

Operating power shall be provided as required by Paragraph "Power Supply for the System". Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire reporting system upon operation of any initiating circuit.

2.1.5 Battery Backup Power

Battery backup power shall be through use of rechargeable, sealed-type storage batteries and battery charger.

2.1.6 Interface With other Equipment

Interfacing components shall be furnished as required to connect to subsystems or devices which interact with the fire alarm system, such as supervisory or alarm contacts in suppression systems, operating interfaces for smoke control systems, door releases, etc.
2.2 STANDARD PRODUCTS

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that can provide service within 24 hours of notification.

2.3 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

2.4 CONTROL PANEL

Control Panel shall comply with the applicable requirements of UL 864. Panel shall be modular, installed in a surface mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic or metal identification plates for LED/LCDs, zones, SLC, controls, meters, fuses, and switches.

a. Nameplates for fuses shall also include ampere rating. The LED/LCD displays shall be located on the exterior of the cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means (single operation) shall be provided for testing the control panel visual indicating devices (meters or LEDs/LCDs). Meters and LEDs shall be plainly visible when the cabinet door is closed. Signals and LEDs/LCDs shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system.

b. Loss of power, including batteries, shall not require the manual reloading of a program. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

c. Visual annunciation shall be provided for LED/LCD visual display as an integral part of the control panel and shall identify with a word description and id number each device. Cabinets shall be provided with ample gutter space to allow proper clearance between the cabinet and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate units. Cabinets shall be painted red.

2.4.1 Circuit Connections

Connect circuit conductors entering or leaving the panel to screw-type terminals with each conductor and terminal marked for identification.
2.4.2 System Expansion and Modification Capabilities

Provide, as part of this Contract, any equipment and software needed by qualified technicians to implement future changes to the fire alarm system.

2.4.3 Addressable Control Module

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems. The module shall be UL listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class B notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled.

2.5 STORAGE BATTERIES

Submit substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component and each panel component, and the battery recharging period shall be included. Provide storage batteries which are 24 Vdc sealed, lead-calcium type requiring no additional water with ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 48 hours. Following this period of battery operation, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 15 minutes. Locate batteries in a separate battery cabinet. Provide batteries with overcurrent protection in accordance with NFPA 72. Separate battery cabinets shall have a lockable, hinged cover similar to the fire alarm panel. The lock shall be keyed the same as the fire alarm control panel. Paint the cabinets to match the fire alarm control panel.

2.6 BATTERY CHARGER

Battery charger shall be completely automatic, 24 Vdc with high/low charging rate, capable of restoring the batteries from full discharge (18 Volts dc) to full charge within 48 hours. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly, if a high rate switch is provided. Locate charger in control panel cabinet or in a separate battery cabinet.

2.7 MANUAL FIRE ALARM STATIONS

Manual fire alarm stations shall be addressable, unless noted otherwise, and conform to the applicable requirements of UL 38. Manual stations shall be connected into signal line circuits. Stations shall be installed on flush mounted outlet boxes. Manual stations shall be mounted at 48 inches. Stations shall be single action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. Stations requiring the breaking of glass or plastic panels for operation are not acceptable. Stations employing glass rods are not acceptable. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Addressable pull stations
shall be capable of being field programmed, shall latch upon operation and remain latched until manually reset. Stations shall have a separate screw terminal for each conductor. Manual fire alarm stations located in electrically classified areas shall be non-addressable devices meeting an electrical classification of Class I Div 2. Manual fire alarms located in electrically classified areas shall be connected into the signal line circuits via addressable modules located outside of the classified area.

2.8 FIRE DETECTING DEVICES

Fire detecting devices shall comply with the applicable requirements of NFPA 72, NFPA 90A, UL 268, UL 268A, and UL 521. The detectors shall be provided as indicated, except where devices are provided with pigtail connectors such as rate-compensating heat detectors. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Detectors located in concealed locations, such as above ceilings, shall have a remote visible indicator LED/LCD. Addressable fire detecting devices shall be dynamically supervised and identified by device in the control panel. All fire alarm initiating devices shall be addressable by zone, except where indicated. Installed devices shall conform to NFPA 70 hazard classification of the area where devices are to be installed.

2.8.1 Heat Detectors

Design heat detectors for detection of fire as indicated on Drawings. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70 and as shown on Drawings, shall be types approved for such locations. Heat detectors located in electrically classified areas shall be non-addressable devices meeting an electrical classification of Class I Div 2.

2.8.1.1 Fixed Temperature Detectors

Detectors shall be designed for semi-recessed mounting. Heat detectors shall be automatically resetting. The detectors shall have a temperature setting range of 135 to 175 degrees F.

2.8.1.2 Rate Compensating Detectors

Detectors shall be surface mounted vertical type, with outlet box supported independently of wiring connections. Detectors shall be hermetically sealed and automatically resetting.

2.8.2 Smoke Detectors

Design smoke detectors for detection of abnormal smoke densities. Smoke detectors shall be photoelectric type. Detectors shall contain a visible indicator LED/LCD that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall be the plug-in type in which the detector base contains terminals for making wiring connections. Detectors that are to be installed in concealed (above false ceilings, etc.) locations shall be provided with a remote indicator LED/LCD suitable for mounting in a finished, visible location.

2.8.2.1 Photoelectric Detectors

Detectors shall operate on a light scattering concept using an LED light
source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268. Addressable smoke detectors shall be capable of having the sensitivity being remotely adjusted by the control panel.

2.8.3 Combination Smoke and Heat Detectors

Combination smoke and heat detectors shall have an audible device (self-contained) and be designed for detection of abnormal smoke densities by the photoelectric principle and abnormal heat by a fixed temperature sensor. Smoke detectors shall be provided with an LED light source. Failure of the LED shall not cause an alarm condition and the sensitivity shall be factory set at a nominal 3 percent and require no field adjustments of any kind. Heat detector portion shall be fixed temperature sensor rated at 135 degrees F. Detectors shall contain a visible indicator LED that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Heat detectors shall connect to a control panel SLC and shall be restorable.

2.9 NOTIFICATION APPLIANCES

Audible appliances shall conform to the applicable requirements of UL 464. Devices shall be connected into notification appliance circuits. Devices shall have a separate screw terminal for each conductor. Audible appliances shall generate a unique audible sound from other devices provided in the building and surrounding area. Surface mounted audible appliances shall be painted red. In finished areas, ceiling mounted recessed audible and visible appliances shall be installed with a grill that is painted white.

2.9.1 Alarm Horns

Horns shall be surface mounted, with the matching mounting back box surface mounted single projector, vibrating type suitable for use in an electrically supervised circuit. Horns shall produce a sound rating of at least 85 dBA at 10 feet. Alarm horns located in electrically classified locations shall be specifically listed or approved for use in Class 1, Div 2 areas.

2.9.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and the Contract Drawings. Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light. Strobe flash rate shall be between 1 to 3 flashes per second and a minimum of 15 candela. Strobe shall be surface mounted. Visual notification devices located in electrically classified locations shall be specifically listed or approved for use in Class 1, Div 2 areas.

2.9.3 Combination Audible/Visual Notification Appliances

Combination audible/visual notification appliances shall provide the same requirements as individual units except they shall mount as a unit in standard backboxes. Units shall be factory assembled. Any other audible notification appliance employed in the fire alarm systems shall be approved by the Contracting Officer.
2.10 FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT

2.10.1 Conduit

Conduit and fittings shall comply with Electrical Specification 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Conduit and fittings in electrically classified locations shall be specifically listed or approved for use in the area in which it is installed. Refer to the electrical plans for electrically classified areas.

2.10.2 Wiring

Wiring shall conform to NFPA 70. Wiring for 120 Vac power shall be No. 12 AWG minimum. The SLC wiring shall be copper cable in accordance with the manufacturers requirements. Wiring for fire alarm dc circuits shall be No. 16 AWG minimum. Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Wiring shall conform to NFPA 70. System field wiring shall be solid copper and installed in conduit. Conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit. Pigtail or T-tap connections to initiating device circuits, supervisory alarm circuits, and notification appliance circuits is prohibited.

2.11 TRANSMITTERS

2.11.1 Radio Alarm Transmitters

Transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall be provided in accordance with applicable portions of NFPA 72, NFPA 1221, and 47 CFR 15. Transmitter electronics module shall be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is a Monaco system and the transceiver shall be fully compatible with this equipment. At the Contractors option, and if UL listed, the transmitter may be housed in the same panel as the fire alarm control panel.

2.11.1.1 Transmitter Power Supply

Each radio alarm transmitter shall be powered by a combination of locally available 120-volt ac power and a sealed, lead-calcium battery.

2.11.1.1.1 Operation

Each transmitter shall operate from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

2.11.1.2 Battery Power

Transmitter standby battery capacity shall provide sufficient power to operate the transmitter in a normal standby status for a minimum of 48 hours and be capable of transmitting alarms during that period.
2.11.2 Radio Alarm Transmitter Housing

Transmitter housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to the fire alarm system for the building. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.11.3 Antenna

Provide omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall be corrosion resistant and designed to withstand wind velocities of 100 mph. Antennas shall not be mounted to any portion of the building roofing system.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install all work as shown, in accordance with NFPA 70 and NFPA 72, and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until construction is essentially complete and the building has been thoroughly cleaned.

3.2.1 Power Supply for the System

Provide a single dedicated circuit connection for supplying power from a branch circuit to each building fire alarm system. The power shall be supplied as shown on the Drawings. The power supply shall be equipped with a locking mechanism and marked in red with the words "FIRE ALARM CIRCUIT CONTROL".

3.2.2 Wiring

Conduit size for wiring shall be in accordance with NFPA 70. Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. Not more than two conductors shall be installed under any device screw terminal. The wires under the screw terminal shall be straight when placed under the terminal then clamped in place under the screw terminal. The wires shall be broken and not twisted around the terminal. Circuit conductors entering or leaving any mounting box, outlet box enclosure, or cabinet shall be connected to screw terminals with each terminal and conductor marked in accordance with the wiring diagram. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors in the system is prohibited. Wiring within any control equipment shall be readily accessible without removing any component parts. The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.
3.2.3 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 12 inches nor more than 78 inches above the finished floor. Manually operable controls shall be between 36 and 42 inches above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

3.2.4 Detectors

Detectors shall be located and installed in accordance with NFPA 72. Detectors shall be connected into signal line circuits as indicated on the Drawings. Detectors shall be at least 12 inches from any part of any lighting fixture. Detectors shall be located at least 5 feet from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in open space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 3 feet, sway bracing shall be provided. Detectors installed in concealed locations, such as above ceilings, shall have a remote visible indicator LED/LCD in a finished, visible location.

3.2.5 Notification Appliances

Wall mounted notification appliances shall be mounted 80 inches above the finished floor or 6 inches below the ceiling, whichever is lower. Ceiling mounted notification device appliances shall be spaced in accordance with NFPA 72.

3.2.6 Addressable Initiating Device Circuits Module

The initiating device circuits module shall be used to connect supervised conventional initiating devices, such as explosion proof manual fire alarm pull stations and explosion proof heat detectors. The module shall mount in an electrical box adjacent to or connected to the device it is monitoring and shall be capable of Style B supervised wiring to the initiating device. In order to maintain proper supervision, there shall be no T-taps allowed on Class B lines. Addressable initiating device circuits modules shall monitor only one initiating device each.

3.2.7 Addressable Control Module

Addressable and control modules shall be installed in the outlet box or adjacent to the device they are controlling. All interconnecting wires shall be supervised unless an open circuit or short circuit abnormal condition does not affect the required operation of the fire alarm system. Control modules that control a group of notification appliances shall be adjacent to the first notification appliance in the notification appliance circuits. Control modules that connect to devices shall supervise the notification appliance circuits. Control modules that connect to auxiliary systems or interface with other systems (non-life safety systems) and where not required by NFPA 72, shall not require the secondary circuits to be supervised.
3.3 OVERVOLTAGE AND SURGE PROTECTION

3.3.1 Power Line Surge Protection

Provide Surge Protection (SPD) on all 120 Vac circuits to control panels, subpanels, transmitters, amplifier panels, and booster panels. SPD shall have both a UL 1449 and UL 1283 listing and shall be located in an adjacent hinged terminal box.

3.4 GROUNDING

Grounding shall be provided by connecting to building ground system.

3.5 TRAINING

Submit lesson plans, operating instructions, maintenance procedures, and training data, furnished in manual format, for the training courses. The operations training shall familiarize designated government personnel with proper operation of the fire alarm system. Conduct the course in the building where the system is installed or as designated by the Contracting Officer.

a. The instructions shall cover items contained in the operating and maintenance instructions. In addition, training shall be provided on performance of expansions or modifications to the fire detection and alarm system. The training period for system expansions and modifications shall consist of at least 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests.

b. The maintenance training course shall provide the designated Government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system. Provide training course for the maintenance staff. The training period for systems maintenance shall consist of 1 training day (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests. Six copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements. Original and backup copies of all software delivered for this Project shall be provided, on each type of media utilized. Manuals shall be approved prior to training.

c. The training period for systems operation shall consist of 1 training days (8 hours per day) and shall start after the system is functionally completed but prior to final acceptance tests. Six copies of operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features.

3.6 TESTING

Notify the Contracting Officer at least 10 days before the preliminary and acceptance tests are to be conducted. Perform the tests in accordance with the approved test procedures in the presence of the Contracting Officer.
The control panel manufacturer's representative shall be present to supervise tests. Furnish instruments and personnel required for the tests.

a. Submit detailed test procedures, prepared by a NICET III technician, and signed by the QFPE for the fire detection and alarm system 60 days prior to performing system tests.

b. Submit test reports, in booklet form, showing field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document readings, test results and indicate the final position of controls. Include the NFPA 72 Certificate of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

### 3.6.1 Preliminary Tests

Upon completion of the installation, subject the system to functional and operational performance tests including tests of each installed initiating and notification appliance, when required. Tests shall include the meggering of system conductors to determine that the system is free from grounded, shorted, or open circuits. Conduct the megger test prior to the installation of fire alarm equipment. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional. After completing the preliminary testing complete and submit the NFPA 72, Certificate of Completion and Testing Form.

### 3.6.2 Acceptance Test

Acceptance testing shall not be performed until the Contractor has completed and submitted the Certificate of Completion. Conduct testing in accordance with NFPA 72. The recommended tests in NFPA 72 are considered mandatory and shall verify that previous deficiencies have been corrected. The Fire alarm Technician supervising the installation of the fire alarm system shall attend the testing of the system. The test shall include all requirements of NFPA 72 and the following:

a. Test of each function of the control panel.

b. Test of each circuit in both trouble and normal modes.

c. Tests of each alarm initiating devices in both normal and trouble conditions.

d. Tests of each control circuit and device.

e. Tests of each alarm notification appliance.

f. Tests of the battery charger and batteries.

g. Complete operational tests under emergency power supply.

h. Visual inspection of wiring connections.

i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.

j. Ground fault.

k. Short circuit faults.
l. Stray voltage.

m. Loop resistance.

-- End of Section --
PART 1  GENERAL

1.1  CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Material character is indicated by the boring logs.

1.2  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


AASHTO T 224  (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600  (2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)


<table>
<thead>
<tr>
<th>Standard</th>
<th>(Year; E Year) Description</th>
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</thead>
<tbody>
<tr>
<td>ASTM D1140</td>
<td>(2014) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve</td>
</tr>
<tr>
<td>ASTM D2167</td>
<td>(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method</td>
</tr>
<tr>
<td>ASTM D2434</td>
<td>(1968; R 2006) Permeability of Granular Soils (Constant Head)</td>
</tr>
<tr>
<td>ASTM D2487</td>
<td>(2011) Soils for Engineering Purposes (Unified Soil Classification System)</td>
</tr>
<tr>
<td>ASTM D2937</td>
<td>(2010) Density of Soil in Place by the Drive-Cylinder Method</td>
</tr>
<tr>
<td>ASTM D4318</td>
<td>(2010; E 2014) Liquid Limit, Plastic Limit, and Plasticity Index of Soils</td>
</tr>
<tr>
<td>ASTM D512</td>
<td>(2012) Chloride Ion in Water</td>
</tr>
<tr>
<td>ASTM D698</td>
<td>(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft.)</td>
</tr>
<tr>
<td>U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)</td>
<td></td>
</tr>
</tbody>
</table>
1.3 DEFINITIONS

1.3.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GC, SW, SP, SM, SC, CL, ML. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements which comprise stones less than 3 inches in any dimension.

1.3.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.3.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C136, and ASTM D1140.

1.3.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.3.5 Topsoil

Material suitable for topsoils obtained from offsite areas is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than 1 inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.3.6 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or
jack hammers for removal.

1.3.7 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.3.8 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.3.9 Select Granular Material

1.3.9.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, SP, by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.002 feet per minute when tested in accordance with ASTM D2434.

1.3.9.2 California Bearing Ratio Values

Bearing Ratio: At 0.1 inch penetration, provide a bearing ratio of 5 percent at 95 percent ASTM D1557 maximum density as determined in accordance with ASTM D1883 for a laboratory soaking period of not less than 4 days. Provide 0.5 percent maximum expansion. Conform the combined material to the following sieve analysis:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inches</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>40 - 85</td>
</tr>
<tr>
<td>No. 10</td>
<td>20 - 80</td>
</tr>
<tr>
<td>No. 40</td>
<td>10 - 60</td>
</tr>
<tr>
<td>No. 200</td>
<td>5 - 25</td>
</tr>
</tbody>
</table>

1.3.10 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 1 inch or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free
the initial backfill material of stones larger than 3 inches in any
dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.3.11 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to
or greater than 25 when tested in accordance with ASTM D4318.

1.3.12 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a
maximum particle size of 0.375 inch and less than 5 percent passing the No. 200 size sieve, and with not more than 3 percent by weight finer than 0.02
mm grain size.

1.4 SYSTEM DESCRIPTION

Subsurface soil boring logs are shown on the Drawings. The subsoil investigation report may be reviewed as part of the Contract Documents. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.4.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

1.4.1.1 Rock Excavation

Submit notification of encountering rock in the Project. Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

1.4.2 Blasting

Blasting will not be permitted.
1.4.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G
Dewatering Work Plan; G

SD-03 Product Data

Utilization of Excavated Materials; G
Shoulder Construction

SD-06 Test Reports

Testing
Borrow Site Testing

Within 24 hours of conclusion of physical tests, submit 4 copies of test results, including calibration curves and results of calibration tests.

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity, and reactivity. Backfill shall contain a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH) and a maximum of 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and shall pass the TCLP test. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Provide Borrow Site Testing for TPH, BTEX, and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the Contracting Officer.
2.2 BURIED WARNING AND IDENTIFICATION TAPE

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

### Warning Tape Color Codes

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Electric</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas, Oil; Dangerous Materials</td>
</tr>
<tr>
<td>Orange</td>
<td>Telephone and Other Communications</td>
</tr>
<tr>
<td>Blue</td>
<td>Water Systems</td>
</tr>
<tr>
<td>Green</td>
<td>Sewer Systems</td>
</tr>
<tr>
<td>White</td>
<td>Steam Systems</td>
</tr>
<tr>
<td>Gray</td>
<td>Compressed Air</td>
</tr>
</tbody>
</table>

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 FUEL PIPE BEDDING MATERIAL

Pipe Bedding Material for exterior coated steel pipe shall be clean, natural sand conforming to ASTM C144 (masonry aggregate) or ASTM C33 (fine concrete aggregate) with not more than 5 percent by weight passing the No. 200 sieve. Resistivity tests for sand backfill shall verify the sand has an average wet Resistivity greater than 10,000 ohm-cm as determined by ASTM G57.
<table>
<thead>
<tr>
<th>Sieve</th>
<th>ASTM C33 Percent Passing</th>
<th>ASTM C144 Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No. 4</td>
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<td>No. 8</td>
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<td>No. 16</td>
<td>50 to 85</td>
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<td>No. 100</td>
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<td>2 to 15</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 to 5</td>
<td></td>
</tr>
</tbody>
</table>

2.5 SAND BACKFILL MATERIAL UNDER FUEL TANK BOTTOMS

a. Sand shall be clean, screened, and free of debris including wood, sticks, vegetation, paper, clay, rocks, silt, or other soils, welding rods, or other metallic of nonmetallic objects, etc.

b. Sand shall be uncrushed natural, river washed sand with no angularities conforming to ASTM C144, ASTM C778 type "20-30 Sand" or type "Graded Sand", or equivalent, and meeting the following gradations.

c. Type "20-30 Sand":

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 16</td>
<td>100</td>
</tr>
<tr>
<td>No. 20</td>
<td>85-100</td>
</tr>
<tr>
<td>No. 30</td>
<td>0-5</td>
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</table>

d. Type "Graded Sand":

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 16</td>
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<td>20-30</td>
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<tr>
<td>No. 100</td>
<td>0-4</td>
</tr>
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</table>

e. ASTM C144, "Natural Sand":

SECTION 31 00 00 Page 8
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
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<td>2-15</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-5</td>
</tr>
</tbody>
</table>

f. Natural sand shall conform to the following:

1. Resistivity: >25,000 ohm-cm in accordance with ASTM G57 or equivalent.

2. pH: 6.5-8.5 in accordance with ASTM G51 or equivalent.

3. Chloride: <100 mg/kg in accordance with ASTM D512 or equivalent.

4. Sulfate: <200 mg/kg per ASTM D516 or equivalent.

2.6 CAPILLARY WATER BARRIER

ASTM C33 coarse aggregate Size 57, 67, or 77 and conforming to the general soil material requirements specified in Paragraph entitled "Satisfactory Materials."

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 4 inches. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Stockpile in locations indicated any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the Project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in Paragraph "Finishing". Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials.
as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Foundation Excavations

Complete foundation excavation in a timely manner. Avoid open excavations during periods of inclement weather.

3.2.2 Over-Excavation

High plasticity, fat clay (MH) materials shall be over-excavated beneath pavements and foundations. The Geotechnical Engineer shall determine when MH materials are present beneath pavements and foundations. MH materials shall be over-excavated 1-1/2 feet below bottom of pavement and 3 feet below bottom of foundations.

3.2.3 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on the Drawings. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.2.4 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for
subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.6 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, at least 3 feet below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.2.7 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 4 feet high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Shore vertical trench walls more than 4 feet high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.7.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.7.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, remove such material 4 inches below the required grade and replaced with suitable materials as provided in Paragraph "Backfilling and Compaction".
3.2.7.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in Paragraph "Backfilling and Compaction". When removal of unstable material is required due to the Contractor’s fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.2.7.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.8 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within 2 feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.2.9 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Backfill and compact over excavations and changes in grade to 95 percent of ASTM D698 maximum density.

3.2.10 Placement of Sand Backfill Material Under Fuel Tank Bottoms

a. Sand shall be compacted in maximum of 6 inch lifts. Sand cushion shall be compacted to 98 percent of the standard proctor maximum dry density (ASTM D698). Surface of sand cushion shall be compacted with a smooth roller or vibratory plate tamper (preferred) (12 percent - 16 percent water content). No oil, diesel, or other substance shall be sprayed on the sand that would interfere with proper Cathodic Protection of the tank bottom. Four compaction readings equally spaced per quadrant (total 16 readings) shall be taken and recorded. Sand above and below the liner shall be compacted.

b. After completing the entire sand cushion, liner, etc., and before installing the new tank inner bottom plates, the Cathodic protection system shall be checked for proper function. This functional testing
of the Cathodic protection system shall be witnessed by Contractor and
documented in detail.

c. After final compaction, sand bedding shall be protected from water
infiltration due to rain and snow by use of a continuous watertight
polyethylene sheet over the entire tank footprint until placement of the
tank bottom plates commences. Water accumulation above the sand
bedding shall be promptly removed.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the
particular fill or embankment for which it is to be used. Obtain borrow
material from the borrow areas from approved private sources or areas on
site approved by the Contracting Officer. Unless otherwise provided in the
Contract, the Contractor is responsible for obtaining the right to procure
material, pay royalties and other charges involved, and bear the expense of
developing the sources, including rights-of-way for hauling from the
owners. Borrow material from approved sources on Government-controlled
land may be obtained without payment of royalties. Unless specifically
provided, do not obtain borrow within the limits of the Project Site
without prior written approval. Consider necessary clearing, grubbing, and
satisfactory drainage of borrow pits and the disposal of debris thereon
related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Contracting Officer sufficiently in advance of the opening of
any excavation or borrow pit or borrow areas to permit elevations and
measurements of the undisturbed ground surface to be taken. Except as
otherwise permitted, excavate borrow pits and other excavation areas
providing adequate drainage. Transport overburden and other spoil material
to designated spoil areas or otherwise dispose of as directed. Provide
neatly trimmed and drained borrow pits after the excavation is completed.
Ensure that excavation of any area, operation of borrow pits, or dumping of
spoil material results in minimum detrimental effects on natural
environmental conditions.

3.5 SHORING

3.5.1 General Requirements

Submit a Shoring and Sheetin plan for approval 15 days prior to starting
work. Submit drawings and calculations, certified by a Registered
Professional Engineer, describing the methods for shoring and sheeting of
excavations. Furnish shoring, including sheet piling, and install as
necessary to protect workmen, banks, adjacent paving, structures, and
utilities. Remove shoring, bracing, and sheeting as excavations are
backfilled, in a manner to prevent caving.

3.5.2 Geotechnical Engineer

The Contractor shall hire a Professional Geotechnical Engineer (registered
in the State of North Carolina) to provide inspection of excavations and
soil/groundwater conditions throughout construction. The Geotechnical
Engineer is responsible for performing pre-construction and periodic site
visits throughout construction to assess site conditions. The Geotechnical
Engineer is responsible for updating the excavation, sheeting and
dewatering plans as construction progresses to reflect changing conditions
and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor’s adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the Contract duration.

3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.8 GROUND SURFACE PREPARATION

3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.8.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.
3.9 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated waste disposal or spoil areas. Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Submit procedure and location for disposal of unused satisfactory material. Submit proposed source of borrow material. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.10 BURIED TAPE AND DETECTION WIRE

3.10.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.10.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over it’s entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.11 BACKFILLING AND COMPACTION

Place select granular material and backfill adjacent to any and all types of structures, in successive horizontal layers of loose material not more than 8 inches in depth. Compact to a minimum of 95 percent of the soils Modified Proctor maximum dry density (ASTM D1557), to prevent wedging action or eccentric loading upon or against the structure. Select granular material and backfill material must be within the range of -2 to +2 percent of optimum moisture content at the time of compaction. The upper 12 inches of select granular material within the parking and drive areas shall be compacted to a minimum of 98 percent of ASTM D1557 maximum dry density at near optimum moisture content.

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of Paragraphs "Ground Surface Preparation". Finish compaction by sheepfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.
3.11.1 Trench Backfill

Backfill trenches to the grade shown. Do not backfill the trench until all specified tests are performed.

3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness as indicated or specified. Place initial backfill material and compact it with approved tampers to a height of at least 1 foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

3.11.1.3.1 Class I

Angular, 0.25 to 1-1/2 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

3.11.1.3.2 Class II

Coarse sands and gravels with maximum particle size of 1-1/2 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

3.11.1.3.3 Sand

Clean, coarse-grained sand classified as cohesionless or coarse fill in accordance with State Standard or SW or SP by ASTM D2487 for bedding and backfill as indicated.

3.11.1.3.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as cohesionless or coarse fill in accordance with State Standard or having a classification of GW in accordance with ASTM D2487 for bedding and backfill as indicated. Do not exceed maximum particle size of 3 inches.
3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.11.1.4.1 Roadways and Airfields

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.11.1.4.2 Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.11.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.12.1 Water Lines

Excavate trenches to a depth that provides a minimum cover of 4 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.12.2 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.13 EMBANKMENTS

3.13.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact to a minimum of 95 percent of the soils Modified Proctor maximum dry density (ASTM D1557). Backfill material must be within the range of -2 to +2 percent of optimum moisture content at the time of compaction.
Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in Paragraph "Subgrade Preparation". Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.14 SUBGRADE PREPARATION

3.14.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a 20 ton, pneumatic-tired roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer. Undercut rutting or pumping of material as directed by the Contracting Officer and replace with select material.

Immediately prior to constructing pavement and foundation sections, proofroll the subgrade to detect any softened, loosened, or disturbed areas that may have been exposed to wet weather or construction traffic. Areas that are found to be disturbed or indicate instability during the proofrolling shall be undercut and replaced with select granular material or repaired as recommended by the Geotechnical Engineer. This proofrolling shall be observed by the Geotechnical Engineer.

3.14.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, diskimg, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. After rolling, do not show deviations for the surface of the subgrade for airfields greater than 1/2 inch when tested with a 12 foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.14.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas, compact each layer of the embankment to at least 95 percent of the soils Modified Proctor maximum dry density. The upper 1 foot of structural fill shall be compacted to 98 percent of the soils Modified
Proctor maximum dry density. The compaction requirements shall be applied under the Proposed Tank Foundation.

3.14.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 98 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 12 inch of subgrade.

3.14.3.2 Subgrade for Shoulders

Compact subgrade for shoulders to at least 98 percentage laboratory maximum density for the depth below the surface of shoulder shown.

3.14.3.3 Subgrade for Airfield Pavements

Compact top 24 inches below finished pavement or top 12 inches of subgrades, whichever is greater, to 100 percent of ASTM D1557; compact fill and backfill material to 100 percent of ASTM D1557.

3.15 SHOULDER CONSTRUCTION

Construct shoulders of satisfactory excavated or borrow material or as otherwise shown or specified. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Contracting Officer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in Paragraph "Subgrade Preparation" above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.16 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in Paragraph "Subgrade Preparation". Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.16.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not
permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.16.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.16.3 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.17 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 4 inches and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas indicated.

3.18 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556, ASTM D2167, or ASTM D6938. When ASTM D6938 is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556. ASTM D6938 results in a wet unit weight of soil in determining the moisture content of the soil when using this method.

b. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. ASTM D2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet Specification Requirements.

c. Perform tests on recompacted areas to determine conformance with Specification Requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the
tests. The following number of tests, if performed at the appropriate
time, will be the minimum acceptable for each type operation.

3.18.1 Fill and Backfill Material Gradation

One test per 500 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with
ASTM C136.

3.18.2 In-Place Densities

a. One test per 1,000 square feet, or fraction thereof, of each lift of
fill or backfill areas compacted by other than hand-operated machines.

b. One test per 100 square feet, or fraction thereof, of each lift of fill
or backfill areas compacted by hand-operated machines.

c. One test per 2,500 linear feet, or fraction thereof, of each lift of
embankment or backfill for roads or airfields.

3.18.3 Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556 as follows:

a. One check test per lift for each 1,000 square feet, or fraction
thereof, of each lift of fill or backfill compacted by other than
hand-operated machines.

b. One check test per lift for each 100 square feet, of fill or backfill
areas compacted by hand-operated machines.

c. One check test per lift for each 2,500 linear feet, or fraction
thereof, of embankment or backfill for roads or airfields.

3.18.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two
tests per day per type of material or source of material being placed
during stable weather conditions. During unstable weather, perform tests
as dictated by local conditions and approved by the Contracting Officer.

3.18.5 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow
material to determine the optimum moisture and laboratory maximum density
values. One representative test per 2,500 cubic yards of fill and
backfill, or when any change in material occurs which may affect the
optimum moisture content or laboratory maximum density.

3.18.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in Paragraph "Subgrade Preparation" during construction of the subgrades.

3.18.7 Fuel Pipe Bedding Material

Perform one test for every fifty cubic yards of material to confirm
compliance with the properties specified in Part 2 of this specification.
3.18.8 Sand Backfill Material Under Fuel Tank Bottoms

Perform testing of the sand at the source to confirm compliance with the properties specified in Part 2 of this specification. At the site, perform one test for every load of material delivered to the site to verify resistivity, pH, chloride content, and sulfate content requirements.

3.19 DISPOSITION OF SURPLUS MATERIAL

Remove surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber from Government property and delivered to a licensed/permitted facility or to a location approved by the Contracting Officer.

-- End of Section --
SECTION 31 11 00
CLEARING AND GRUBBING
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. DEPARTMENT OF DEFENSE (DOD)
DODI 4150.07 DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
   Herbicide Application Plan

SD-03 Product Data
   Nonsaleable Materials; G
   Herbicides; G

SD-04 Samples
   Tree Wound Paint

SD-07 Certificates
   Qualifications; G

SD-11 Closeout Submittals
   Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site: http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf.
1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permitted unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Submit samples in cans with manufacturer's label of bituminous based paint of standard manufacture specially formulated for tree wounds.

2.1.2 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.
3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 30 00 ADMINISTRATIVE REQUIREMENTS and Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 Application

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 CLEARING

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 1-1/2 inches or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 1-1/2 inches in diameter shall be painted with an approved tree-wound paint.
Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.1 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Trees shall be disposed of as specified in paragraph DISPOSAL OF MATERIALS.

3.3.2 Pruning

Trim trees designated to be left standing within the cleared areas of dead branches 1-1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to thebole of the tree or main branches. Paint cuts more than 1-1/4 inches in diameter with an approved tree wound paint.

3.3.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

3.4.1 Saleable Timber

All timber on the project site noted for clearing and grubbing shall become the property of the Contractor, and shall be removed from the project site and disposed of off stations.

3.4.2 Nonsaleable Materials

Written permission to dispose of such products on private property shall be filed with the Contracting Officer. Logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations, except for salable timber, shall be disposed of outside the limits of Government-controlled land at the Contractor's responsibility, except when otherwise directed in writing. Such directive will state the conditions covering the disposal of such products and will also state the areas in which they may be placed.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of application used.
--- End of Section ---
PART 1    GENERAL

1.1    SYSTEM DESCRIPTION

1.1.1    General

Work under this Section consists of furnishing all labor, equipment, and materials necessary to install, monitor and maintain as well as subsequent abandoning of settlement gauges and monitoring points required to record fill induced settlement in and around Drydocks 6, 7, 3, & 4.

Contractor shall procure the services of local personnel from a geotechnical specialty firm hereafter called the "Contractor's Geotechnical Engineer" to perform all required settlement analysis and data interpretation.

The system of settlement monitoring equipment is to enable the Contractor's Geotechnical Engineer to observe and determine the magnitude and rate of settlement. The settlement data and monitoring gauges shall be utilized to confirm engineering analyses and to confirm that post construction total settlement of foundations supported by fill under total loads (dead + live) will be no greater than 1 inch total or 1/4 inch over 40 feet.

1.2    REFERENCES

Navy - SH- Naval Sea Systems Command (Ship Systems)
HH-P-117 Packing, Jute, Twisted

1.3    RELATED SECTIONS

Sections related to this include:
a. Earthwork: DIVISION 31 - EARTHWORK Sections.

1.4    EXPERIENCE REQUIREMENT

All other guidelines for submitting Subcontractor information shall be followed in accordance with that specified elsewhere under Division 01.

1.4.1    Contractor's Geotechnical Engineer

Interpret data and release signed and sealed reporting data and plots.

Contractor's Geotechnical Engineer shall be licensed in North Carolina as a Professional Engineer.

1.4.2    Contractor’s Surveyor

Measure settlement gauges and bench marks and release signed and sealed reporting data and plots.

Contractor's Surveyor shall be licensed in the North Carolina as a
1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having "G" designations are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.

SD-01 Preconstruction Submittals

At least two weeks prior to proposed Drydock filling operations:

List of proposed subcontractors; G

Proposed personnel resumes identifying the specific expertise and past experience of each member of the geotechnical specialty firm to be employed for this work activity.

Proposed surveying personnel; G

SD-06 Test Reports

Settlement Records; G

Submit elevation measurements to the nearest 0.001 foot, or settlement monitoring locations indicated.

Submit surface settlement information to Contracting Officer the day after measurements are obtained.

Settlement Report; G

Submit at conclusion of settlement monitoring program. Report shall include settlement prediction curves and settlement data and findings of analysis that provide basis for Contractor's Geotechnical Engineer conclusion that specified settlement tolerances for fill have been achieved.

1.6 SITE CONDITIONS

Contractor shall at all times take precautions to prevent damage to settlement gauges. A suitable portable barricade shall be maintained around pipe sleeves projecting above grade during construction operations. In the event the settlement gauges become damaged, fail to function properly or in any way become unreliable through failure on the part of the Contractor to use due care in their operations, the settlement gauges shall be replaced, cleaned out, or reset as required, without any additional cost to the Government.

Provide access to settlement monitoring locations, and facilitate monitoring by temporarily stopping or interrupting certain portions of the Work as they may be required for monitoring and taking readings. Perform monitoring and measuring in a manner that will not delay the work unnecessarily, and schedule and perform the work in a manner that will not delay monitoring and measuring.
PART 2 PRODUCTS

2.1 EQUIPMENT

All equipment necessary for monitoring settlement. All proposed procedures for monitoring program shall be submitted to Government in advance of purchasing and installing.

2.2 SETTLEMENT GAUGES

2.2.1 Plate

Plate: 0.5 inch thick steel plate, 30 inches square.

2.2.2 Riser Pipe

Riser pipe: 1-1/2 inch diameter standard galvanized, steel pipe with threaded ends and couplings.

2.2.3 Sleeve Pipe

Sleeve pipe: 3 inch diameter standard galvanized, steel pipe with threaded ends and couplings.

2.2.4 End Cap

1-1/2 inch standard galvanized steel threaded cap.

2.2.5 Oakum

Commercially produced hemp or jute fiber meeting requirements of Federal Specifications HH-P-117.

PART 3 EXECUTION

3.1 SETTLEMENT GAUGES

3.1.1 Construction Requirements

Settlement gauge plates and bench marks shall be furnished and installed at locations indicated on the Drawings.

Settlement plates shall be approved by the Contracting Officer before beginning tank backfill installation.

The first section of riser pipe shall be shop welded in position perpendicular to the steel plate and at its center.

Riser pipe shall not extend above the surface of the fill more than 5 feet.

Sections of sleeve pipe are intended to be continuous so as to prevent embankment soils from coming in contact with riser pipe as progressive lifts of fill are placed.

Sections of riser pipe in place shall be held firmly so as to prevent turning as each section of pipe is added. Each section of riser pipe shall be joined using joint compound.

Fill material shall be compacted around the sleeve pipes and bottom section
of riser pipe to a radius of 3 feet in 3 inch layers with a power tamper. The power-tamped material shall be carried at least 12 inches above the adjacent fill elevation at all times.

Contractor shall keep riser and sleeve pipes plumb and cap shall be kept on the riser pipe to prevent foreign debris and water from entering during fill placement and settlement monitoring.

Sleeve and riser pipes extending above final grade shall be painted with safety yellow enamel.

The distance from the top of plate to the top of pipe shall be accurately measured and recorded by the Contractor’s surveyor.

3.1.2 Installation

Install settlement gauges prior to the placement of fill.

Prior to placement of the fill, excavate down through the sand drainage blanket to the native in-place soils. Place a minimum 1 inch thick sand leveling course upon the native in-place soils.

Place the 0.5 inch thick steel plate upon the leveling sand.

Assure that the leveling course sand extends a minimum of 6 inches in all directions beyond the edges of the steel settlement plate.

Place end cap at the top of the riser pipe.

Restore the drainage blanket over the steel settlement plate and surrounding region.

Obtain the first measured readings of the settlement plate and end cap.

Place embankment fill as indicated.

As soon as drainage blanket and embankment soils achieves 2 feet of cover over the steel settlement plate, center sleeve pipe around the riser pipe to isolate and protect the inner pipe for subsequent readings.

Fill bottom 6 inches of first section of sleeve pipe with tightly packed Oakum as indicated, to keep sleeve centered on riser pipe and prevent intrusion of soil into annular space.

Fill material shall be compacted around bottom section of riser pipe and sleeve pipe to a radius of 3 feet in 3 inch layers with a power tamper.

The power-tamped material shall be carried at least 12 inches above the adjacent fill elevation at all times.

Progressively add both inner riser pipe and sleeve pipe in section increments of 5.0 feet (or other calibrated and measured increments) as embankment fill is continued to be placed, always transferring the end cap to the newest riser pipe top and obtaining new elevation readings at each time of extension addition. No embankment fill shall be placed around settlement gauges until the elevation of the top of the new riser section has been determined by Contractor's Surveyor.

Fill top 6 inches of sleeve pipe with tightly packed Oakum as indicated,
prior to fill placement, to keep sleeve centered on riser pipe and prevent intrusion of soil into annular space. Remove prior to extending riser and sleeve pipe.

The Contractor shall notify the Contracting Officer a minimum of one day in advance to and immediately upon completing each installation.

Submit updated elevation readings at the end of each day's activities to Contracting Officer.

Take precautions to prevent damage to gauges. In the event settlement gauges become damaged or material enters the annular space between sleeve and riser pipe, through failure on the part of the Contractor to use care in his operations, the settlement gauges shall be replaced, cleaned out, or reset as required, without any additional cost to the Owner.

3.1.3 Surveying

Bench marks registering their coordinate locations and elevations to the nearest 0.001 feet elevation shall be established.

Bench marks shall be located sufficiently outside of the zone of stress-settlement influence from on-going construction activities.

The method of determining elevations, along with the method of preserving control points will be subject to review and approval by Contracting Officer.

Approval shall not relieve the Contractor from the responsibility for the correctness of the survey work by the Contractor's Surveyor.

Plan cross-sections shall not be permitted as a means to establishing bench marks or initial plate elevation readings for vertical or horizontal control.

3.1.4 Settlement Readings

Once each settlement gauge is installed at its specific location, Contractor's Geotechnical Engineer will prepare a location-specific settlement curve based upon the actual fill at each settlement gauge location. Curves specific to each planned settlement gauge location will be incorporated for construction observation based upon completed design settlement predictions from backfill materials selected.

Contractor's Surveyor shall obtain settlement to the nearest 0.001 foot and record with the corresponding height of fill placed at each respective settlement gauge location, daily during fill placement operations. Following completion of embankment fill placement perform elevation readings daily for a period of one week, and three times per week for the next 8 weeks.

Contractor's Geotechnical Engineer shall evaluate the settlement readings as they are taken to compare to the site-specific predicted settlement curves.

Readings shall continue at specified frequency until Contractor's Geotechnical Engineer advises that predicted future settlement of fill achieves specified tolerances. Contractor shall submit Settlement Report. Construction shall not recommence until findings of settlement monitoring
are approved by Contracting Officer.

3.1.5 Abandoning Settlement Gauges

Upon completion of monitoring and when advised by Contracting Officer, abandon all settlement gauges in-place. Cut off and remove all steel pipe to a minimum of 3 feet below finished grade and then inject under pressure a cement-based grout via a tremie pipe into both the inner steel riser pipe and the outer steel protective sleeve until both are completely filled.

3.2 SETTLEMENT MONITORING POINTS

3.2.1 Installation

Settlement monitoring points shall be furnished and installed at locations indicated on the Drawings. Establish settlement monitoring points by marking or etching a readily observable "x" into the surface of the concrete that will permit elevation measurement by approved surveying method.

3.2.2 Settlement Monitoring Point Readings

Record elevation of settlement monitoring points to the nearest 0.001 foot at the same frequency as the settlement gauges.

-- End of Section --
PART 1 GENERAL

1.1 SUMMARY

The work consists of furnishing and installing temporary and permanent soil surface erosion control materials to prevent the pollution of air, water, and land, including fine grading, blanketing, stapling, mulching, vegetative measures, structural measures, and miscellaneous related work, within project limits and in areas outside the project limits where the soil surface is disturbed from work under this Contract at the designated locations. This work includes all necessary materials, labor, supervision and equipment for installation of a complete system. Submit a listing of equipment to be used for the application of erosion control materials. Coordinate this Section with the requirements of Section 31 00 00 EARTHWORK and Section 32 92 19 SEEDING. Complete backfilling the openings in synthetic grid systems and articulating cellular concrete block systems a maximum 7 days after placement to protect the material from ultraviolet radiation.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM D1777 (1996; E 2011; R 2011) Thickness of Textile Materials

ASTM D3776 (2009a; R 2013) Standard Test Method for Mass Per Unit Area (Weight) of Fabric

ASTM D3787 (2016) Bursting Strength of Textiles - Constant-Rate-of-Traversal (CRT), Ball Burst Test


ASTM D4355 (2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus


ASTM D4632 (2015a) Grab Breaking Load and Elongation of Geotextiles


ASTM D4833 (2007; E 2013; R 2013) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

ASTM D4972 (2013) pH of Soils

ASTM D5268 (2013) Topsoil Used for Landscaping Purposes

ASTM D5852 (2000; R 2007; E 2014) Standard Test Method for Erodibility Determination of Soil in the Field or in the Laboratory by the Jet Index Method


U.S. GREEN BUILDING COUNCIL (USGBC)


1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Work Sequence Schedule; G
Erosion Control Plan; G

SD-02 Shop Drawings

Layout
Obstructions Below Ground; G

Maintenance Record
SD-03 Product Data

Local/Regional Materials

Biobased Materials

Recycled Plastic

Mulch Control Netting and Filter Fabric

Hydraulic Mulch; G

Erosion Control Blankets Type XI

Geotextile Fabrics; G

Equipment

Finished Grade

Erosion Control Blankets

Submit manufacturer's literature including physical characteristics, application and installation instructions. Documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in Project.

SD-04 Samples

In addition to the samples, submit certification of recycled content or Statement of recycled content. Also submit certification of origin including the name, address and telephone number of manufacturer.

Geosynthetic Binders

1 quart

Mulch

2 pounds

Hydraulic Mulch

2 pounds

Geotextile Fabrics

6 inch square

Erosion Control Blankets

6 inch square

Synthetic Grid Systems

One sample grid
Articulating Cellular Concrete Block Systems

100 square feet area sample and two color charts displaying the colors and finishes.

SD-06 Test Reports

Geosynthetic Binders
Hydraulic Mulch
Geotextile Fabrics
Erosion Control Blankets
Synthetic Grid Systems
Articulating Cellular Concrete Block Systems

SD-07 Certificates

Fill Material
Mulch
Hydraulic Mulch
Geotextile Fabrics
Geosynthetic Binders
Synthetic Soil Binders
Installer's Qualification
Recycled Plastic
Wood By-Products
Wood Cellulose Fiber

SD-10 Operation and Maintenance Data

Maintenance Instructions; G

1.4 QUALITY ASSURANCE

1.4.1 Installer's Qualification

The installer shall be certified by the manufacturer for training and experience installing the material. Submit the installer's company name and address, and/or certification.

1.4.2 Erosion Potential

Assess potential effects of soil management practices on soil loss in accordance with ASTM D6629. Assess erodibility of soil with dominant soil structure less than 2.8 to 3.1 inches in accordance with ASTM D5852.
1.4.3 Substitutions

Substitutions will not be allowed without written request and approval from the Contracting Officer.

1.4.4 SUSTAINABLE DESIGN REQUIREMENTS

1.4.4.1 Local/Regional Materials

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the Project Site, if available from a minimum of three sources. See Section 01 33 29 SUSTAINABILITY REPORTING for cumulative total local material requirements. Erosion control materials may be locally available. Submit LEED documentation relative to local/regional materials credit in accordance with LEED GBDC Ref Guide. Submit documentation indicating distance between manufacturing facility and the Project Site. Indicate distance of raw material origin from the Project Site. Indicate relative dollar value of local/regional materials to total dollar value of products included in Project.

1.4.4.2 Biobased Materials

Use biobased materials when feasible and as specified. Submit documentation indicating type of biobased material in product and biobased content.

1.5 DELIVERY, STORAGE, AND HANDLING

Prior to delivery of materials, submit certificates of compliance attesting that materials meet the specified requirements. Store materials in designated areas and as recommended by the manufacturer protected from the elements, direct exposure, and damage. Do not drop containers from trucks. Material shall be free of defects that would void required performance or warranty. Deliver geosynthetic binders and synthetic soil binders in the manufacturer's original sealed containers and stored in a secure area.

a. Furnish erosion control blankets and geotextile fabric in rolls with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement. Label erosion control blanket and geotextile fabric rolls to provide identification sufficient for inventory and quality control purposes.

b. All synthetic grids, synthetic sheets, and articulating cellular concrete block grids shall be sound and free of defects that would interfere with the proper placing of the block or impair the strength or permanence of the construction. Minor cracks in synthetic grids and concrete cellular block, incidental to the usual methods of manufacture, or resulting from standard methods of handling in shipment and delivery, will not be deemed grounds for rejection.

c. Inspect seed upon arrival at the jobsite for conformity to species and quality. Seed that is wet, moldy, or bears a test date five months or older, shall be rejected.
1.6 SCHEDULING

Submit a construction work sequence schedule, with the approved erosion control plan a minimum of 30 days prior to start of construction. The work schedule shall coordinate the timing of land disturbing activities with the provision of erosion control measures to reduce on-site erosion and off-site sedimentation. Coordinate installation of temporary erosion control features with the construction of permanent erosion control features to assure effective and continuous control of erosion, pollution, and sediment deposition. Include a vegetative plan with planting and seeding dates and fertilizer, lime, and mulching rates. Distribute copies of the work schedule and erosion control plan to site subcontractors. Address the following in the erosion control plan:

a. Statement of erosion control and stormwater control objectives.
b. Description of temporary and permanent erosion control, stormwater control, and air pollution control measures to be implemented on site.
c. Description of the type and frequency of maintenance activities required for the chosen erosion control methods.
d. Comparison of proposed post-development stormwater runoff conditions with predevelopment conditions.

1.7 WARRANTY

Erosion control material shall have a warranty for use and durable condition for project specific installations. Temporary erosion control materials shall carry a minimum eighteen month warranty. Permanent erosion control materials shall carry a minimum three year warranty.

PART 2 PRODUCTS

2.1 RECYCLED PLASTIC

Submit individual component and assembled unit structural integrity test results; creep tolerance; deflection tolerance; and vertical load test results and Life-cycle durability. Recycled plastic shall contain a minimum 85 percent of recycled post-consumer product. Recycled material shall be constructed or manufactured with a maximum 1/4 inch deflection or creep in any member, according to ASTM D1248. The components shall be molded of ultraviolet (UV) and color stabilized polyethylene. The material shall consist of a minimum 75 percent plastic profile of high-density polyethylene, low-density polyethylene, and polypropylene raw material. The material shall be non-toxic and have no discernible contaminates such as paper, foil, or wood. The material shall contain a maximum 3 percent air voids and shall be free of splinters, chips, peels, buckling, and cracks. Material shall be resistant to deformation from solar heat gain.

2.2 MULCH

2.2.1 Mulch Control Netting and Filter Fabric

Mulch control netting and filter fabric may be constructed of lightweight recycled plastic, cotton, or paper or organic fiber. The recycled plastic shall be a woven or nonwoven polypropylene, nylon, or polyester containing stabilizers and/or inhibitors to make the fabric resistant to deterioration from UV, and with the following properties:
2.3 GEOTEXTILE FABRICS

Geotextile fabrics shall be woven of polyester filaments formed into a stable network so that the filaments retain their relative position to each other. See Section 01 33 29 SUSTAINABILITY REPORTING for cumulative total recycled content requirements. Geotextile fabric may contain post-consumer or post-industrial recycled content. Sewn seams shall have strength equal to or greater than the geotextile itself. Install fabric to withstand maximum velocity flows as recommended by the manufacturer. The geotextile shall conform to the following minimum average roll values:

<table>
<thead>
<tr>
<th>Property</th>
<th>Performance</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>264 g/m²</td>
<td>ASTM D3776</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.635 mm</td>
<td>ASTM D1777</td>
</tr>
<tr>
<td>Permeability</td>
<td>0.12 cm/sec</td>
<td>ASTM D4491</td>
</tr>
<tr>
<td>Abrasion Resistance, Type (percent strength retained)</td>
<td>58 percent X 81 percent</td>
<td>ASTM D3884</td>
</tr>
<tr>
<td>Tensile Grab Strength</td>
<td>1467 N X 1933 N</td>
<td>ASTM D4632</td>
</tr>
<tr>
<td>Grab Elongation</td>
<td>15 percent X 20 percent</td>
<td>ASTM D4632</td>
</tr>
<tr>
<td>Burst Strength</td>
<td>5510 kN/m²</td>
<td>ASTM D3787</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>733 N</td>
<td>ASTM D4833</td>
</tr>
<tr>
<td>Trapezoid Tear</td>
<td>533 N X 533 N</td>
<td>ASTM D4533</td>
</tr>
<tr>
<td>Apparent Opening Size</td>
<td>40 US Std Sieve</td>
<td>ASTM D4751</td>
</tr>
<tr>
<td>UV Resistance @ 500 hours</td>
<td>90 percent</td>
<td>ASTM D4355</td>
</tr>
</tbody>
</table>

2.4 EROSION CONTROL BLANKETS

2.4.1 Erosion Control Blankets Type I

Use Type I blankets for erosion control and vegetation establishment on roadside embankments, abutments, berms, shoulders, and median swales where natural vegetation will provide long term stabilization. Erosion control blankets shall be a machine-produced mat of 100 percent straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. Cover the blanket on the top side with a photodegradable polypropylene netting having an approximate 1/2 by 1/2 inch
mesh and be sewn together on a maximum 1.5 inch centers with degradable thread. The erosion control blanket shall have the following properties:

<table>
<thead>
<tr>
<th>Material Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
</tr>
<tr>
<td>100 percent with approximately 0.50 lb/yd² weight</td>
</tr>
<tr>
<td>Netting</td>
</tr>
<tr>
<td>One side only, lightweight photodegradable with approximately 1.64 lb/1,000 ft² weight</td>
</tr>
<tr>
<td>Thread</td>
</tr>
<tr>
<td>Degradable</td>
</tr>
</tbody>
</table>

Note 1: Photodegradable life a minimum of 2 months with a minimum 90 percent light penetration. Apply to slopes up to a maximum 3:1 gradient.

2.4.2 Erosion Control Blankets Type II

Erosion control blankets shall be a machine-produced mat of 100 percent straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. Cover the blanket on the top side with a polypropylene netting having an approximate 1/2 by 1/2 inch mesh with photodegradable accelerators to provide breakdown of the netting within approximately 45 days, depending upon geographic location and elevation. Sew the blanket together on a maximum 1.5 inch centers with degradable thread. The erosion control blanket shall have the following properties:

<table>
<thead>
<tr>
<th>Material Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
</tr>
<tr>
<td>100 percent with approximately 0.50 lb/yd² weight</td>
</tr>
<tr>
<td>Netting</td>
</tr>
<tr>
<td>One side only, lightweight photodegradable with photo accelerators and approximately 1.64 lb/1,000 ft² weight</td>
</tr>
<tr>
<td>Thread</td>
</tr>
<tr>
<td>Degradable</td>
</tr>
</tbody>
</table>

Note 1: Photodegradable life a minimum of 10 months with a minimum 90 percent light penetration. Apply to slopes up to a maximum 3:1 gradient.

2.4.3 Erosion Control Blankets Type IV

Erosion control blanket shall be a machine-produced mat of 100 percent straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. Cover the blanket on the top and bottom sides with lightweight photodegradable polypropylene netting having an approximate 1/2- by 1/2-inch mesh. Sew the blanket together on 1.5 inch centers with degradable thread. The erosion control blanket shall have the following properties:

<table>
<thead>
<tr>
<th>Material Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
</tr>
<tr>
<td>100 percent with approximately 0.50 lb/yd² weight</td>
</tr>
<tr>
<td>Material Content</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td><strong>Netting</strong></td>
</tr>
<tr>
<td>Both sides lightweight photodegradable with approximately 1.64 lb/1,000 ft² weight.</td>
</tr>
<tr>
<td><strong>Thread</strong></td>
</tr>
<tr>
<td>Degradable</td>
</tr>
</tbody>
</table>

**Note:** Photodegradable life a minimum of 2 months with a minimum 90 percent light penetration. Apply to slopes with a gradient of less than 1.5:1.

### 2.4.4 Erosion Control Blankets Type V

Erosion control blanket shall be a machine-produced mat of 100 percent straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. Cover the blanket on the top side with polypropylene netting having an approximate 1/2- by 1/2-inch mesh with photodegradable accelerators to provide breakdown of the netting within approximately 45 days, depending upon geographic location and elevation. Cover the bottom with a polypropylene netting having an approximate 1/2 by 1/2 inch mesh with photo accelerators. Sew the blanket together on 1.5 inch centers with degradable thread. The erosion control blanket shall have the following properties:

<table>
<thead>
<tr>
<th>Material Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straw</strong></td>
</tr>
<tr>
<td>70 percent by approximately 0.35 lb/yd²</td>
</tr>
<tr>
<td><strong>Netting</strong></td>
</tr>
<tr>
<td>Top side lightweight photodegradable with photo accelerators with approximately 1.64 lb/1,000 ft² weight</td>
</tr>
<tr>
<td>Bottom side lightweight photodegradable with photo accelerators and approximately 1.64 lb/1,000 ft² weight</td>
</tr>
</tbody>
</table>

**NOTE:** Photodegradable life a minimum of 10 months with a minimum 90 percent light penetration. Apply to slopes up to a maximum 2:1 gradient.

### 2.4.5 Erosion Control Blankets Type VI

Erosion control blanket shall be a machine-produced 100 percent biodegradable mat with a 100 percent straw fiber matrix. The blanket shall be of consistent thickness with the straw fiber evenly distributed over the entire area of the mat. Cover the blanket on the top side with a 100 percent biodegradable woven natural organic fiber netting. The netting shall consist of machine directional strands formed from two intertwined yarns with cross directional strands interwoven through the twisted machine strands (commonly referred to as a Leno weave) to form an approximate 1/2-by 1/2-inch mesh. Sew the blanket together with biodegradable thread on 1.5 inch centers. The erosion control blanket shall have the following properties:
Material Content

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>100 percent straw fiber with approximately 0.50 lb/yd² weight</td>
</tr>
<tr>
<td>Netting</td>
<td>One side only, Leno woven 100 percent biodegradable natural organic fiber</td>
</tr>
<tr>
<td>Weight</td>
<td>Approximately 9.3 lb/1,000 ft²</td>
</tr>
<tr>
<td>Thread</td>
<td>Biodegradable</td>
</tr>
</tbody>
</table>

NOTE: Photodegradable life a minimum of 10 months with a minimum 90 Percent light penetration. Apply to slopes up to a maximum 2:1 gradient.

2.4.6 Erosion Control Blankets Type VII

Erosion control blanket shall be a machine-produced 100 percent biodegradable mat with an herbaceous straw fiber matrix. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. Cover the blanket on the top and bottom sides with 100 percent biodegradable woven natural fiber netting. The netting shall consist of machine directional strands formed from two intertwined yarns with cross directional strands interwoven through the twisted machine strands (commonly referred to as a Leno weave) to form an approximate 1/2-by 1/2-inch mesh. Sew the blanket together with biodegradable thread on 1.5 inch centers. The blanket shall have the following properties:

Material Content

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>100 percent straw fiber with approximately 0.50 lb/yd² weight</td>
</tr>
<tr>
<td>Netting</td>
<td>Top and bottom sides, Leno woven 100 percent biodegradable natural organic fiber with approximately 9.3 lb/1,000 ft² weight</td>
</tr>
<tr>
<td>Thread</td>
<td>Biodegradable</td>
</tr>
</tbody>
</table>

Note: Photodegradable life a minimum of 18 months with a minimum 90 percent light penetration. Apply to slopes up to a maximum 1.5:1 gradient.

2.4.7 Erosion Control Blankets Type XII (Compost Mat)

Compost blanket shall consist of a layer of 100 percent biobased stable and mature compost uniformly distributed to a depth of 3/4 to 3 inches along slopes with erosion potential. Compost shall encourage plant growth and seed shall be applied following compost application. The blanket shall have the following properties:
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>3/8-1/2 inch sieve and 2-3 inch sieve (ratio = 3:1)</td>
</tr>
<tr>
<td>Moisture content</td>
<td>20 - 50 percent</td>
</tr>
<tr>
<td>Soluble salt</td>
<td>3.0 - 6.0 mmhos/cm</td>
</tr>
<tr>
<td>Organic matter</td>
<td>40 - 70 percent</td>
</tr>
<tr>
<td>pH</td>
<td>6.0 - 8.0</td>
</tr>
<tr>
<td>Nitrogen content</td>
<td>0.5 - 2.0 percent</td>
</tr>
<tr>
<td>Human made inerts</td>
<td>0.0 - 1.0 percent</td>
</tr>
</tbody>
</table>

2.4.8 Seed

Seed shall comply with Specification Section 32 92 19 SEEDING.

2.4.9 Staking

Stakes shall be 100 percent biodegradable manufactured from recycled plastic or wood and shall be designed to safely and effectively secure erosion control blankets for temporary or permanent applications. The biodegradable stake shall be fully degradable by biological activity within a reasonable time frame. The bio-plastic resin used in production of the biodegradable stake shall consist of polylactide, a natural, completely biodegradable substance derived from renewable agricultural resources. The biodegradable stake must exhibit ample rigidity to enable being driven into hard ground, with sufficient flexibility to resist shattering. Serrate the biodegradable stake on the leg to increase resistance to pull-out from the soil.

2.4.10 Staples

Staples shall be as recommended by the manufacturer.

2.5 COMPOST FILTER BERMS

Compost berms shall consist of 100 percent biobased windrow-shaped compost piles arranged across slopes. Berms shall have the following properties:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>3/8-1/2 inch sieve and 2-3 inch sieve (ratio = 1:1)</td>
</tr>
<tr>
<td>Moisture content</td>
<td>20 - 50 percent</td>
</tr>
<tr>
<td>Soluble salt</td>
<td>4.0 - 6.0 mmhos/cm</td>
</tr>
<tr>
<td>Organic matter</td>
<td>40 - 70 percent</td>
</tr>
<tr>
<td>Parameter</td>
<td>Range</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>pH</td>
<td>6.0 - 8.0</td>
</tr>
<tr>
<td>Nitrogen content</td>
<td>0.5 - 2.0 percent</td>
</tr>
<tr>
<td>Human made inerts</td>
<td>0.0 - 1.0 percent</td>
</tr>
<tr>
<td>Size</td>
<td>1 - 2 feet H x 2.5 - 4 feet W</td>
</tr>
</tbody>
</table>

2.6 WATER

Unless otherwise directed, water is the responsibility of the Contractor. Water shall be potable or supplied by an existing irrigation system.

PART 3 EXECUTION

3.1 WEATHER CONDITIONS

Perform erosion control operations under favorable weather conditions; when excessive moisture, frozen ground or other unsatisfactory conditions prevail, the work shall be stopped as directed. When special conditions warrant a variance to earthwork operations, submit a revised construction schedule for approval. Do not apply erosion control materials in adverse weather conditions which could affect their performance.

3.1.1 Finished Grade

Provide condition of finish grade status prior to installation, location of underground utilities and facilities. Verify that finished grades are as indicated on the drawings; complete finish grading and compaction in accordance with Section 31 00 00 EARTHWORK, prior to the commencement of the work. Verify and mark the location of underground utilities and facilities in the area of the work. Repair damage to underground utilities and facilities at the Contractor's expense.

3.1.2 Placement of Erosion Control Blankets

Before placing the erosion control blankets, ensure the subgrade has been graded smooth; has no depressed, void areas; is free from obstructions, such as tree roots, projecting stones or other foreign matter. Verify that mesh does not include invasive species. Vehicles will not be permitted directly on the blankets.

3.2 SITE PREPARATION

3.2.1 Soil Test

Test soil in accordance with ASTM D5268 and ASTM D4972 for determining the particle size and mechanical analysis. Sample collection onsite shall be random over the entire site. The test shall determine the soil particle size as compatible for the specified material.

3.2.2 Layout

Submit scale drawings defining areas to receive recommended materials as required by federal, state or local regulations. Erosion control material locations may be adjusted to meet field conditions. When soil tests result
in unacceptable particle sizes, submit a shop drawing indicating the corrective measures.

3.2.3 Protecting Existing Vegetation

When there are established lawns in the work area, the turf shall be covered and/or protected or replaced after construction operations. Identify existing trees, shrubs, plant beds, and landscape features that are to be preserved on site by appropriate tags and barricade with reusable, high-visibility fencing along the dripline. Mitigate damage to existing trees at no additional cost to the Government. Damage shall be assessed by a state certified arborist or other approved professional using the National Arborist Association's tree valuation guideline.

3.2.4 Obstructions Below Ground

When obstructions below ground affect the work, submit shop drawings showing proposed adjustments to placement of erosion control material for approval.

3.3 INSTALLATION

Immediately stabilize exposed soil using fabric, and seed. Stabilize areas for construction access immediately as specified in the paragraph Construction Entrance. Install principal sediment basins and traps before any major site grading takes place. Provide additional sediment traps and sediment fences as grading progresses. Provide inlet and outlet protection at the ends of new drainage systems. Remove temporary erosion control measures at the end of construction and provide permanent seeding.

3.3.1 Construction Entrance

Provide as indicated on drawings, a minimum of 6 inches thick, at points of vehicular ingress and egress on the construction site. Construction entrances shall be cleared and grubbed, and then excavated a minimum of 3 inches prior to placement of the filter fabric and aggregate. The aggregate shall be placed in a manner that will prevent damage and movement of the fabric. Place fabric in one piece, where possible. Overlap fabric joints a minimum of 12 inches.

3.3.2 Compost Filter Berms

Place compost filter berm uncompacted on bare soil as indicated on drawings, parallel to base of slope, and according to manufacturer recommendations. Place second berm in the same manner at top of slope parallel to first berm. When no longer required, berm material may be left to decompose naturally, or distributed over an adjacent area for use as a soil amendment or ground cover.

3.3.3 Seeding

When seeding is required prior to installing mulch on synthetic grid systems verify that seeding will be completed in accordance with Sections 31 00 00 EARTHWORK and 32 92 19 SEEDING.

3.3.4 Mechanical Anchor

Mechanical anchor shall be a V-type-wheel land packer; a scalloped-disk land packer designed to force mulch into the soil surface; or other
suitable equipment.

3.3.5 Hydraulic Mulch Application

3.3.6 Erosion Control Blankets

a. Install erosion control blankets as indicated and in accordance with manufacturer's recommendations. The extent of erosion control blankets shall be as indicated.

b. Orient erosion control blankets in vertical strips and anchored with staples, as indicated. Abut adjacent strips to allow for installation of a common row of staples. Overlap horizontal joints between erosion control blankets sufficiently to accommodate a common row of staples with the uphill end on top.

c. Where exposed to overland sheet flow, locate a trench at the uphill termination. Staple the erosion control blanket to the bottom of the trench. Backfill and compact the trench as required.

d. Where terminating in a channel containing an installed blanket, the erosion control blanket shall overlap installed blanket sufficiently to accommodate a common row of staples.

3.3.7 Articulating Cellular Concrete Block System Installation

3.3.7.1 Seeding, Fertilizing, Mulching

Install seed in accordance with Section 32 92 19 SEEDING.

3.4 CLEAN-UP

Dispose of excess material, debris, and waste materials offsite at an approved landfill or recycling center. Clear adjacent paved areas. Immediately upon completion of the installation in an area, protect the area against traffic or other use by erecting barricades and providing signage as required, or as directed. Signage shall be in accordance with Section 10 14 00.20 INTERIOR/EXTERIOR SIGNAGE.

3.5 MAINTENANCE RECORD

Furnish a record describing the maintenance work performed, record of measurements and findings for product failure, recommendations for repair, and products replaced.

3.5.1 Maintenance

Maintenance shall include eradicating weeds; protecting embankments and ditches from surface erosion; maintaining the performance of the erosion control materials and mulch; protecting installed areas from traffic.

3.5.2 Maintenance Instructions

Furnish written instructions containing drawings and other necessary information, describing the care of the installed material; including, when and where maintenance should occur, and the procedures for material replacement. Submit instruction for year-round care of installed material. Include manufacturer supplied spare parts.
3.5.3 Patching and Replacement

Unless otherwise directed, material shall be placed, seamed or patched as recommended by the manufacturer. Remove material not meeting the required performance as a result of placement, seaming or patching from the site. Replace the unacceptable material at no additional cost to the Government.

-- End of Section --
PART 1    GENERAL

1.1 SUMMARY

The work under this Specification includes furnishing, assembling, filling and tying open wire mesh rectangular compartmented gabions placed on a prepared surface or as specified, and in accordance with the lines, grades, and dimensions shown on the Drawings.

a. Gabions are wire mesh containers of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the Project Site to form flexible, permeable, monolithic earth retaining structures. Gabions shall be manufactured with all components mechanically connected at the production facility with the exception of the mattress lid, which is produced separately from the base. The supply to the jobsite of unassembled individual wire mesh components (panels) forming gabions will not be permitted.

b. Definitions of terms specific to this Specification and to all materials furnished on the jobsite, with the exception of the rock to fill the baskets and the filter material, shall refer and be in compliance with ASTM A975 for double twisted wire mesh, or with ASTM A974 for welded wire fabric.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM A428 (2010; R 2014) Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles


ASTM A975  (2011; R 2016) Standard Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire With Poly(Vinyl Chloride) (PVC) Coating)


ASTM D1499  (2013) Filtered Open-Flame Carbon-Arc Type Exposures of Plastics


ASTM D792  (2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
1.3 DEFINITIONS

1.3.1 Rate of Aggressiveness

The determination of the rate of aggressiveness (non-aggressive, moderately, or highly aggressive) shall be made on a project-to-project basis, due to the many variables involved and the lack of criteria of general validity. It is normally recommended for the choice to be based on all the available data and on the experience of existing gabion structures in similar environments.

1.3.2 Double Twisted Wire Mesh Gabions

Classified according to the wire coating, which is applied prior to manufacturing the mesh. Coating styles are as follows:

1.3.2.1 Style 1

Wire mesh made from wire which is zinc coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are produced from zinc-coated wire. Style 1 for the wire coating is normally recommended for:

1.3.2.1.1 Permanent

Gabion structures, for works installed in non-aggressive or non-polluted environments, and this condition remains unaltered over time.

1.3.2.2 Style 2

Wire mesh made from wire which is coated with Zn-5Al-MM before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from Zn-5Al-MM coated wire. Style 2 for the wire coating is normally recommended for:

1.3.2.2.1 Permanent

Gabion structures, for works installed in moderately aggressive environments.

1.3.2.3 Style 3

Wire mesh, lacing wire, and stiffeners as Style 1 and overcoated with PVC. Fasteners shall be of stainless steel wire. Style 3 for the wire coating is normally recommended for both permanent and temporary gabion structures, for works installed in aggressive or polluted environments, or when the aggressiveness of the site is moderately unpredictable or variable from low to high.
1.3.2.4 Style 4

Wire mesh made from wire which is aluminum-coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from aluminum-coated wire. Style 4 for the wire coating is very seldom used in the gabion industry. Its life expectancy shall be adequately documented to guarantee its consistency and reliability.

1.3.3 Welded Wire Fabric Gabions

Classified according to wire coating styles as follows:

1.3.3.1 Style 1

Welded wire fabric made from wire which is zinc coated before being welded into fabric. Spiral binders, lacing wire, and stiffeners are produced from zinc-coated wire. Style 1 for the wire coating is normally recommended for temporary gabion structures, for works in non-aggressive or non-polluted environments.

1.3.3.2 Style 2

Welded wire fabric which is made from uncoated wire and the fabric is subsequently zinc-coated after fabrication. Spiral binders, lacing wire, and stiffeners are produced from zinc-coated wire. Style 2 for the wire coating is normally recommended for permanent gabion structures, for works installed in non-aggressive or non-polluted environments, and this condition remains unchanged over time.

1.3.3.3 Style 3

Welded wire fabric made from wire which is coated with zinc-5 percent aluminum-mischmetal alloy (Zn-5Al-MM) before being welded into fabric. Spiral binders, lacing wire, and stiffeners are also produced from zinc-5 percent aluminum-mischmetal alloy (Zn-5Al-MM) coated wire. Style 3 for the wire coating is normally recommended for:

1.3.3.3.1 Permanent

Gabion structures, for works installed in moderately aggressive environments.

1.3.3.4 Style 4

Welded wire fabric made from wire which is aluminum-coated before being welded into fabric. Spiral binders, lacing wire, and stiffeners are also produced from aluminum-coated (aluminized) wire. Style 4 for the wire coating is very seldom used in the gabion industry. Its life expectancy shall be adequately documented to guarantee its consistency and reliability.

1.3.3.5 Style 5

Welded wire fabric, spiral binders, lacing wire, and stiffeners as Styles 1, 2, 3, or 4, and overcoated with PVC. Style 5 for the wire coating is normally recommended for both permanent and temporary gabion structures, for works installed in aggressive or polluted environments, or when the aggressiveness of the site is moderately unpredictable or variable from low to high.
1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples
Gabions or Mattresses
Alternative Wire Fasteners

SD-06 Test Reports
Gabions or Mattresses
Alternative Wire Fasteners; G

SD-07 Certificates
Stone Fill
Filter Material

1.5 QUALITY ASSURANCE

1.5.1 Samples

Furnish samples of materials used to fabricate the gabions or mattresses to the Contracting Officer 60 days prior to start of installation. Samples will be tested in accordance with specification and either ASTM A974 or ASTM A975 depending on which system is being furnished by the Contractor. The Government reserves the right to test additional samples to verify the submitted test records at the Government's expense. When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

Gabions shall be delivered with all components mechanically connected at the production facility. All gabions are supplied in the collapsed form, either folded or bundled or rolled, for shipping. Bundles are banded together at the factory for ease of shipping and handling.

a. Mattress lids may be supplied either as individual units (bundled) or in roll form. Lacing wire shall be shipped in coils with a diameter of the coil approximately 2 feet. Fasteners shall be shipped in boxes. Preformed stiffeners shall be shipped in bundles.

b. Deliver gabions to the jobsite labeled in bundles. Labels show the dimensions of the gabions included, the number of pieces and the color code.
PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Double twisted wire mesh Gabions

Double twisted wire mesh gabions shall be Style 1, Style 2, Style 3, and Style 4 manufactured with a non-raveling mesh made by twisting continuous pairs of wires through three half turns (commonly called double twisted) to form a hexagonal-shaped opening. Gabion sizes, wire diameters, mesh opening sizes, and tolerances shall comply with the requirements of ASTM A975 (Tables 1, 3, 4, 5, 6, and Sections 9). Gabions shall meet the following test requirements:

2.1.1.1 Metallic Coating

The coating weights shall conform to the requirements of ASTM A641, Class 3 (Style 1), ASTM A856 (Style 2), ASTM A90 or ASTM A428 as applicable, and ASTM A809 (Style 4).

2.1.1.2 PVC for Coating

The PVC coating shall show no cracks or breaks after the wires are twisted in the fabrication of the mesh. The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements:

2.1.1.2.1 Specific Gravity

In the range from 1.30 to 1.35 dN/dm3, when tested in accordance with test method ASTM D792.

2.1.1.2.2 Tensile Strength

Not less than 2985 psi when tested in accordance with test method ASTM D412.

2.1.1.2.3 Modulus of Elasticity

Not less than 2700 psi when tested in accordance with test method ASTM D412.

2.1.1.2.4 Hardness

Shore "D" between 50 and 60, when tested in accordance with test method ASTM D2240.

2.1.1.2.5 Brittleness Temperature

Not higher than 15 degrees F, or lower temperature when specified by the purchaser, when tested in accordance with test method ASTM D746.

2.1.1.2.6 Resistance to Abrasion

The percentage of the weight loss shall be less than 12 percent.

2.1.1.2.7 Salt Spray Exposure and Ultra Violet Light Exposure

The PVC shall show no effect after 3,000 h of salt spray exposure in accordance with ASTM B117. The PVC shall show no effect of exposure to ultra violet light with test exposure of 3,000 h, using apparatus Spectral
Irradiance of Open Flame Carbon Arc with Daylight Filters and 145 degrees F, when tested in accordance with practice ASTM D1499 and ASTM G152.

2.1.1.2.8 Evaluation of Coating After Salt Spray and Ultraviolet Exposure Test

After the salt spray test and exposure to ultraviolet light, the PVC coating shall not show cracks nor noticeable change of color, or blisters or splits. In addition, the specific gravity, tensile strength, hardness and resistance to abrasion shall not change more than 6 percent, 25 percent, and 10 percent respectively, from their initial values.

2.1.1.3 Wire Tensile Strength

The tensile strength of the wire used for the double twisted mesh, lacing wire, and stiffener, when tested in accordance with Test Methods and definitions ASTM A370, shall be in accordance with the requirements of ASTM A641 (Style 1), ASTM A809 (Style 4), and ASTM A856 (Style 2), for soft temper wire.

2.1.1.4 Mesh Strength and Panel to Panel Joint Strength

The minimum strength requirements of the mesh, selvedge wire to mesh connection, panel to panel connection, and punch test, when tested in accordance with ASTM A975 Section 13.1, shall be as shown in Table 1. The strength values reported in lb/ft are referred to the unitary width of the specimen. The panel to panel test shall demonstrate the ability of the fastening system to achieve the required strength, and indicate the number of wire revolutions for the lacing wire or the ring spacing for ring fasteners used. The same number of wire revolutions or ring spacing shall be used in the field installation. Pleating the based panel to obtain internal panels is prohibited.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Strength Requirements of Mesh and Connections</strong></td>
</tr>
<tr>
<td><strong>Test Description</strong></td>
</tr>
<tr>
<td>Tensile strength parallel to twist</td>
</tr>
<tr>
<td>Tensile strength perpendicular to twist</td>
</tr>
<tr>
<td>Connection to selvedges</td>
</tr>
<tr>
<td>Panel to panel (using lacing wire or ring fasteners)</td>
</tr>
<tr>
<td>Punch Test</td>
</tr>
</tbody>
</table>

2.1.2 Welded Wire Fabric Gabions

Welded wire fabric gabions shall be Style 1, Style 2, Style 3, Style 4, and Style 5 manufactured with a welded wire mesh composed of a series of longitudinal and transverse steel wires arranged substantially at right angles to each other, and welded together at the points of intersection by electrical resistance welding to form fabricated sheets. Gabion sizes,
wire diameters, mesh opening sizes, physical properties of the PVC for coating, and tolerances shall comply with the requirements of ASTM A974 (Tables 1, 2, 3, and Sections 9). Gabions shall meet the following test requirements:

2.1.2.1 Metallic Coating

The coating weights shall conform to the requirements of ASTM A641, Class 3 (Style 1), ASTM A856 (Style 2), ASTM A90 or ASTM A428 as applicable, and ASTM A809 (Style 4).

2.1.2.2 PVC for Coating

PVC adhesion test shall be PVC coating shall show no cracks or breaks after the wires are twisted in the fabrication of the mesh. The initial properties of the PVC coating on the wire and welded wire fabric shall have a demonstrated ability to conform to the following requirements:

2.1.2.2.1 Adhesion

The PVC coating shall adhere to the wire such that the coating breaks rather than separates from the wire, in accordance with test method ASTM A974 Section 13.3;

2.1.2.2.2 Mandrel Bend

The PVC-coated wire when subjected to a single 360 bend at 0 degrees F around a mandrel ten times the diameter of the wire, shall not exhibit breaks or cracks in the PVC coating;

2.1.2.2.3 Specific Gravity

In the range from 1.20 to 1.40 dN/dm3, when tested in accordance with test method ASTM D792;

2.1.2.2.4 Tensile Strength

Not less than 2275 psi when tested in accordance with test method ASTM D638;

2.1.2.2.5 Modulus of Elasticity

Not less than 1980 psi at 100 percent strain, when tested in accordance with test method ASTM D638;

2.1.2.2.6 Hardness

Shore "A" not less than 75, when tested in accordance with test method ASTM D2240;

2.1.2.2.7 Britteness Temperature

Not higher than 15 degrees F, or lower temperature when specified by the purchaser, when tested in accordance with test method ASTM D746.

2.1.2.2.8 Resistance to Abrasion

The percentage of the weight loss shall be less than 12 percent;
2.1.2.2.9 Salt Spray Exposure and Ultra Violet Light Exposure

The PVC shall show no effect after 3,000 h of salt spray exposure in accordance with ASTM B117. The PVC shall show no effect of exposure to ultra violet light with test exposure of 3,000 h, using apparatus Spectral Irradiance of Open Flame Carbon Arc with Daylight Filters and 145 degrees F, when tested in accordance with practice ASTM D1499 and ASTM G152;

2.1.2.2.10 Evaluation of Coating After Salt Spray and Ultraviolet Exposure Test

After the salt spray test and exposure to ultraviolet light, the PVC coating shall not show cracks nor noticeable change of color, or blisters or splits. In addition, the specific gravity, tensile strength, hardness and resistance to abrasion shall not change more than 6 percent, 25 percent, and 10 percent respectively, from their initial values.

2.1.2.3 Wire Tensile strength

The tensile strength of the wire used for the welded wire fabric, spiral binders, lacing wire and stiffeners shall be soft medium in accordance with ASTM A641 (Style 1), ASTM A856 (Style 3), and ASTM A809 (Style 4) or hand drawn in accordance with ASTM A853 (Style 2). The cross-sectional area of the test specimen shall be based on the diameter of the metallic coated wire. All the wires used in the fabrication of gabions must use the same temper wire in accordance with given order.

2.1.2.4 Weld Shear Strength

2.1.2.4.1 Minimum Average Shear Value

The minimum average shear value in pounds-force shall be 70 percent of the breaking strength of the wire or as indicated in the table as follows, whichever is greater, when tested in accordance with ASTM A974 Section 13.4. Typical minimum average shear strengths as specified are as follows:

<table>
<thead>
<tr>
<th>Wire diameter inch</th>
<th>Min. Av. Shear Strength lbs</th>
<th>Min. Shear Strength lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.087</td>
<td>292</td>
<td>225</td>
</tr>
<tr>
<td>0.106</td>
<td>472</td>
<td>360</td>
</tr>
<tr>
<td>0.120</td>
<td>584</td>
<td>450</td>
</tr>
</tbody>
</table>

The material shall be deemed to conform with the requirements for weld shear strength if the average of the test results of the first four specimens or if the average of the test results for all welds tested comply with TABLE 2.

2.1.2.4.2 Panel to Panel Joint Strength

The minimum strength of the joined panels, when tested as described in ASTM A974 Section 13.5, shall be as follows:
### TABLE 3
Panel to panel joint strength for welded gabions

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Gabions, metallic coated (lb/ft)</th>
<th>Gabions, PVC coated (lb/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection to selvedges</td>
<td>1400</td>
<td>1200</td>
</tr>
<tr>
<td>Panel to panel (using lacing wire or ring fasteners)</td>
<td>1400</td>
<td>1200</td>
</tr>
</tbody>
</table>

The strength values reported in lb/ft are referred to the unitary width of the specimen. The panel to panel test shall demonstrate the ability of the fastening system to achieve the required strength, and indicate the number of wire revolutions for the lacing wire used. The same number of wire revolutions shall be used in the field installation.

#### 2.1.3 Alternative Wire Fasteners for Gabions

Subject to approval of the Contracting Officer, alternative fastening systems may be used in lieu of lacing wire. Alternative fasteners to lacing wire recommended for woven wire gabions, according to ASTM A975, are steel ring fasteners for metallic coated gabions, or stainless steel rings for PVC coated gabions. For each shipment of wire gabions delivered to the site, furnish the Contracting Officer, in duplicate, test reports or records that have been performed during the last year on all material contained within the shipment meets the composition, physical, and manufacturing requirements stated in this Specification. Ring fasteners for woven wire gabions shall comply with the minimum requirements indicated in Paragraph "Ring Fasteners" below, and they shall develop a minimum panel to panel joint strength as indicated in TABLE 1. Alternative fasteners to lacing wire for welded wire gabions, according to ASTM A974, are spiral binders. Spiral binders for welded wire gabions shall comply with the minimum requirements indicated in Paragraph "Spiral Binders" below. Ring fasteners may alternatively be used for welded wire gabions, provided that they comply with the minimum specified requirements (salt spray and pull-apart resistance). Connections panel to panel for welded gabions with ring fasteners shall develop a minimum joint strength as indicated in TABLE 3. Provide a complete description of the fastener system and a description of a properly installed fastener, including drawings or photographs if necessary. Provide test results that demonstrate that the alternative-fastening system meets the requirements of the Specifications, according to the following criteria:

a. That the proposed fastener system can consistently produce a panel to panel joint strength as indicated in the TABLE 1 for double twisted wire mesh gabions and TABLE 3 for welded wire mesh gabions;

b. That the proposed fastener system does not cause damage to the protective coating on the wire;

c. That the Contractor has the proper equipment and trained employees to correctly install the fasteners;

d. That proper installation can be readily verified by visual inspection.

Samples of wire fasteners with their certified test records shall be submitted at least 60 days in advance to the Contracting Officer for approval. The Government reserves the right to test additional samples to
verify the submitted test records at the Government's expense. When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

2.1.3.1 Ring Fasteners

The tensile strength of the zinc-coated steel wire, zinc-5 percent aluminum coated mischmetal alloy-coated steel wire and aluminum-coated steel wire used for fasteners shall be in accordance with the requirements of ASTM A764, Type A, B, or C, Table 2 or Table 3. The tensile strength of stainless steel wire used for fasteners shall be in accordance with the requirements of ASTM A313, Type 302, Table 2. Any fastener system shall give the number of fasteners required to comply with TABLE 1, in accordance with ASTM A975 (Section 13.1.2) for woven wire gabions, and TABLE 3, in accordance with ASTM A974 (Section 7.3), for welded wire gabions and mattresses. Ring fasteners shall not be installed more than 4 inches apart. Each fastener type shall be closed and the free ends of the fastener shall overlap a minimum of 1 inch. The manufacturer or supplier shall state the number of fasteners required for all vertical and horizontal connections for single and multiple basket joining. Approved ring fasteners including fasteners made of stainless steel shall be subject to the salt spray test and pull-apart resistance test and shall be documented by actual testing of panel to panel connections within the last year by validated laboratories.

2.1.3.1.1 Salt Spray Test

A set of two identical rectangular gabion panels, each with a width about 10-1/2 mesh openings along a selvedge wire, shall be joined by properly installed wire fasteners along the two selvedge wires so that each fastener confines two selvedge and two mesh wires. If the fasteners are also to be used to joint two individual empty gabion baskets, two additional selvedge wires which are each mechanically wrapped with mesh wires shall be included so that each fastener confines four selvedge and four mesh wires. The set of the jointed panels shall be subject to salt spray test, ASTM B117, for a period of not less than 48 hours. At the end of the test, the fasteners, the selvedge, or mesh wires confined by the fasteners shall show no rusty spots on any part of the surface excluding the cut ends. A properly installed fastener shall meet the following requirements:

a. Each interlocking fastener shall be in a locked and closed position.

b. Each ring fastener shall be closed, and the free ends of the fastener shall overlap a minimum of 1 inch.

2.1.3.1.2 Pull-Apart Resistance Test

A new set of the jointed panels, which are prepared by the same method as specified in the salt spray test but without being subject to the 48-hour salt spray test, shall be mounted on a loading machine with grips or clamps such that the panels are uniformly secured along the full width. The grips or clamps shall be designed to transmit only tension forces. The load will then be applied at a uniform rate of 50 lbs/sec until failure occurs. The failure is defined as when the maximum load is reached and a drop of strength is observed with subsequent loading or the opening between any two closest selvedge wires, applicable to a fastener confining either two or four selvedge wires, becomes greater than 2 inches at any place along the panel width. The strength of the jointed panels at failure shall have a minimum as indicated in TABLE 1 or TABLE 3.
2.1.3.2 Spiral Binders

Spiral binders are defined as a length of metallic coated steel wire or metallic coated steel wire with PVC coating preformed into a spiral, used to assemble and interconnect empty gabion, and to close and secure stone-filled units. Spiral binders shall be fabricated with the same wire and coating style as the wire mesh. Test requirements for spiral binders shall refer to TABLE 3 regarding Metallic Coating, PVC for coating, Tensile Strength, and Panel to Panel Joint Strength.

2.1.4 Testing

Test records made within one year by certified laboratories and Government agencies will be used to determine the acceptability of the fastening system. Samples of wire fasteners and samples of material for fabricating the gabions with their certified test records shall be submitted at least 60 days in advance to the Contracting Officer for approval. The Government reserves the right to test additional samples to verify the submitted test records at the Government's expense. When the first test results indicate that the fasteners do not meet the specified requirements, the additional test will be at the Contractor's expense. The fasteners will be rejected after two tests failing to meet the requirements.

2.1.5 Stone Fill

Submit a certificate or affidavit signed by a legally authorized official of the supplier of the stone fill and the supplier of the natural filter material (see next main paragraph below) that it meets the quality required and gradation limits specified.

2.1.5.1 General

For gabions, the ability to function properly depends upon their stability, which is partly depending upon the rocks filling them. Rock sizes should be chosen to prevent them from falling through the mesh of the gabions. The rock has also to withstand natural weathering processes during the life of the Project that would cause it to breakdown to sizes smaller than the wire mesh opening dimensions. Rock to fill gabions shall be durable and of suitable quality to ensure permanence in the structure and climate in which it is to be used.

2.1.5.1.1 Delivery

Deliver rock to the work site in a manner to minimize its reduction in sizes (breakdown) during the handling of the rock, and place and secure within the assembled and interconnected gabion.

2.1.5.1.2 Sources

The sources from which the Contractor proposes to obtain the material shall be selected well in advance of the time when the material will be required in the work. The inclusion of more than 5 percent by weight of dirt, sand, clay, and rock fines will not be permitted. Rock may be of a natural deposit of the required sizes, or may be crushed rock produced by any suitable method and by the use of any device that yields the required size limits chosen in TABLE 4.
2.1.5.1.3 Properties

Rocks shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of the structure. All stone shall be obtained from approved sources.

2.1.5.1.4 Non-Listed Source

As an option, propose to furnish stone from one non-listed source. The Government may make such investigations and tests as necessary to determine whether acceptable stone can be produced from the proposed source. Suitable samples of stone fill material shall be collected in the presence of a Government representative and submitted to the Contracting Officer for approval prior to delivery of any such material to the work site. Unless otherwise specified, all test samples shall be obtained and delivered at the Contractor's expense to location provided by Contracting Officer at least 60 days in advance of the time when placing of the stone-filled gabions is expected to begin. Suitable tests and/or service records will be used to determine the acceptability of the stone. In the event suitable test reports and service records are not available, as in the case of newly operated sources, the material may be subjected to petrography analysis, specific gravity, absorption, wetting and drying, freezing and thawing, and such other tests as may be considered necessary to demonstrate to the satisfaction of the Contracting Officer that the materials are acceptable for use in the work. All tests will be made by or under the supervision of the Government and at its expense.

2.1.5.2 Stone Quality

Stone fill, crushed stone, shall meet the quality requirements of ASTM C33, and freezing and thawing requirements of ASTM D5312 for the region of the United States in which the structure will be constructed.

2.1.5.3 Gradation

Gradation of stone for gabions shall be performed every 1000 tons placed under this Contract in accordance with ASTM C136. Sizes of rock to fill gabions are chosen on the basis of the mesh sizes, the structure's thickness, and within the limits shown in TABLE 4. Within each range of sizes, the rock shall be large enough to prevent individual pieces from passing through the mesh openings. Each range of sizes may allow for a variation of 5 percent oversize rock by weight, or 5 percent undersize rock by weight, or both.

2.1.5.3.1 Oversize Rock

In all cases, the sizes of any oversize rock shall allow for the placement of three or more layers of rock within each gabion compartment and two or more layers of rock within each mattress compartment dependent upon the height of the mattress.

2.1.5.3.2 Undersize Rock

In all cases, undersize rock shall be placed within the interior of the gabion or mattress compartment and shall not be placed on the exposed surface of the structure. There shall be a maximum limit of 5 percent undersize or 5 percent oversize rock, or both, within each gabion compartment. The required rock gradation is reported in Table 4.
### TABLE 4
Required rock gradation for gabions [and mattresses]

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Thickness/Height (inch)</th>
<th>Rock Sizes (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabions</td>
<td>12</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Gabions</td>
<td>18 or higher</td>
<td>4 - 8</td>
</tr>
</tbody>
</table>

#### 2.1.6 Filter Material

The material shall meet the quality requirements of ASTM C33 for the region in which the structure is located. The gradation test shall be performed in accordance with ASTM C136. Filter material shall consist of sand and gravel or crushed stone, well graded and conforming to "Filter Design" Appendix D of EM 1110-2-1913.

#### PART 3 EXECUTION

##### 3.1 FOUNDATION PREPARATION

Foundation preparation shall not take place on frozen or snow-covered ground. After excavation or stripping, to the extent indicated on the Drawings or as directed by the Contracting Officer, all remaining loose or otherwise unsuitable materials shall be removed. All depressions shall be carefully backfilled to grade. If pervious materials are encountered in the foundation depressions, the areas shall be backfilled with free-draining materials. Otherwise, the depressions shall be backfilled with suitable materials from adjacent required excavation, or other approved source, and compacted to a density at least equal to that of the adjacent foundation. Any debris that will impede the proper installation and final appearance of the gabion layer shall also be removed, and the voids carefully backfilled and compacted as specified above. Immediately prior to placing the material, the Contracting Officer shall inspect the prepared foundation surface, and no material shall be placed thereon until that area has been approved.

##### 3.2 FILTER PLACEMENT

Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Contracting Officer, and to the slopes, lines, and grades as indicated on the Drawings or as directed. Placing of filter material by methods, which will tend to segregate particle sizes, will not be permitted. Any damage to the foundation surface during the filter placement shall be repaired before proceeding with the work. Compaction of the filter materials will not be required, but it shall be finished to present a reasonably even surface free from mounds or windrows.

##### 3.3 ASSEMBLY

#### 3.3.1 Double twisted wire mesh Gabions

The gabions shall be opened and unfolded one by one on a flat, hard surface. Gabion units over 6 foot in length usually have an extra shipping fold, which must be removed. The sides, ends and diaphragms shall be lifted up into a vertical position to form an open box shape. The back and the front panels of the gabion shall be connected to the end panels and center diaphragms. The top corner of the end panels and center diaphragms
have a selvedge wire extending approximately 4 inches out from the corner edge. The end panels and the diaphragms shall be raised to a vertical position and the selvedge wire shall be wrapped around the edge wire of the top and back panels.

3.3.2 Welded Wire Fabric Gabions

The gabions shall be opened and unfolded on a flat, hard surface. The units shall be rotated into position and the edges joined with fasteners for assembly. Where spiral fasteners are used, the ends shall be crimped to secure them in place. Where lacing wire is used, the wire shall be wrapped with alternating double and single loops with spacings not to exceed 6 inches. Ends shall be secured with two complete revolutions and finished with a one-half hitch. The same fastening procedures shall be used to secure interior diaphragms and end panels. When two gabions are placed side by side, the two end panels may be connected along the vertical edges with a single spiral fastener.

3.4 LACING OPERATIONS

3.4.1 Double Twisted Wire Mesh Gabions

Either lacing wire or ring fasteners are permitted to lace double twisted wire mesh gabions.

3.4.1.1 Lacing Wire

When using lacing wire, a piece of wire 1.2 to 1.5 times the length of the edge to be laced shall be cut off. If the edge of the basket is 3 foot long, no more than 4 to 5 feet of wire should be used at a time to lace. For vertical joints, starting at the bottom end of the panel, the lacing wire shall be twisted and wrapped two times around the bottom selvedge and double and single loops shall be alternated through at intervals not bigger than 4 to 6 inches. The operation shall be finished by looping around the top selvedge wire. The use of pliers to assemble the units with lacing wire is normally recommended.

3.4.1.2 Steel Wire Ring Fasteners

When steel wire ring fasteners are used, the rings shall be installed at the top and bottom connections of the end and center diaphragms. The ring spacing shall be based on the minimum pull apart strength as specified in TABLE 1. In any case, the maximum ring spacing along the edges shall not exceed 6 inches. The use of either a mechanical or a pneumatic fastening tool for steel wire ring fasteners is required. Ring fasteners shall be galvanized, stainless steel or Zn-5 percent aluminum-mischmetal alloy coated.

3.4.2 Welded Wire Mesh Gabions

Either lacing wire or spiral binders are permitted to lace welded wire mesh gabions. The empty units shall be placed on the foundation and interconnected with the adjacent unit along the top, bottom and vertical edges using spiral fasteners. Lacing wire may be used in lieu of spiral binders for the interconnection of gabions as specified above. The connection with lacing wire or spiral binders shall be based on the minimum panel to panel joint strength as specified in TABLE 3. Spiral binders shall be screwed along the connecting edges, and then each end crimped to secure the spiral in place. Each layer of gabions shall be interconnected
to the underlying layer along the front, back, and sides.

3.5 INSTALLATION AND FILLING

Empty gabion units shall be assembled individually and placed on the approved surface to the lines and grades as shown or as directed, with the sides, ends, and diaphragms erected in such a manner to ensure the correct position of all creases and that the tops of all sides are level. All gabion units shall be properly staggered horizontally and vertically as shown in the construction drawings. Finished gabion structures shall have no gaps along the perimeter of the contact surfaces between adjoining units. All adjoining empty gabion units shall be connected along the perimeter of their contact surfaces in order to obtain a monolithic structure. All lacing wire terminals shall be securely fastened. All joining shall be made through selvedge-to-selvedge or selvedge-to-edge wire connection; mesh-to-mesh or selvedge-to-mesh wire connection is prohibited except in the case where baskets are offset or stacked and selvedge-to-mesh or mesh-to-mesh wire connection would be necessary. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selvedge or edge wire.

a. The initial line of basket units shall be placed on the prepared foundation and adjoining empty baskets set to line and grade, and common sides with adjacent units thoroughly laced or fastened. They shall be placed in a manner to remove any kinks from the mesh and to a uniform alignment. The basket units then shall be partially filled to provide anchorage against deformation and displacement during the filling operation. The stone shall be placed in the units as specified in Paragraph "Stone Fill", Subparagraph "Gradation", Part B.

b. Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. Care shall be taken, when placing the stone by hand or machine, to assure that the PVC coating on gabions will not be damaged. All visible faces shall be filled with some hand placement to ensure a neat and compact appearance and that the void ratio is kept to a minimum.

c. Uniformly overfill gabions by about 1 to 2 inches to compensate for future rock settlements. Gabions can be filled by any kind of earth-filling equipment, such as a backhoe, gradall, crane, etc. The maximum height from which the stones may be dropped into the baskets shall be 3 to 4 feet. If PVC coated materials are used, no work shall take place unless the ambient temperature is above 20 degrees F.

3.5.1 Double Twisted Wire Mesh Gabions

After the foundation has been prepared, the pre-assembled gabions shall be placed in their proper location to form the structure. Gabions shall be connected together and aligned before filling the baskets with rock. All connections (panel-to-panel) and basket-to-basket shall be already carried out as described in Paragraph "Assembly". Stone fill shall have a gradation of 4 to 8 inches, as described in Paragraph "Gradation", and shall be placed in 1 foot lifts. Cells shall be filled to a depth not exceeding 1 foot at a time. The fill layer should never be more than 1 foot higher than any adjoining cell. Stiffeners or internal cross ties shall be installed in all front and side of the gabions at 1/3 and 2/3 of the height for 3 feet or higher gabions, as the cell is being filled. Stiffeners shall be installed in the center of the cells. In 1-1/2 foot high units, stiffeners or internal crossties are not required. Internal
cross ties, or alternatively the preformed stiffeners, shall be looped around three twisted wire mesh openings at each basket face and the wire terminals shall be securely twisted to prevent their loosening. The number of voids shall be minimized by using a well-graded stone in order to achieve a dense, compact stone fill. All corners shall be securely connected to the neighboring baskets of the same layer before filling the units. When more than one layer of gabions is required, in order for the individual units to become incorporated into one continuous structure, the next layer of gabions shall be connected to the layer underneath after this layer has been securely closed. Gabions shall be uniformly overfilled by about 1 to 2 inches to compensate for future rock settlements.

3.5.2 Welded Wire Fabric Gabions

After the foundation has been leveled, the assembled gabions shall be placed in their proper location to form the structure. Care shall be taken to ensure that the top of the diaphragms are aligned correctly. The diaphragms shall be securely connected by either spiral binders or lacing wire. Gabions shall be connected together and aligned before filling them with 4 to 8 inch diameter rocks. Rock filling material shall be as specified in paragraph Gradation and shall be placed in 1 foot lifts. The fill layer shall be carefully hand-packed and braced to prevent bulging. Stiffeners shall be provided every 12 inch levels for 3 foot or higher gabions. Stiffeners shall be formed from lacing wire and placed across the corners at 12 inches from the corner, providing a diagonal bracing. Preformed hooked stiffeners can be utilized. Care shall be taken to ensure the number of voids is minimized by using a well-graded stone and avoiding large rocks in order to achieve a dense, compact compartment. After each 1 foot lift has been placed, it shall be leveled for the next lift. Almost all gabion structures consist of more than one course of gabions; in order that the individual gabions may become incorporated into one continuous structure, they shall be wired to neighboring gabions and the course below, before filling. Gabions shall be uniformly overfilled by about 1 to 2 inches to compensate for future rock settlements.

3.5.3 Non-Rectangular Shapes

Gabion units can conform to bends up to a radius of curvature of 60 to 70 feet without alterations. Units shall be securely connected together first, and be placed to the required curvature, holding them in position by staking the units to the ground with hardwood pegs before filling. For other shapes, bevels and miters can be easily formed by cutting and folding the panels to the required angles.

3.6 CLOSING

Lids shall be tightly secured along all edges, ends, and diaphragms in the same manner as described for assembling. Adjacent lids may be securely attached simultaneously. The panel edges shall be pulled to be connected using the appropriate closing tools where necessary. Single point leverage tools, such as crowbars, may damage the wire mesh and shall not be used. All end wires shall then be turned in.

-- End of Section --
PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Separate Unit Prices

1.1.1.1 Additional Drilled Shaft Lengths

Additional drilled shaft lengths will be paid for at the contract unit price for "Additional Drilled Shaft Length" for each diameter of drilled shaft installed as approved.

1.1.1.2 Omitted Drilled Shaft Lengths

The contract price will be reduced by the amount bid for "Omitted Drilled Shaft Length" for each diameter of drilled shaft omitted as directed.

1.1.1.3 Casings Permanently Left in Place

Steel casings permanently left in place due to contract conditions:

a. Total pounds of steel beyond casings indicated will be paid for at the contract unit price per pound for "Additional Steel Casing."

b. Omitted Casing Steel: The contract price will be reduced by the amount bid for "Omitted Casing Steel" omitted as directed.

1.1.1.4 Reinforcing Steel for Additional Drilled Shaft

Reinforcing steel for additional drilled shaft lengths will be paid for at the contract unit price for "Additional Drilled Shaft Reinforcing Steel" installed as approved.

1.1.1.5 Reinforcing Steel for Drilled Shaft Omitted

The contract price will be reduced by the amount bid for "Omitted Drilled Shaft Reinforcing Steel" omitted as directed.

1.1.1.6 Removal of Rock

Removal of rock within the limit of drilled shafts will be paid for at the contract unit price for "Removal of Rock" per linear foot, for each diameter of drilled shaft installed. Rock excavation is defined as any hard dense material that cannot be removed with drilled shaft drilling equipment having the specified capacity and could only be removed by hand, air tools, blasting, or other specialized methods. Slurry construction techniques are not permitted for rock socketed drilled shafts.

1.1.1.7 Removal of Obstructions Other Than Rock

Removal of obstructions other than rock within the limits of the drilled shafts which cannot be removed using standard drilled shaft drilling
equipment with the specified capacity will be paid for at the contract unit price per linear foot for "Removal of Obstructions" for each diameter of drilled shaft installed.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)


ASTM INTERNATIONAL (ASTM)


ASTM A615 (2016) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Drilled Shafts; G
Survey of Drilled Shaft Locations; G

SD-07 Certificates
Drilled Shafts
Qualifications; G

SD-11 Closeout Submittals
Records

1.4 QUALITY ASSURANCE

1.4.1 Survey of Drilled Shaft Locations

Submit a certified survey meeting the requirements specified herein.
1.4.2 Specialty Subcontractor Qualifications

Submit Contractor Qualifications for foundation systems, proving its engagement in the successful installation of similar drilled shafts for at least 5 years.

1.4.3 Pre-installation Conference

At the Pre-installation conference provide, for approval, the following schedule of submittals: Preliminary detailed drawings in an approved form, for each drilled shaft, showing shaft and bell diameters, depths of test holes, top and bottom elevations, bearing strata description, casing description, water conditions, concrete strength, concrete volume, rock elevations, dates of excavation and concrete placement, and other pertinent information.

1.4.4 Contractor Supervision

Provide for the supervision of all phases of drilled pier construction. Supervision is the Contractor's responsibility as outlined in Quality Control provisions of the Specialty Subcontractor Requirements. Check each drilled pier excavation for its depth, water removal, cleanup, workmanship, and for all tolerance requirements before any concrete is placed.

1.4.5 Government Inspection

The Contracting Officer will inspect each drilled pier excavation. Do not place concrete until the excavation has been approved by the Contracting Officer. Furnish the Contracting Officer all necessary equipment required for proper inspection of drilled pier excavations.

1.5 DELIVERY, STORAGE, and HANDLING

Deliver casings and appurtenant equipment to the job site in an undamaged and ready to place condition. Deliver concrete in accordance with requirements of Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Subsurface Data

The subsurface investigation report and samples of materials, as taken from subsurface investigations, is available from the Contracting Officer.

1.6.2 Drilled Shaft Drilling Equipment

Provide drilled shaft drilling equipment having a minimum torque capacity and downward force capacity for the contract site conditions.

1.7 SEQUENCING

1.7.1 Drilled Shaft Excavation

Perform excavation of drilled shafts or groups of drilled shafts so that reinforcing steel and concrete placement is a continuous operation performed the same day that the excavation is completed. Do not leave excavations open overnight.
1.7.2 Acceptance

Place concrete within 3 hours after approval of the completed excavation.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Concrete Work

Perform all concrete work in accordance with requirements of Section 03 30 00.10 CAST-IN-PLACE CONCRETE, as modified herein:

2.1.1.1 Strength

Provide 5,000 psi strength concrete at 28 days, with slumps specified in Section 03 30 00, except as follows.

a. Slump requirements for concrete placed in drilled shafts shall be based on the construction method used, as follows:

(1) For dry uncased excavations: 4 to 6 inches.
(2) For temporarily cased excavations: 6 to 8 inches.
(3) For slurry excavations or placement of concrete under water: 7 to 9 inches.

2.1.1.2 Coarse Aggregate

Provide 1-inch maximum size coarse aggregate.

2.1.1.3 Reinforcing Steel

Provide reinforcing steel conforming to ASTM A615 Grade 60, inserted securely in the drilled shafts, in position and alignment, as shown, prior to concrete placement.

2.1.2 Casing Steel

ASTM A36. Provide zinc coating of casing steel conforming to ASTM A123. Provide casings with an outside diameters not less than indicated shaft sizes and a minimum of 1/4 inch thick.

2.1.3 Slurry

Slurry shall consist of a mixture of bentonite (sodium montmorillonite conforming to API Spec 13A) or anionic polymer and water to produce a slurry of sufficient density to maintain stability of the shaft walls and bottom and to facilitate removal of coarser grained soils from the excavation. Slurry techniques are not permitted for rock socketed drilled shafts.

2.2 DRILLED SHAFT DRILLING EQUIPMENT

Provide drilled shaft drilling equipment with minimum torque capacity and downward force capacity suitable for the site conditions.
PART 3 EXECUTION

3.1 PREPARATION

Excavate drilled shafts to established depths and dimensions shown; clean bottoms of drilled shafts free of loose or soft material; level drilled shafts; and dispose of excavated material in accordance with Section 312300 EXCAVATION AND FILL. Submit a certified copy of the survey. Establish lines, levels, and drilled shaft centerline locations, staked and maintained by a registered surveyor or engineer.

a. When drilling drilled shafts, protect the surrounding soil and the earth walls against cave-ins, displacement of the surrounding earth, and retention of ground water, by means of temporary steel casings. Provide casings with outside diameters not less than indicated shaft sizes, and a minimum of 1/4 inch thick. Do not remove if the structural integrity of the drilled shaft will be impaired, as determined by the Contracting Officer. Withdraw temporary steel casings as the concrete is being placed, maintaining sufficient head of concrete within the casing to prevent extraneous material from falling in from the sides and mixing with the concrete. Casings may be jerked upward a maximum of 4 inches to break the bottom seal, but remove thereafter with a smooth, continuous motion.

b. Thoroughly clean and oil the inside of steel casings before reuse.

c. Leave the temporary casing in place from the drilled shaft top to the ground surface until the concrete has set if the elevation of the top of the drilled shaft is below the adjacent ground surface.

d. Provide temporary casing with outside diameter the same as the nominal shaft diameter. Wall thickness of temporary casings shall be a minimum of 3/16 inches.

e. Continuously remove all water that flows into the excavations and from the excavation bottom, to the extent possible, prior to concrete placement. The maximum permissible depth of water is 2 inches. In the event of a severe water condition that makes it impossible or impractical to dewater the excavation, advance the excavation through use of slurry. When slurry is used, maintain a positive head in the excavation at all times. Circulate the slurry with sufficient consistency and velocity to remove the dislodged materials from the hole.

f. Each drilled shaft excavation will be inspected and approved by the Contracting Officer prior to placing concrete. Keep a record of all inspections, with related construction changes. Provide support personnel for inspection and testing procedures.

3.2 INSTALLATION

a. Continuously place concrete by methods that ensure against segregation and dislodging of excavation sidewalls, and completely fill the shaft. Place concrete by pumping or drop chutes in dry holes or pumping in wet holes. Keep the discharge a minimum of 3 feet below the fresh concrete surface during placement. Drilling of drilled shafts or driving of casings shall not be within 20 feet of concrete placed within the last 3 days. Concrete not placed within 90 minutes from batch time shall be rejected.
b. When slurry is used, use a rigid pipe or flexible hose. Use of a
tremie pipe, in lieu of pumping, shall not be permitted. Displace the
slurry mud or water as the concrete is placed. Keep the end of the
pipe or hose embedded in the concrete as the concrete is placed.
Should the end of the pipe or hose be accidentally pulled out of the
concrete during the placement, discontinue the concrete placing
immediately and withdraw the pipe or hose to the surface. Reseal the
pipe or hose at its bottom. Reinsert pipe in the shaft with the sealed
end extending into the concrete to the level before the pullout.
Concrete placement may then be resumed.

c. Bring concrete to a true level surface inside the shaft and a full
width cross key formed, or dowels installed, if it becomes necessary to
interrupt placing concrete in any drilled shaft. Prior to placing
additional concrete, clean surfaces of laitance and slush with
one-to-one Portland cement grout, having a water-cement ratio not
exceeding that of the concrete.

d. Vibrate concrete for upper 5 feet of drilled shaft.

3.3 TOLERANCES

a. Correct any drilled shaft out of center or plumb beyond the tolerance
specified as necessary to comply with the tolerances. Any corrective
cost is the responsibility of the Contractor.

b. Make cross sections of shafts not less than design dimensions.

c. Install drilled shafts with top location deviating a maximum of 3 inches
from centerline locations.

d. Install vertical drilled shafts plumb within a maximum of 1-1/2 inches
for the first 10 feet and within 1/2 inch for each 10 feet of
additional depth.

3.4 PROTECTION

Provide protection around top of the excavation to prevent debris from
being dislodged into the excavation and concrete.

3.5 RECORDS

Keep and submit complete, detailed and accurate records for each shaft
installation. Include locations, shaft diameters, top and bottom
elevations, depths of test holes, casing dimensions, concrete strength,
concrete volume, quantity of rock excavation, excavation condition, dates
of excavation and concrete placement, bearing strata description, and
subsurface water conditions. Base location on the survey of the registered
surveys or engineer provided by the Contractor. Tabulate all records,
including corrective measures. Upon completion of shaft work, provide a
record of centerline locations based on the survey of the registered
surveyor or engineer provided by the Contractor. In addition, also record
corrective measures. Deliver a complete tabulation of all records
pertaining to approved shafts to the Contracting Officer.

--- End of Section ---
COLD MILLING ASPHALT PAVING

PART 1   GENERAL

1.1   QUALITY ASSURANCE

1.1.1   Grade

Mill pavement such that the finished surface conforms to the lines, grades, and cross sections indicated. The maximum allowable deviation of the finished milled pavement surfaces from the established plan grade line and elevation will be 1/4 inch. The deviations from the plan grade line and elevation will not be permitted in areas of pavements where closer conformance with planned grade and elevation is required for the proper functioning of appurtenant structures involved.

1.1.2   Surface Smoothness

The maximum allowable deviation of the finished surfaces from the testing edge in the transverse or longitudinal direction will be 1/4 inch.

1.1.3   Traffic Control

Provide all necessary traffic controls during milling operations.

1.2   EQUIPMENT, TOOLS, AND MACHINES

Maintain in a satisfactory working condition equipment, tools, and machines used in the performance of the work.

1.2.1   Cold-Milling Machine

Provide a cold-milling machine which is self-propelled, capable of milling the pavement to a specified depth and smoothness and of establishing grade control; with means of controlling transverse slope and dust produced during the pavement milling operation. Machine will have capability of adding water in front of equipment to minimize dust during milling operation. The machine will have the ability to remove the millings or cuttings from the pavement and load them into a truck. The milling machine will not damage any part of the pavement structure that is not to be removed.

1.2.2   Cleaning Equipment

Provide cleaning equipment suitable for removing and cleaning loose material from the pavement surface.

1.2.3   Straightedge

Furnish and maintain at the site, in good condition, one 12 foot straightedge or other suitable device for each milling machine, for testing the finished surface. Make straightedge available for Government use. Use straightedges constructed of aluminum or other lightweight metal, with blades of box or box-girder cross section with flat bottom reinforced to
insure rigidity and accuracy. Use straightedges with handles to facilitate movement on the pavement.

1.3 ENVIRONMENTAL REQUIREMENTS

Do not perform milling when there is accumulation of snow or ice on the pavement surface.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 MILLING OPERATION

A minimum of seven days notice is required, prior to start work, for the Contracting Officer to coordinate the milling operation with other activities at the site. Make sufficient passes so that the designated area is milled to the grades and cross sections indicated. Mill the pavement in depth increments that will not damage the pavement below the designated finished grade. If scabbing occurs, the surface will not meet smoothness requirements. Take steps to modify the process as needed to prevent scabbing from occurring. Repair or replace, as directed, items damaged during milling such as manholes, valve boxes, utility lines, pavement that is torn, cracked, gouged, broken, or undercut. Remove the milled material from the pavement and load into trucks.

3.2 GRADE AND SURFACE-SMOOTHNESS TESTING

3.2.1 Grade-Conformance Tests

Test the finished milled surface of the pavement for conformance with the plan-grade requirements and for acceptance by the Contracting Officer by running lines of levels at intervals of 25 feet longitudinally and 25 feet transversely to determine the elevation of the completed pavement. Correct variations from the designated grade line and elevation in excess of the plan-grade requirements as directed. Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 1 inch of asphalt concrete to be placed.

3.2.2 Surface-Smoothness Tests

After completion of the final milling, the finished milled surface will be tested by the Government with a straightedge. Other approved devices may be used, provided that when satisfactorily and properly operated, such devices reveal all surface irregularities exceeding the tolerances specified. Correct surface irregularities that depart from the testing edge by more than 1/4 inch. Skin patching for correcting low areas will not be permitted. Remove and replace the deficient low area. Remove sufficient material to allow at least 1 inch of asphalt concrete to be placed.

3.3 REMOVAL OF MILLED MATERIAL

Material that is removed will become the property of the Contractor and removed from the site as designated by the Contracting Officer.
SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS

08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


U.S. ARMY CORPS OF ENGINEERS (USACE)


U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200 (Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:
1.3 QUALITY ASSURANCE

1.3.1 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 30 days prior to the use of the materials at the Job Site. Samples will be retained by the Government for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials. Submit samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 30 days prior to the beginning of Work. No material will be allowed to be used until it has been approved.

1.3.2 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire Project, prepare a test section at least 200 feet long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the Project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work and paid for at the Contract unit price per linear foot for sealing items scheduled. Prepare and seal all other joints in the manner approved for sealing the test section.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.5 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint
wall shall be a minimum of 50 degrees F and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

PART 2  PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Sealing Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refueler Parking Concrete Pavement</td>
<td>ASTM D7116</td>
</tr>
<tr>
<td>Roadway and Site Pavement</td>
<td>ASTM D5893 for Concrete Pavements; ASTM D6690 Type III for Asphalt to Concrete Joints, or COE CRD-C 525</td>
</tr>
<tr>
<td>Airfield Fuel Pits and Joints Between Existing PCC and New PCC Joints</td>
<td>ASTM D5893 or COE CRD-C 525</td>
</tr>
</tbody>
</table>

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C1016. Use backup material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinking, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch wider than the nominal width of the joint and shall not bond to the joint sealant.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this Section shall be approved before the work is started maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 30 days prior to use on the Project.
3.1.1 Joint Cleaning Equipment

3.1.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

3.1.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

3.1.1.3 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

3.1.1.4 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

3.1.2 Sealing Equipment

3.1.2.1 Hot-Poured Sealing Equipment

The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

3.1.2.2 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good
working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

3.2 SAFETY

Do not place joint sealant within 25 feet of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

3.3 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.3.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the tractor-mounted routing equipment or concrete saw as specified in Paragraph "Equipment". Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks. Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.3.2 Sawing

3.3.2.1 Refacing of Joints

Accomplish facing of joints using a concrete saw as specified in Paragraph "Equipment" to remove all residual old sealant and a minimum of concrete from the joint face to provide exposure of newly cleaned concrete, and, if required, to enlarge the joint opening to the width and depth shown on the drawings. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.3.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in Paragraph "Equipment". The saw blade shall be 6 inches or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

3.3.3 Waterblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 1/2 inch from the joint edges shall be waterblasted clean. Use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final
cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. At the Contractor's discretion, a number of joints will be tested to verify that the sidewalls of the joint are clean. If the joint sidewalls are not clean, the Contractor will be required to reclean the joints until the can provide a clean joint wall.

3.3.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.3.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

3.3.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.4 PREPARATION OF SEALANT

3.4.1 Hot-Poured Sealants

Do not heat sealants conforming to ASTM D6690 in excess of the safe heating temperature recommended by the manufacturer as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.4.2 Type M Sealants

Inspect the FS SS-S-200 Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed 90 degrees F by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.
3.4.3 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.4.4 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893 sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection.

3.5 INSTALLATION OF SEALANT

3.5.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

3.5.2 Sealing Joints

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/16 inch minimum and 1/4 inch maximum below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.6 INSPECTION

3.6.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.6.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.
3.6.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

3.7 CLEAN-UP

Upon completion of the Project, remove all unused materials from the Site and leave the pavement in a clean condition.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM D5851  (1995; R 2015) Planning and Implementing a Water Monitoring Program

U.S. GREEN BUILDING COUNCIL (USGBC)


1.2  DEFINITIONS

1.2.1  Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematicides, molluscicides, and rodenticides.

1.2.2  Stand of Turf

95 percent ground cover of the established species.

1.2.3  Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: Shrubs, vines, wildflowers, annuals, perennials, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3  RELATED REQUIREMENTS

Section 32 92 19 SEEDING applies to this Section for installation of seed requirements, with additions and modifications herein.

1.4  SUBMITTALS

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
Integrated Pest Management Plan; G

SD-03 Product Data
Local/Regional Materials; (LEED NC)
Submit documentation indicating distance between manufacturing facility and the Project Site. Indicate distance of raw material origin from the Project Site. Indicate relative dollar value of local/regional materials to total dollar value of products included in Project.
Fertilizer; G
Hose; (LEED NC)
Mulches Topdressing; (LEED NC)
Submit documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in Project.

Organic Mulch Materials
Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in Project.

SD-07 Certificates
Maintenance inspection report
Plant quantities; G

SD-10 Operation and Maintenance Data
Maintenance

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery
Deliver fertilizer, gypsum, iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum may be furnished in bulk with a certificate indicating the above information.
1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, Mulch Storage

Material shall be stored in designated areas. Lime and fertilizer shall be stored in cool, dry locations away from contaminants.

1.5.2.2 Antidessicants Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

1.6 SUSTAINABLE DESIGN REQUIREMENTS

1.6.1 Local/Regional Materials

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the Project Site, if available from a minimum of three sources. See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total local material requirements. Landscaping materials may be locally available.

1.7 MAINTENANCE

Submit Operation and Maintenance (O&M) Manuals for planting materials. Include instructions indicating procedures during one typical year including variations of maintenance for climatic conditions throughout the year. Provide instructions and procedures for watering; promotion of growth, including fertilizing, pruning, and mowing; and integrated pest management.

Develop a water monitoring program for surface and ground water on the Project Site in accordance with ASTM D5851 and consistent with the water management program utilized during construction operations.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing minimum percentages, by weight, or plant food nutrients as required by the soil analysis.

2.2 WATER

Source of water shall be approved by the Contracting Officer, and be of suitable quality for irrigation. Use collected storm water or graywater when available.

2.2.1 Hose

Hoses used for watering shall be provided by the Landscape Contractor for temporary irrigation and turf establishment. Landscape Contractor shall remove all hoses from site when maintenance is complete.
2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.3.1 Organic Mulch Materials

Biobased content shall be a minimum of 100 percent. Wood cellulose fiber shall be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch shall contain a minimum of 100 percent post-consumer recycled content. Wood-based hydraulic mulch shall contain a minimum of 100 percent recycled material.

2.3.2 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. It shall be cleaned of all sticks a minimum 1 inch in diameter and plastic materials a minimum 3 inch length. The material shall be treated to retard the growth of mold and fungi.

2.4 PESTICIDES

Pesticides and herbicides are not permitted. Use black sheet polyethylene conforming to ASTM D2103, minimum thickness 5/32 inch. Submit an Integrated Pest Management Plan, including weed and pest management strategies.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include mowing, edging, overseeding, aeration, fertilizing, watering, weeding, newly installed landscape areas, unless indicated otherwise, and at all areas inside or outside the limits of the construction that are disturbed by the Contractor's operations.

3.1.1 Policing

The Contractor shall police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Policing shall extend to both sides of fencing or walls. Collected debris shall be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

The Contractor shall remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels shall be clear of any encroachment by vegetation.
3.2 TEMPORARY IRRIGATION

The Landscape Contractor shall provide temporary irrigation for all newly planted turf areas during the maintenance period. Temporary irrigation may be provided by water trucks, temporary irrigation systems, and/or hoses and moveable sprinklers. All materials utilized for temporary irrigation shall be provided by Landscape Contractor and removed at the end of the maintenance period. The Landscape Contractor shall be responsible for maintaining temporary irrigation system components during the establishment period. Water for temporary irrigation shall be provided by the Landscape Contractor unless otherwise approved by the Contracting Officer.

3.2.1 Water Restrictions

The Contractor shall abide by state, local, or other water conservation regulations in force during the establishment period. Temporary use of an Automatic Controller shall be adjusted to comply with the water conservation regulations schedule.

3.2.2 Fire Hydrants

To use a fire hydrant for irrigation, the Contractor shall obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Contractor shall provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used shall be tested once per month by a certified backflow preventer tester.

3.2.3 Final Acceptance

Upon completion of the maintenance period, all equipment, piping, and hoses utilized for temporary irrigation shall be removed by the Landscape Contractor.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new turf furnished under this Contract has been satisfactorily installed to a 95 percent stand of coverage. The establishment period shall continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Groundcover shall be maintained in a manner that promotes proper health, growth, natural color. Turf shall have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, overseed, aerate, topdress and perform other operations necessary to promote growth, as approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.
3.3.3 Mowing

3.3.3.1 Turf

Turf shall be mowed at a uniform finished height. Mow turfed areas to a minimum average height of 2 inches when average height of grass becomes 3 inches. The height of turf is measured from the soil. Mowing of turf shall be performed in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on a turf area shall be picked up and disposed. Adjacent paved areas shall be swept/vacuumed clean.

3.3.4 Turf Edging and Trimming

Perimeter of planter bed edges, sidewalks, driveways, curbs, and other paved surfaces shall be edged. Uniformly edge these areas to prevent encroachment of vegetation onto paved surfaces and to provide a clear cut division line between planter beds, turf, and ground cover. Edging is to be accomplished in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Edging shall be performed on the same day that turf is mowed. Use of string line trimmers is permitted in "soft" areas such as an edge between turfgrass and a planter bed. Care shall be exercised to avoid damage to any plant materials, structures, and other landscape features.

Trimming around trees, fences, poles, walls, and other similar objects is to be accomplished to match the height and appearance of surrounding mowed turf growth. Trimming shall be performed on the same day the turf's mowed. Care shall be exercised to avoid "Girdling" trees located in turf areas. The use of protective tree collars on trees in turf areas may be utilized as a temporary means to avoid injury to tree trunks. At the end of the plant establishment period Contractor will be responsible for removing all protective tree collars.

3.3.5 Post-Fertilizer Application

Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type, and frequencies shall be determined by the laboratory soil analysis results the requirements of the particular turf species. Organic fertilizer shall be used. In the event that organic fertilizer is not producing the desired effect, the Contractor shall contract the Contracting Officer for approval prior to the use of a synthetic type of fertilizer. Fertilizer shall be applied by approved methods in accordance with the manufacturer's recommendations.

3.3.6 Turf Watering

The Contractor shall perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor shall be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. The Contractor shall abide by state, local, or other water conservation regulations or restrictions in force during the establishment period.
3.3.7 Turf Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas by approved device. Core, by pulling soil plugs, to a minimum depth of 3 inches. Leave all soil plugs that are produced in the turf area.

Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete.

3.3.8 Turf Clearance Area

Trees located in turf areas shall be maintained with a growth free clearance of 18 inches from the tree trunk base. The use of mechanical weed whips to accomplish the turf growth free bed area is prohibited.

3.3.9 Replanting

Replant in accordance with Section 32 92 19 SEEDING and within specified planting dates areas which do not have a satisfactory stand of turf. Replant areas which do not have a satisfactory stand of other groundcover and grasses.

3.3.10 Final Inspection and Acceptance

Final inspection will be make upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf. Final acceptance of grass areas will be based upon a stand of 95 percent groundcover of established species.

3.3.11 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.4 FIELD QUALITY CONTROL

3.4.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations shall be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Results of site observation visits shall be submitted to the Contracting Officer within 7 calendar days of each site observation visit.

3.4.2 Plant Quantities

The Contractor shall provide Contracting Officer with total exterior area of landscaping such as turf.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


AASHTO T 224  (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)


1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction. GCA is similar to ABC, but it has more stringent requirements and it produces a base course with higher strength and stability.

1.2.2 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve are expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL
PROCEDURES:

SD-03 Product Data
   Plant, Equipment, and Tools
   Waybills and Delivery Tickets
SD-06 Test Reports
   Sampling and Testing; G
   Field Density Tests; G

1.4 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor and performed by a testing laboratory approved in accordance with Section 01 45 00.00 10 01 45 00.00 2001 45 00.00 40 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements; perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.4.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.4.2 Tests

Perform the following tests in conformance with the applicable standards listed.

1.4.2.1 Sieve Analysis

Make sieve analysis in conformance with ASTM C117 and ASTM C136. Sieves shall conform to ASTM E11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D422.

1.4.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.4.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with AASHTO T 180, Method D and corrected with AASHTO T 224.

1.4.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556, ASTM D2167, or ASTM D6938. For the method presented in ASTM D6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil, and ASTM D6938 shall be used to determine the moisture content of the
soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed.

a. Submit certified copies of test results for approval not less than 30 days before material is required for the work.

b. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

c. Submit copies of field test results within 24 hours after the tests are performed.

1.4.2.5 Wear Test

Perform wear tests on GCA course material in conformance with ASTM C131.

1.4.2.6 Soundness

Perform soundness tests on GCA in accordance with ASTM C88.

1.4.3 Testing Frequency

1.4.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis including the No. 635 sieve.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Soundness.

1.4.3.2 In Place Tests

Perform each of the following tests on samples taken from the placed and compacted GCA. Samples shall be taken and tested at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.

b. Perform sieve analysis including the No. 635 sieve on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.
d. Measure the total thickness of the base course at intervals, in such a manner as to ensure one measurement for each 500 square yards of base course. Measurements shall be made in 3 inch diameter test holes penetrating the base course.

1.4.4 Approval of Material

Select the source of the material 30 days prior to the time the material will be required in the work. Tentative approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted course(s).

1.5 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, AND TOOLS

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

2.2 AGGREGATES

Provide GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, angular sand, or other approved material. GCA shall be free of silt and clay as defined by ASTM D2487, organic matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve is known as coarse aggregate; that portion passing the No. 4 sieve is known as fine aggregate.

2.2.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

a. Crushed Gravel: Crushed gravel manufactured by crushing gravels, and meets all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

2.2.1.1 Graded-Crushed Aggregate Base Course

GCA coarse aggregate shall not show more than 40 percent loss when
subjected to the Los Angeles abrasion test in accordance with ASTM C131. GCA coarse aggregate shall not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with ASTM C88. The amount of flat and elongated particles shall not exceed 20 percent for the fraction retained on the 1/2 inch sieve nor 20 percent for the fraction passing the 1/2 inch sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregate shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 1.

2.2.2 Fine Aggregate

Fine aggregates shall be angular particles of uniform density. When the fine aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements.

2.2.2.1 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Fine aggregate shall be produced by crushing only particles larger than No. 4 sieve in size. The fine aggregate shall contain at least 90 percent by weight of particles having two or more freshly fractured faces in the portion passing the No. 4 sieve and retained on the No. 10 sieve, and in the portion passing the No. 10 sieve and retained on the No. 40 sieve. Fine aggregate shall be manufactured from gravel particles 95 percent of which by weight are retained on the 1/2 inch sieve.

2.2.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. The aggregates shall be continuously well graded within the limits specified in TABLE 1. Sieves shall conform to ASTM E11.

<table>
<thead>
<tr>
<th>TABLE 1. GRADATION OF AGGREGATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage by Weight Passing Square-Mesh Sieve</td>
</tr>
<tr>
<td>Sieve Designation</td>
</tr>
<tr>
<td>2 inch</td>
</tr>
<tr>
<td>1-1/2 inch</td>
</tr>
<tr>
<td>1 inch</td>
</tr>
</tbody>
</table>
### TABLE 1. GRADATION OF AGGREGATES

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch</td>
<td>30-65</td>
</tr>
<tr>
<td>No. 4</td>
<td>20-50</td>
</tr>
<tr>
<td>No. 10</td>
<td>15-40</td>
</tr>
<tr>
<td>No. 40</td>
<td>5-25</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-8</td>
</tr>
</tbody>
</table>

**NOTE 1:** Particles having diameters less than No. 635 shall not be in excess of 3 percent by weight of the total sample tested.

**NOTE 2:** The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, they shall be tested in accordance with ASTM C127 and ASTM C128 to determine their specific gravities. If the specific gravities vary by more than 10 percent, the percentages passing the various sieves shall be corrected as directed by the Contracting Officer.

### 2.3 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the No. 40 sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

### PART 3 EXECUTION

#### 3.1 GENERAL REQUIREMENTS

When the GCA is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area. Provide line and grade stakes as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

#### 3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating are the responsibility of the Contractor. Operate the aggregate sources to produce the quantity and quality of materials meeting the specified requirements in the specified time limit. Aggregate sources on private lands shall be conditioned in agreement with local laws or authorities.

#### 3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile
all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.4 PREPARATION OF UNDERLYING COURSE

Prior to constructing the base course(s), the underlying course or subgrade shall be cleaned of all foreign substances. At the time of construction of the base course(s), the underlying course shall contain no frozen material. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 31 00 00 EARTHWORK. Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses containing sands or gravels, as defined in ASTM D2487, the surface shall be stabilized prior to placement of the base course(s). Stabilization shall be accomplished by mixing GCA into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the base course is placed.

3.5 INSTALLATION

3.5.1 Mixing the Materials

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification.

3.5.2 Placing

Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 6 inches or less in thickness is required, place the material in a single layer. When a compacted layer in excess of 6 inches is required, place the material in layers of equal thickness. No layer shall be thicker than 6 inches or thinner than 3 inches when compacted. The layers shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.5.3 Grade Control

The finished and completed base course shall conform to the lines, grades,
and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required base course thickness so that the finished base course and the subsequent surface course will meet the designated grades.

3.5.4 Edges of Base Course

The base course(s) shall be placed so that the completed section will be a minimum of 2 feet wider, on all sides, than the next layer that will be placed above it. Additionally, place approved fill material along the outer edges of the base course in sufficient quantities to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple layer course, allowing in each operation at least a 2 foot width of this material to be rolled and compacted simultaneously with rolling and compacting of each layer of base course. If this base course material is to be placed adjacent to another pavement section, then the layers for both of these sections shall be placed and compacted along this edge at the same time.

3.5.5 Compaction

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified in this Section. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Continue compaction until each layer has a degree of compaction that is at least 100 percent of laboratory maximum density through the full depth of the layer. Make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.6 Thickness

Construct the compacted thickness of the base course as indicated on the Drawings. No individual layer shall be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. The total compacted thickness of the base course(s) shall be within 1/2 inch of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 1/4 inch of the thickness indicated. The total thickness of the base course shall be measured at intervals in such a manner as to ensure one measurement for each 500 square yards of base course. Measurements shall be made in 3 inch diameter test holes penetrating the base course.
3.5.7 Finishing

The surface of the top layer of base course shall be finished after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, then the top layer should be scarified to a depth of at least 3 inches and new material shall be blended in and compacted to bring to grade. Adjustments to rolling and finishing procedures shall be made as directed to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, the unsatisfactory portion shall be scarified, reworked and recompacted or it shall be replaced as directed.

3.5.8 Smoothness

The surface of the top layer shall show no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 50 foot intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.6 TRAFFIC

Do not allow traffic on the completed base course for airfield pavements. Completed portions of the base course on non-airfield pavements may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.7 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter, shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.8 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that must be removed outside the limits of Government-controlled land. No additional payments will be made for materials that must be replaced.

-- End of Section --
PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 102 (2009; R 2013) Standard Method of Test for Spot Test of Asphal tic Materials

AASHTO T 40 (2002; R 2006) Sampling Bituminous Materials

ASTM INTERNATIONAL (ASTM)


ASTM D2995 (1999; R 2009) Determining Application Rate of Bituminous Distributors

ASTM D977 (2013; E 2014) Emulsified Asphalt

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.3 QUALITY ASSURANCE

Use Local/Regional Materials or products extracted, harvested, or
recovered, as well as manufactured, within a 500 mile radius from the project site, if available from a minimum of three sources. See Section 01 33 29 SUSTAINABILITY REPORTING for cumulative total local material requirements. Tack and prime coat materials may be locally available.

1.4 DELIVERY, STORAGE, AND HANDLING
Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 ENVIRONMENTAL REQUIREMENTS
Apply bituminous coat only when the surface to receive the bituminous coat is dry. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PLANT, EQUIPMENT, MACHINES AND TOOLS
Plant, equipment, machines and tools used in the work are subject to approval and must be maintained in a satisfactory working condition at all times. Calibrated equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment, must have been recalibrated by a calibration laboratory within 12 months prior to commencing work and every 12 months thereafter, by such laboratory from the date of recalibration, during the term of the Contract.

2.1.1 Bituminous Distributor
Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 650 psi of tire width to prevent rutting, shoving or otherwise damaging the base surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process.

2.1.2 Heating Equipment for Storage Tanks
The equipment for heating the bituminous material shall be steam, electric, or hot oil heaters. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot get into the material. Fix an armored thermometer to the tank with a temperature range from 40 to 400 degrees F so that the temperature of the bituminous material may be determined at all times.
2.1.3 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

2.2 PRIME COAT

2.2.1 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h or ASTM D2397, Type CSS-1 CSS-1h.

2.3 TACK COAT

2.3.1 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 SS1h or ASTM D2397, Type CSS-1 CSS-1h. The base asphalt used to manufacture the emulsion shall show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. The surface shall be dry and clean at the time of treatment.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than 0.05 gallon nor more than 0.15 gallon per square yard of pavement surface.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.18 gallon nor more than 0.35 gallon per square yard of pavement surface.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Asphalt application temperature shall provide an application viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:
3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the Bituminous Distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots missed by the distributor with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of bituminous material other than bituminous emulsions. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat shall conform to all requirements as described herein.

3.4.2 Prime Coat

Apply a prime coat at locations shown on the Drawings. The prime coat is required if it will be at least 7 days before the surfacing (Asphalt cement hot mix concrete) layer is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate shall be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface.
3.7.1 Sampling

The samples of bituminous material, unless otherwise specified, shall be in accordance with ASTM D140 or AASHTO T 40. Sources from which bituminous materials are to be obtained shall be selected and notification furnished the Contracting Officer within 15 days after the award of the Contract.
3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibration shall be made with the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before providing the complete bituminous coat, apply three lengths of at least 100 feet for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.05 gallons per square yard. Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.25 gallon per square yard. Other trial applications shall be made using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --
PART 1   GENERAL

1.1   FULL PAYMENT

1.1.1   Basis of Payment

The measured quantity of hot-mixed asphalt will be paid for and included in the Lump Sum Contract Price.

1.2   PERCENT PAYMENT

When a lot of material fails to meet the specification requirements for 100 percent pay as outlined in the following paragraphs, that lot shall be removed and replaced, or accepted at a reduced price which will be computed by multiplying the unit price by the lot's pay factor. The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, grade or smoothness (each discussed below). Pay factors based on different criteria (i.e., laboratory air voids and in-place density) of the same lot will not be multiplied together to get a lower lot pay factor. At the end of the project, an average of all lot pay factors will be calculated. If this average lot pay factor exceeds 95.0 percent and no individual lot has a pay factor less than 75.1 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2000 short tons, a weighted lot pay factor will be used to calculate the average lot pay factor.

1.2.1   Mat and Joint Densities

The average in-place mat and joint densities are expressed as a percentage of the average theoretical maximum density (TMD) for the lot. The average TMD for each lot will be determined as the average TMD of the two random samples per lot. The average in-place mat density and joint density for a lot are determined and compared with Table 1 to calculate a single pay factor per lot based on in-place density, as described below. First, a pay factor for both mat density and joint density are determined from Table 1. The area associated with the joint is then determined and will be considered to be 10 feet wide times the length of completed longitudinal construction joint in the lot. This area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of hot-mix asphalt pavement, either an adjacent freshly paved lane or one paved at any time previously. The area associated with the joint is then determined as a percentage of the total lot area. A weighted pay factor for the joint is determined based on this percentage (see example below). The pay factor for mat density and the weighted pay factor for joint density is compared and the lowest selected. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD will be used as the TMD needed to calculate the percent...
joint density. Rejected lots shall be removed and replaced. Rejected areas adjacent to longitudinal joints shall be removed 4 inches into the cold (existing) lane. All density results for a lot will be completed and reported within 24 hours after the construction of that lot.

<table>
<thead>
<tr>
<th>Average Mat Density (4 cores)</th>
<th>Pay Factor, percent</th>
<th>Average Joint Density (4 cores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.0 - 96.0</td>
<td>100.0</td>
<td>Above 92.5</td>
</tr>
<tr>
<td>93.9</td>
<td>100.0</td>
<td>92.4</td>
</tr>
<tr>
<td>93.8 or 96.1</td>
<td>99.9</td>
<td>92.3</td>
</tr>
<tr>
<td>93.7</td>
<td>99.8</td>
<td>92.2</td>
</tr>
<tr>
<td>93.6 or 96.2</td>
<td>99.6</td>
<td>92.1</td>
</tr>
<tr>
<td>93.5</td>
<td>99.4</td>
<td>92.0</td>
</tr>
<tr>
<td>93.4 or 96.3</td>
<td>99.1</td>
<td>91.9</td>
</tr>
<tr>
<td>93.3</td>
<td>98.7</td>
<td>91.8</td>
</tr>
<tr>
<td>93.2 or 96.4</td>
<td>98.3</td>
<td>91.7</td>
</tr>
<tr>
<td>93.1</td>
<td>97.8</td>
<td>91.6</td>
</tr>
<tr>
<td>93.0 or 96.5</td>
<td>97.3</td>
<td>91.5</td>
</tr>
<tr>
<td>92.9</td>
<td>96.3</td>
<td>91.4</td>
</tr>
<tr>
<td>92.8 or 96.6</td>
<td>94.1</td>
<td>91.3</td>
</tr>
<tr>
<td>92.7</td>
<td>92.2</td>
<td>91.2</td>
</tr>
<tr>
<td>92.6 or 96.7</td>
<td>90.3</td>
<td>91.1</td>
</tr>
<tr>
<td>92.5</td>
<td>87.9</td>
<td>91.0</td>
</tr>
<tr>
<td>92.4 or 96.8</td>
<td>85.7</td>
<td>90.9</td>
</tr>
<tr>
<td>92.3</td>
<td>83.3</td>
<td>90.8</td>
</tr>
<tr>
<td>92.2 or 96.9</td>
<td>80.6</td>
<td>90.7</td>
</tr>
<tr>
<td>92.1</td>
<td>78.0</td>
<td>90.6</td>
</tr>
<tr>
<td>92.0 or 97.0</td>
<td>75.0</td>
<td>90.5</td>
</tr>
</tbody>
</table>
Table 1. Pay Factor Based on In-place Density

<table>
<thead>
<tr>
<th>Average Mat Density (4 cores)</th>
<th>Pay Factor, percent</th>
<th>Average Joint Density (4 cores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>below 92.0, above 97.0</td>
<td>0.0 (reject)</td>
<td>below 90.5</td>
</tr>
</tbody>
</table>

1.2.2 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 93.2 percent (of lab TMD). (2) Average joint density = 91.5 percent (of lab TMD). (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2,000 feet.

a. Step 1: Determine pay factor based on mat density and on joint density, using Table 1:
   
   Mat density of 93.2 percent = 98.3 pay factor.
   
   Joint density of 91.5 percent = 97.3 pay factor.

b. Step 2: Determine ratio of joint area (length of longitudinal joint x 10 feet) to mat area (total paved area in the lot): Multiply the length of completed longitudinal construction joint by the specified 10 feet width and divide by the mat area (total paved area in the lot).
   
   (2,000 feet x 10 feet)/30000 square feet = 0.6667 ratio of joint area to mat area (ratio).

c. Step 3: Weighted pay factor (wpf) for joint is determined as indicated below:
   
   \[ wpf = \text{joint pay factor} + (100 - \text{joint pay factor}) (1 - \text{ratio}) \]
   
   \[ wpf = 97.3 + (100-97.3) (1-0.6667) = 98.2 \text{ percent}. \]

d. Step 4: Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

   Pay factor for mat density: 98.3 percent. Weighted pay factor for joint density: 98.2 percent.

   Select the smaller of the two values as pay factor based on density: 98.2 percent.

1.2.3 Payment Adjustment for Smoothness (Final Wearing Surface Only)

Profilograph Testing. Record the location and data from all profilograph measurements. When the Profile Index of a lot exceeds the tolerance specified in paragraph SMOOTHNESS REQUIREMENTS by 1.0 inch per mile, but less than 2.0 inches per mile, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches per mile, but less than 3.0 inches per mile, the computed pay factor will be 90 percent. When the Profile Index exceeds the tolerance by
3.0 inches per mile, but less than 4.0 inches per mile, the computed pay factor will be 75 percent. Remove and replace the lot when the Profile Index exceeds the tolerance by 4.0 inches per mile or more, at no additional cost to the Government/Owner. Regardless of the above, correct any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches per mile or more, by grinding to meet the specification requirements above or remove and replace at no additional cost to the Government/Owner.

1.2.4 Laboratory Air Voids and Theoretical Maximum Density

Laboratory air voids will be calculated in accordance with ASTM D3203 by determining the density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method in ASTM D2726 and determining the theoretical maximum density (TMD) of two of the sublots using ASTM D2041. Laboratory air void calculations for each lot will use the average theoretical maximum density values obtained for the lot. The mean absolute deviation of the four laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated and a pay factor determined from Table 2. All laboratory air void tests will be completed and reported within 24 hours after completion of construction of each lot. The TMD is also used for computation of compaction, as required in paragraph MAT AND JOINT DENSITIES above.

1.2.5 Mean Absolute Deviation

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 random samples of a lot (where 3 specimens were compacted from each sample). The average laboratory air voids for each subplot sample are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

\[
\text{Mean Absolute Deviation} = \frac{(|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|)}{4} = \frac{(0.5 + 1.0 + 0.0 + 0.3)}{4} = \frac{1.8}{4} = 0.45
\]

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 2 that the lot's pay factor based on laboratory air voids, is 100 percent.

<table>
<thead>
<tr>
<th>Mean Absolute Deviation of Lab Air Voids from JMF</th>
<th>Pay Factor, Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60 or less</td>
<td>100</td>
</tr>
<tr>
<td>0.61 - 0.80</td>
<td>98</td>
</tr>
<tr>
<td>0.81 - 1.00</td>
<td>95</td>
</tr>
<tr>
<td>1.01 - 1.20</td>
<td>90</td>
</tr>
</tbody>
</table>
### Table 2. Pay Factor Based on Laboratory Air Voids

<table>
<thead>
<tr>
<th>Mean Absolute Deviation of Lab Air Voids from JMF</th>
<th>Pay Factor, Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 1.20</td>
<td>reject (0)</td>
</tr>
</tbody>
</table>

#### 1.2.6 Pay Adjustment Based on Grade

Within 5 working days after completion of a particular lot incorporating the final wearing course, test the final wearing surface of the pavement for conformance with specified plan grade requirements. Perform all testing in the presence of the Contracting Officer/Engineer. Provide a final wearing surface of pavement conforming to the elevations and cross sections shown and not vary more than 0.03 foot for runways or 0.05 foot for taxiways and aprons from the plan grade established and approved at site of work. Match finished surfaces at juncture with other pavements with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Maintain detailed notes of the results of the testing and provide a copy to the Government/Engineer immediately after each day's testing. When more than 5 percent of all measurements made within a lot are outside the 0.03 or 0.05 foot tolerance, the pay factor based on grade for that lot will be 95 percent. In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth; and replace the lift with hot-mix asphalt to meet specification requirements, at no additional cost to the Contracting Officer/Engineer. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

#### 1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

**AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)**

- **AASHTO T 304** (2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate
- **AASHTO T 308** (2016) Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

Asphalt Institute (AI)

AI MS-2 (2015) Asphalt Mix Design Methods

ASTM International (ASTM)


ASTM D1461 (2011) Moisture or Volatile Distillates in Bituminous Paving Mixtures

ASTM D2041 (2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

ASTM D2172 (2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D2726</td>
<td>(2014) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures</td>
</tr>
<tr>
<td>ASTM D3203</td>
<td>(2011) Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D4125</td>
<td>(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method</td>
</tr>
<tr>
<td>ASTM D4791</td>
<td>(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM D4867</td>
<td>(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D979</td>
<td>(2015) Sampling Bituminous Paving Mixtures</td>
</tr>
</tbody>
</table>
1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Placement Plan; G

SD-03 Product Data
Diamond Grinding Plan; G
Mix Design; G
Contractor Quality Control; G

SD-04 Samples
Aggregates
Asphalt Cement Binder

SD-06 Test Reports
Aggregates; G
QC Monitoring

SD-07 Certificates
Asphalt Cement Binder; G
Testing Laboratory

1.5 QUALITY ASSURANCE

The Government Engineer's quality assurance (QA) program for this Project is separate and distinct from the Contractor's quality control (QC) program specified in Part 3. Testing for acceptability of work will be performed by the Government Engineer or by an independent laboratory hired by the Contracting Officer Engineer, except for grade and smoothness testing which shall be performed by the Contractor. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 2000 short tons. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness determinations will be made on the lot as a whole. Exceptions or
adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

1.5.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Government/Engineer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D3203. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

1.5.2 Additional Sampling and Testing

The Contracting Officer Engineer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government Owner. Testing in these areas will be treated as a separate lot. Payment will be made for the quantity of HMA represented by these tests in accordance with the provisions of this Section.

1.5.3 In-place Density

For determining in-place density, obtain one random core (4 inches or 6 inches in diameter) at locations identified by the Government Engineer from the mat (interior of the lane and at least 12 inches from longitudinal joint or pavement edge) of each sublot, and one random core taken from the joint (immediately over joint) of each sublot, in accordance with ASTM D979. Fill all core holes with hot-mix and compact using a standard Marshall hammer to a mat density as specified. Tack coat dry core holes before filling. Each random core will be full thickness of the layer being placed. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, another random core will be taken. After air drying to meet the requirements for laboratory-prepared, thoroughly dry specimens, cores obtained from the mat and from the joints will be used for in-place density determination in accordance with ASTM D2726.

1.5.4 Surface Smoothness

Use a straightedge and profilograph for measuring surface smoothness of runway pavements. Use a straightedge for measuring surface smoothness of all other pavement surfaces. Perform all testing in the presence of the Government Engineer. Maintain detailed notes of the testing results and provide a copy to the Government Engineer immediately after each day's testing. Where drawings show required deviations from a plane surface (for instance crowns, drainage inlets), finish the surface to meet the approval of the Government Engineer.
1.5.4.1 Smoothness Requirements

1.5.4.1.1 Straightedge Testing

Provide finished surfaces of the pavements with no abrupt change of 1/8 inch or more, and all pavements within the tolerances specified in Table 3 when checked with an approved 12 foot straightedge.

<table>
<thead>
<tr>
<th>Pavement Category</th>
<th>Direction of Testing</th>
<th>Tolerance, inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulders (outside edge stripe)</td>
<td>Longitudinal</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>1/4</td>
</tr>
<tr>
<td>All other airfields and helicopter paved areas</td>
<td>Longitudinal</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>1/4</td>
</tr>
</tbody>
</table>

1.5.4.1.2 Profilograph Testing

Provide finished surfaces of runways with a Profile Index not greater than 7 inches per mile when tested with an approved California-type profilograph.

1.5.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in a manner to reveal surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. The maximum area allowed to be corrected by diamond grinding is 10 percent of the total area of the lot. Test the entire area of the pavement with a profilograph. Check a number of random locations along with any observed suspicious locations primarily at transverse and longitudinal joints with the straightedge.

1.5.4.2.1 Straightedge Testing

Hold the straightedge in contact with the pavement surface and measure the maximum distance between the straightedge and the pavement surface. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Use the straightedge to measure abrupt changes in surface grade.

1.6 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The
temperature requirements may be waived by the Government Engineer, if requested; provided all other requirements, including compaction, are met.

<table>
<thead>
<tr>
<th>Mat Thickness, inches</th>
<th>Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 or greater</td>
<td>40</td>
</tr>
<tr>
<td>Less than 3</td>
<td>45</td>
</tr>
</tbody>
</table>

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. Provide hot-mix asphalt (HMA) designed and constructed in accordance with this section conforming to the lines, grades, thicknesses, and typical cross sections shown on the drawings. Construct each course to the depth, section, or elevation required by the drawings and rolled, finished, and approved before the placement of the next course. Submit proposed Placement Plan, indicating lane widths, longitudinal joints, and transverse joints for each course or lift.

2.1.1 Asphalt Mixing Plant

Provide plants used for the preparation of hot-mix asphalt conforming to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved scales, or on certified public scales at no additional expense to the Government. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Inspection of Plant

Provide access to the Contracting Officer Engineer at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government Engineer to procure any desired samples.

2.1.1.3 Storage Bins

The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. Provide the mix drawn from bins that meets the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment
Provide trucks used for hauling hot-mix asphalt that have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, lightly coat the truck beds with a minimum amount of paraffin oil, lime solution, or other approved material. Do not use petroleum based products as a release agent. Provide each truck with a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture is delivered to the site at the specified temperature, provide insulated or heated truck beds with covers (tarps) that are securely fastened.

2.1.3 Material Transfer Vehicle (MTV)

Provide Material transfer Vehicles for placement of the hot mix asphalt. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that delivers material to the paver from outside the paving lane and without making contact with the paver. Provide MTV capable to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. Provide Material Transfer Vehicle with remixing and storage capability to prevent physical and thermal segregation. The use of a Material Transfer Vehicle is optional for shoulder construction.

2.1.4 Asphalt Pavers

Provide mechanical spreading and finishing equipment consisting of a self-powered paver, capable of spreading and finishing the mixture to the specified line, grade, and cross section. Provide paver screed capable of laying a uniform mixture to meet the specified thickness, smoothness, and grade without physical or temperature segregation, the full width of the material being placed. Provide a screed equipped with a compaction device to be used during all placement.

2.1.4.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and a distribution system to place the mixture uniformly in front of the screed without segregation. Provide a screed that effectively produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4.2 Automatic Grade Controls

If an automatic grade control device is used, provide a paver equipped with a control system capable of automatically maintaining the specified screed elevation that is automatically actuated from either a reference line or through a system of mechanical sensors or sensor-directed mechanisms or devices which maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. Provide transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. Do not use the transverse slope controller to control grade. Provide controls capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet in length.

b. Taut stringline set to grade.
c. Short ski or shoe for joint matching.

d. Laser control.

2.1.5 Rollers

Provide rollers in good condition and operated at slow speeds to avoid displacement of the asphalt mixture. Provide sufficient number, type, and weight of rollers to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.1.6 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 ft wide. Diamond grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints is not be permitted. The maximum area corrected by diamond grinding the surface of the hardened concrete is 10 percent of the total area of any subplot. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. All areas in which diamond grinding has been performed will be subject to the thickness tolerances specified in paragraph THICKNESS, above.

Prior to production diamond grinding operations, perform a test section at the approved location, consisting of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish, transition between adjacent passes, and the results of crossing a transverse joint. Production diamond grinding operations cannot be performed prior to approval.

2.2 AGGREGATES

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75 and be representative of the materials to be used for the Project. Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The portion of material retained on the No. 4 sieve is coarse
aggregate. The portion of material passing the No. 4 sieve and retained on
the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve
is defined as mineral filler. Submit sufficient materials to produce 200
pounds of blended mixture for mix design verification. Submit all aggregate
test results and samples to the Government Engineer at least 14 days prior
to start of construction. Perform job aggregate testing no earlier than 6
months before Contract Award.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free
from films of material that would prevent thorough coating and bonding with
the asphalt material and free from organic matter and other deleterious
substances. Provide coarse aggregate particles meeting the following
requirements:

a. The percentage of loss not be greater than 40 percent after 500
   revolutions when tested in accordance with ASTM C131.

b. The sodium sulfate soundness loss not exceeding 12 percent, or the
   magnesium sulfate soundness loss not exceeding 18 percent after five
   cycles when tested in accordance with ASTM C88.

c. At least 75 percent by weight of coarse aggregate contain at least two
   or more fractured faces when tested in accordance with COE CRD-C 171
   with fractured faces produced by crushing.

d. The particle shape essentially cubical and the aggregate containing not
   more than 20 percent, by weight, of flat particles and elongated
   particles (3:1 ratio of maximum to minimum) when tested in accordance
   with ASTM D4791.

e. Slag consisting of air-cooled, blast furnace slag, with a compacted
   weight of not less than 75 pounds per cubic foot when tested in
   accordance with ASTM C29.

f. Clay lumps and friable particles not exceeding 0.3 percent, by weight,
   when tested in accordance with ASTM C142.

2.2.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, tough, durable particles.
Provide aggregate particles that are free from coatings of clay, silt, or
any objectionable material, contain no clay balls, and meet the following
requirements:

a. Quantity of natural sand (noncrushed material) added to the aggregate
   blend not exceeding 15 percent by weight of total aggregate.

b. Individual fine aggregate sources with a sand equivalent value greater
   than 45 when tested in accordance with ASTM D2419.

c. Fine aggregate portion of the blended aggregate with an uncompacted
   void content greater than 45.0 percent when tested in accordance with
   AASHTO T 304 Method A.
d. Clay lumps and friable particles not exceeding 0.3 percent, by weight, when tested in accordance with ASTM C142.

2.2.3 Mineral Filler

Provide mineral filler consisting of a nonplastic material meeting the requirements of ASTM D242.

2.2.4 Aggregate Gradation

Provide a combined aggregate gradation that conforms to gradations specified in Table 5, when tested in accordance with ASTM C136 and ASTM C117, and does not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grades uniformly from coarse to fine. Provide a JMF within the specification limits; however, the gradation can exceed the limits when the allowable deviation from the JMF shown in Tables 8 and 9 are applied.

<table>
<thead>
<tr>
<th>Table 5. Aggregate Gradations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation 3</td>
</tr>
<tr>
<td>Sieve Size, inch</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>3/4</td>
</tr>
<tr>
<td>1/2</td>
</tr>
<tr>
<td>3/8</td>
</tr>
<tr>
<td>No. 4</td>
</tr>
<tr>
<td>No. 8</td>
</tr>
<tr>
<td>No. 16</td>
</tr>
<tr>
<td>No. 30</td>
</tr>
<tr>
<td>No. 50</td>
</tr>
<tr>
<td>No. 100</td>
</tr>
<tr>
<td>No. 200</td>
</tr>
</tbody>
</table>

2.3 ASPHALT CEMENT BINDER

Provide asphalt cement binder that conforms to AASHTO M 320 Performance Grade (PG) 64-22. Provide test data indicating grade certification by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Government Engineer. The supplier is defined as the last source of any modification to the binder. The
Government Engineer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with ASTM D140 and in the presence of the Government Engineer. Provide these samples to the Government Engineer for the verification testing, which will be performed at the Governments expense. Submit 5 gallon sample of the asphalt cement specified for mix design verification and approval not less than 14 days before start of the test section.

2.4 MIX DESIGN

a. Develop the mix design. Perform Job Mix formula (JMF) and aggregates testing no earlier than 6 months before Contract Award. Provide asphalt mix composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. Provide aggregate fractions sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of Table 5. Do not produce hot-mix asphalt for payment until a JMF has been approved. Design the hot-mix asphalt using hand-held hammer procedures contained in AI MS-2 and the criteria shown in Table 6 or design the hot-mix asphalt using the Superpave gyratory compactor set at 50 gyrations. Prepare samples at various asphalt contents and compacted in accordance with ASTM D6925. Use laboratory compaction temperatures for Polymer Modified Asphalts as recommended by the asphalt cement manufacturer. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867 is less than 75, reject the aggregates or the asphalt mixture treated with an anti-stripping agent. Add a sufficient amount of anti-stripping agent to produce a TSR of not less than 75. If an antistrip agent is required, provided it at no additional cost to the Government. Provide sufficient materials to produce 200 pound of blended mixture to the Government Engineer for verification of mix design at least 14 days prior to construction of test section.

b. At the option of the Contractor, a currently used North Carolina DOT SuperPave mix may be used for shoulders in lieu of developing a Marshall hot mix design as described herein. The DOT standard mix shall meet all requirements of this Specification and a complete JMF must be submitted for review and approval prior to any paving work on the Project.

2.4.1 JMF Requirements

Submit the proposed JMF in writing, for approval, at least 14 days prior to the start of the test section, including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hammer per side of molded specimen or number of Superpave gyratory compactor gyrations.
f. Laboratory mixing temperature.

g. Lab compaction temperature.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

j. Graphical plots and summary tabulation of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2. Include summary tabulation that includes individual specimen data for each specimen tested.

k. Specific gravity and absorption of each aggregate.

l. Percent natural sand.

m. Percent particles with two or more fractured faces (in coarse aggregate).

n. Fine aggregate angularity.

o. Percent flat or elongated particles (in coarse aggregate).

p. Tensile Strength Ratio and wet/dry specimen test results.

q. Antistrip agent (if required).

r. List of all modifiers.

s. Percentage and properties (asphalt content, binder properties, and aggregate properties) of RAP in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

<table>
<thead>
<tr>
<th>Table 6. Marshall Design Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Property</td>
</tr>
<tr>
<td>Stability, pounds minimum</td>
</tr>
<tr>
<td>Flow, 0.01 inch</td>
</tr>
<tr>
<td>Air voids, percent</td>
</tr>
<tr>
<td>Percent Voids in mineral aggregate (minimum)</td>
</tr>
<tr>
<td>Dust Proportion(3)</td>
</tr>
<tr>
<td>TSR, minimum percent</td>
</tr>
<tr>
<td>TSR Conditioned Strength (minimum psi)</td>
</tr>
</tbody>
</table>
Table 6. Marshall Design Criteria

<table>
<thead>
<tr>
<th>Test Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Blow Mix</td>
<td></td>
</tr>
</tbody>
</table>

(1) This is a minimum requirement. Provide significantly higher average during construction to ensure compliance with the specifications.

(2) The flow requirement is not applicable for Polymer Modified Asphalts.

(3) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the mixture.

(4) Select the JMF asphalt content corresponding to an air void content of 4 percent. Verify the other properties of Table 6 meet the specification requirements at this asphalt content.

Table 6. Superpave Gyratory Compaction Criteria

<table>
<thead>
<tr>
<th>Test Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air voids, percent</td>
<td>4(1)</td>
</tr>
<tr>
<td>Percent Voids in mineral aggregate (minimum)</td>
<td>See Table 7</td>
</tr>
<tr>
<td>Dust Proportion(2)</td>
<td>0.8-1.2</td>
</tr>
<tr>
<td>TSR, minimum percent</td>
<td>75</td>
</tr>
</tbody>
</table>

(1) Select the JMF asphalt content corresponding to an air void content of 4 percent. Verify the other properties of Table 6 meet the specification requirements at this asphalt content.

(2) Dust Proportion is calculated as the aggregate content, expressed as a percent of mass, passing the No. 200 sieve, divided by the effective asphalt content, in percent of total mass of the mixture.

Table 7. Minimum Percent Voids in Mineral Aggregate (VMA)(1)

<table>
<thead>
<tr>
<th>Aggregate (See Table 5)</th>
<th>Minimum VMA, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation 3</td>
<td>15</td>
</tr>
</tbody>
</table>

(1) Calculate VMA in accordance with AI MS-2, based on ASTM D2726 bulk specific gravity for the aggregate.

2.4.2 Adjustments to JMF

The JMF for each mixture is in effect until a new formula is approved in writing by the Government Engineer. Should a change in sources of any materials be made, perform a new mix design and a new JMF approved before
the new material is used. Make minor adjustments within the specification limits to the JMF to optimize mix volumetric properties. Adjustments to the original JMF are limited to plus or minus 4 percent on the No. 4 and coarser sieves; plus or minus 3 percent on the No. 8 to No. 50 sieves; and plus or minus 1 percent on the No. 100 sieve. Adjustments to the JMF are limited to plus or minus 1.0 percent on the No. 200 sieve. Asphalt content adjustments are limited to plus or minus 0.40 from the original JMF. If adjustments are needed that exceed these limits, develop a new mix design.

PART 3 EXECUTION

3.1 CONTRACTOR QUALITY CONTROL

3.1.1 General Quality Control Requirements

Submit the Quality Control Plan. Do not produce hot-mix asphalt for payment until the quality control plan has been approved. In the quality control plan, address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design and unique JMF identification code.
b. Aggregate Grading.
c. Quality of Materials.
d. Stockpile Management and procedures to prevent contamination.
e. Proportioning.
f. Mixing and Transportation.
g. Correlation of mechanical hammer to hand hammer. Determine the number of blows of the mechanical hammer required to provide the same density of the JMF as provided by the hand hammer. Use the average of three specimens per trial blow application.
h. Mixture Volumetrics.
i. Moisture Content of Mixtures.
j. Placing and Finishing.
k. Joints.
l. Compaction, including HMA-Portland Cement Concrete joints.
m. Surface Smoothness.
n. Truck bed release agent.

3.1.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site that is equipped with heating and air conditioning units to maintain a temperature of 75 plus or minus 5 degrees F. Provide laboratory facilities that are kept clean and all equipment maintained in proper working
condition. Provide the Government Engineer with unrestricted access to inspect the laboratory facility, to witness quality control activities, and to perform any check testing desired. The Government Engineer will advise in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, immediately suspend the incorporation of the materials into the work. Incorporation of the materials into the work will not be permitted to resume until the deficiencies are corrected.

3.1.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. Required elements of the testing program include, but are not limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability, flow, in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.1.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph QUALITY ASSURANCE) by one of the following methods: Extraction method in accordance with ASTM D2172, Method A or B, the ignition method in accordance with the AASHTO T 308, ASTM D6307, or the nuclear method in accordance with ASTM D4125, provided each method is calibrated for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. Use the last weight of ash value in the calculation of the asphalt content for the mixture.

3.1.3.2 Aggregate Properties

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444 or ASTM D6307. For batch plants, test aggregates in accordance with ASTM C136 using actual batch weights to determine the combined aggregate gradation of the mixture. Determine the specific gravity of each aggregate size grouping for each 20,000 tons in accordance with ASTM C127 or ASTM C128. Determine fractured faces for gravel sources for each 20,000 tons in accordance with COE CRD-C 171. Determine the uncompacted void content of manufactured sand for each 20,000 tons in accordance with AASHTO T 304 Method A.

3.1.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the Job Site.

3.1.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.
3.1.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with AASHTO T 329.

3.1.3.6 Laboratory Air Voids, VMA, Marshall Stability and Flow

Obtain mixture samples at least four times per lot and compacted into specimens, using 50 blows per side with the Marshall hand-held hammer as described in ASTM D6926. After compaction, determine the laboratory air voids and VMA of each specimen, as well as the Marshall stability and flow, as described in ASTM D6927. Provide VMA within the limits of Table 7.

3.1.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge or other non-destructive testing device may be used to monitor pavement density.

3.1.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph QUALITY ASSURANCE.

3.1.3.9 Additional Testing

Perform any additional testing, deemed necessary to control the process.

3.1.3.10 QC Monitoring

Submit all QC test results to the Government Engineer on a daily basis as the tests are performed. The Government Engineer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.1.4 Sampling

When directed by the Government Engineer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected. Perform all sampling in accordance with standard procedures specified.

3.1.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. Post the control charts as directed by the Government Engineer and maintain current at all times. Identify the following on the control charts, the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the test results. Also show target values (JMF) on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable
Suspension Limit, halt production until the problem is solved. When the Suspension Limit is exceeded for individual values or running average values, the Government Engineer has the option to require removal and replacement of the material represented by the samples or to leave in place and base acceptance on mixture volumetric properties and in place density. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. In the Quality Control Plan, indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

<table>
<thead>
<tr>
<th>Parameter to be Plotted</th>
<th>Individual Samples</th>
<th>Running Average of Last Four Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Action Limit</td>
<td>Suspension Limit</td>
</tr>
<tr>
<td>No. 4 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>No. 30 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>No. 200 sieve, Cumulative Percent Passing, deviation from JMF target; plus or minus values</td>
<td>1.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Asphalt content, percent deviation from JMF target; plus or minus value</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Laboratory Air Voids, percent deviation from JMF target value</td>
<td>No specific action and suspension limits set since this parameter is used to determine percent payment</td>
<td></td>
</tr>
</tbody>
</table>
Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

<table>
<thead>
<tr>
<th>Parameter to be Plotted</th>
<th>Individual Samples</th>
<th>Running Average of Last Four Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Action Limit</td>
<td>Suspension Limit</td>
</tr>
<tr>
<td>In-place Mat Density, percent of TMD</td>
<td>No specific action and suspension limits set since this parameter is used to determine percent payment</td>
<td></td>
</tr>
<tr>
<td>In-place Joint Density, percent of TMD</td>
<td>No specific action and suspension limits set since this parameter is used to determine percent payment</td>
<td></td>
</tr>
<tr>
<td>VMA</td>
<td>Gradation 3</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Table 8 cont'd. Marshall Compaction

<table>
<thead>
<tr>
<th></th>
<th>Stability, pounds (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 blow JMF</td>
</tr>
<tr>
<td>Flow, 0.01 inch</td>
<td>50 blow JMF</td>
</tr>
<tr>
<td></td>
<td>18 max.</td>
</tr>
</tbody>
</table>

3.2 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material while avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. Maintain the temperature of unmodified asphalts to no more than 325 degrees F when added to the aggregates. The temperature of modified asphalts is not to exceed 350 degrees F.

3.3 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage to the aggregates due to the maximum temperature and rate of heating used is allowed. Limit the temperature of the aggregate and mineral filler to 350 degrees F when the asphalt cement is added. Maintain the temperature no lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.4 PREPARATION OF HOT-MIX ASPHALT MIXTURE

Weigh or meter the aggregates and the asphalt cement and introduce into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a thorough and uniform coating of asphalt binder (testing in accordance with ASTM D2489 may be required by the Contracting
Officer) and is thoroughly distributed throughout the mixture. The moisture content of all hot-mix asphalt upon discharge from the plant is not to exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.5 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a prime coat or tack coat in accordance with the Contract Specifications.

3.6 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section consisting of a maximum of 250 tons and two paver passes wide placed in two lanes, with a longitudinal cold joint. Do not place the second lane of test section until the temperature of pavement edge is less than 175 degrees F. Construct the test section with the same depth as the course which it represents. Ensure the underlying grade or pavement structure upon which the test section is to be constructed is the same or very similar to the underlying layer for the Project. Use the same equipment in construction of the test section as on the remainder of the course represented by the test section. Construct the test section as part of the project pavement as approved by the Government Engineer.

3.6.1 Sampling and Testing for Test Section

Obtain one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Test an additional portion of the sample to determine the Tensile Strength Ratio (TSR). Adjust the compactive effort as required to provide TSR specimens with an air void content of 7 plus or minus 1 percent. Obtain four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Perform random sampling in accordance with procedures contained in ASTM D3665. Construction may continue provided the test results are within the tolerances or exceed the minimum values shown in Table 9. If all test results meet the specified requirements, the test section may remain as part of the project pavement. If test results exceed the tolerances shown, remove and replace the test section and construct another test sectional no additional cost to the Government Owner.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Gradation-Percent Passing (Individual Test Result)</td>
<td></td>
</tr>
<tr>
<td>No. 4 and larger</td>
<td>JMF plus or minus 8</td>
</tr>
<tr>
<td>No. 8, No. 16, No. 30, and No. 50</td>
<td>JMF plus or minus 6</td>
</tr>
<tr>
<td>No. 100 and No. 200</td>
<td>JMF plus or minus 2.0</td>
</tr>
</tbody>
</table>
Table 9. Test Section Requirements for Material and Mixture Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Content, Percent (Individual Test Result)</td>
<td>JMF plus or minus 0.5</td>
</tr>
<tr>
<td>Laboratory Air Voids, Percent (Average of 3 specimens)</td>
<td>JMF plus or minus 1.0</td>
</tr>
<tr>
<td>VMA, Percent (Average of 3 specimens)</td>
<td>See Table 7</td>
</tr>
<tr>
<td>Tensile Strength Ratio (TSR) (At 7 percent plus/minus 1 percent air void content)</td>
<td>75 percent minimum</td>
</tr>
<tr>
<td>Conditioned Strength</td>
<td>60 psi minimum</td>
</tr>
<tr>
<td>Mat Density, Percent of TMD (Average of 4 Random Cores)</td>
<td>92.0 – 96.0</td>
</tr>
<tr>
<td>Joint Density, Percent of TMD (Average of 4 Random Cores)</td>
<td>90.5 minimum</td>
</tr>
</tbody>
</table>

Table 9. cont'd - Marshall Compaction

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability, (Average of 3 specimens)</td>
<td>1350 pounds minimum for 50-blow</td>
</tr>
<tr>
<td>Flow, 0.01 inch (Average of 3 specimens)</td>
<td>8 – 18 for 50-blow</td>
</tr>
</tbody>
</table>

3.6.2 Additional Test Sections

If the initial test section proves to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and rolling procedures before beginning construction of a second test section. Construct and evaluate additional test sections, as required, for conformance to the Specifications. Full production paving is not allowed until an acceptable test section has been constructed and accepted.

3.7 TESTING LABORATORY

Laboratories used to develop the JMF, perform Contractor Quality Control testing, and Government Engineer quality assurance and acceptance testing are required to meet the requirements of ASTM D3666. Perform all required test methods by an accredited laboratory. The Government will inspect the laboratory equipment and test procedures prior to the start of hot-mix operations for conformance with ASTM D3666. Maintain the laboratory validation for the duration of the Project. Submit a certification of compliance signed by the manager of the laboratory stating that it meets these requirements to the Government Engineer prior to the start of construction. At a minimum, include the following certifications:
a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.8 TRANSPORTING AND PLACING

3.8.1 Transporting

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material is not permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F.

3.8.2 Placing

Place the mix in lifts of adequate thickness and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; strike off in a uniform layer of such depth that, when the work is completed, the required thickness and conform to the grade and contour indicated. Do not broadcast waste mixture onto the mat or recycled into the paver hopper. Collect waste mixture and dispose off site. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Begin placement of the mixture along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. Offset the longitudinal joint in one course from the longitudinal joint in the course immediately below by at least 1 foot; however, locate the joint in the surface course at the centerline of the pavement. Offset transverse joints in one course by at least 10 feet from transverse joints in the previous course. Offset transverse joints in adjacent lanes a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.9 COMPACTION OF MIXTURE

3.9.1 General

a. After placing, thoroughly and uniformly compact the mixture by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. Determine the sequence of rolling operations and the type of rollers used, except as specified in paragraph HMA-PORTLAND CEMENT CONCRETE JOINTS and with the exception that application of more than three passes with a vibratory roller in the vibrating mode is prohibited. Maintain the speed of the roller, at all times, sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Correct at once any displacement occurring as
a result of reversing the direction of the roller, or from any other cause.

b. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened, but excessive water is not permitted. In areas not accessible to the roller, thoroughly compact the mixture with hand tampers. Remove the full depth of any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective, replace with fresh hot mixture and immediately compact to conform to the surrounding area. Perform this work at no expense to the Government. Skin patching is not allowed.

3.9.2 Segregation

The Government Engineer can sample and test any material that looks deficient. When the in-place material appears to be segregated, the Government Engineer has the option to sample the material and have it tested and compared to the aggregate gradation, asphalt content, and in-place density requirements in Table 9. If the material fails to meet these specification requirements, remove and replace the extent of the segregated material the full depth of the layer of asphalt mixture at no additional cost to the Government. When segregation occurs in the mat, take appropriate action to correct the process so that additional segregation does not occur.

3.10 JOINTS

Construct joints to ensure a continuous bond between the courses and to obtain the required density. Provide all joints with the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.10.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, construct by means of placing a bulkhead or by tapering the course. Utilize a dry saw cut on the transverse joint full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. Cutting equipment that uses water as a cooling or cutting agent nor milling equipment is permitted. Remove the cutback material from the Project. In both methods, provide a light tack coat of asphalt material to all contact surfaces before placing any fresh mixture against the joint.

3.10.2 Longitudinal Joints

Cut back longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing the adjacent lane), or otherwise defective, a maximum of 3 inches from the top edge of the lift with a cutting wheel to expose a clean, sound, near vertical surface for the full depth of the course. Remove all cutback material from the Project. Cutting equipment that uses water as a cooling or cutting agent nor milling equipment is permitted. Provide a light tack coat of asphalt material to all contact surfaces prior to placing any fresh mixture against the joint.
3.10.3 HMA-Portland Cement Concrete Joints

Joints between HMA and PCC require specific construction procedures for the HMA. The following criteria are applicable to the first 10 feet or paver width of HMA adjacent to the PCC.

a. Pave the HMA side of the joint in a direction parallel to the joint.

b. Place the HMA side sufficiently high so that when fully compacted the HMA is greater than 1/8 inch but less than 1/4 inch higher than the PCC side of the joint.

c. Compact with steel wheel rollers and at least one rubber tire roller. Compact with a rubber tire roller that weighs at least 20 tons with tires inflated to at least 90 psi. Avoid spalling the PCC during placement and compaction of the HMA. Operate steel wheel rollers in a way that prevents spalling the PCC. Repair any damage to PCC edges or joints as directed by the Government Engineer. If damage to the PCC joint or panel edge exceeds a total of 3 feet, remove and replace the PCC panel at no additional expense to the Government.

d. After compaction is finished, diamond grind the HMA so that the HMA side is less than 1/8 inch higher than the PCC side. Perform diamond grinding in accordance with subparagraph DIAMOND GRINDING above. The HMA immediately adjacent to the joint is not allowed to be lower than the PCC after the grinding operation. Transition the grinding into the HMA in a way that ensures good smoothness and provides drainage of water. The joint and adjacent materials when completed is required to meet all of the requirements for grade and smoothness. Measure smoothness across the HMA-PCC joint using a 12 feet straightedge. The acceptable tolerance is 1/8 inch.

e. Consider the HMA next to the PCC as a separate lot for evaluation. Lots are based on individual lifts. Do not commingle cores from different lifts for density evaluation purposes. Take four cores for each lot of material placed adjacent to the joint. The size of lot is 10 feet wide by the length of the joint being paved. Locate the center of each of the four cores 6 inches from the edge of the concrete. Take each core at a random location along the length of the joint. The requirements for density for this lot, adjacent to the joint, are the same as that for the mat specified earlier. For HMA-PCC joints at taxiways abutting runways, aprons, or other taxiways, take two additional randomly located cores along each taxiway intersection.

f. All procedures, including repair of damaged PCC, are required to be in accordance with the approved Quality Control Plan.

-- End of Section --
PART 1  GENERAL

1.1  UNIT PRICES

1.1.1  Basis of Payment

The measured quantity of hot-mix asphalt will be paid for and included in the Lump Sum Contract Price. Payment will constitute full compensation for furnishing all materials, equipment, plant, and tools; and for all labor and other incidentals necessary to complete work required by this Section of the specification.

1.1.2  Percent Payment

Submit pay calculations. When a lot of material fails to meet the specification requirements for 100 percent pay, as outlined in the following paragraphs, that lot shall be removed and replaced, or accepted at a reduced price which will be computed by multiplying the unit price by the lot's pay factor. The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, grade or smoothness (each discussed below). At the end of the project, an average of all lot pay factors will be calculated. If this average lot pay factor equals or exceeds 95.0 percent, and no individual lot has a pay factor less than 75.1 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2000 short tons, a weighted lot pay factor will be used to calculate the average lot pay factor.

1.1.3  Laboratory Air Voids and Theoretical Maximum Density

Laboratory air voids will be calculated by determining the Marshall or Superpave density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method of ASTM D2726 and determining the theoretical maximum density of every other sublot sample using ASTM D2041. Laboratory air void calculations for each sublot will use the latest theoretical maximum density values obtained, either for that sublot or the previous sublot. The mean absolute deviation of the four laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated and a pay factor determined from Table 1. All laboratory air void tests will be completed and reported within 24 hours after completion of construction of each lot.

1.1.4  Mean Absolute Deviation

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 random samples of a lot (where 3 specimens were compacted from each sample). The average laboratory air voids for each sublot sample are
determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

\[
\text{Mean Absolute Deviation} = \frac{|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|}{4} = \frac{0.5 + 1.0 + 0.0 + 0.3}{4} = \frac{1.8}{4} = 0.45
\]

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 1 that the lot's pay factor based on laboratory air voids, is 100 percent.

<table>
<thead>
<tr>
<th>Mean Absolute Deviation of Lab Air Voids from JMF</th>
<th>Pay Factor, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60 or less</td>
<td>100</td>
</tr>
<tr>
<td>0.61 - 0.80</td>
<td>98</td>
</tr>
<tr>
<td>0.81 - 1.00</td>
<td>95</td>
</tr>
<tr>
<td>1.01 - 1.20</td>
<td>90</td>
</tr>
<tr>
<td>Above 1.20</td>
<td>reject (0)</td>
</tr>
</tbody>
</table>

### 1.1.5 In-place Density

For determining in-place density, one random core (4 inches or 6 inches in diameter) will be taken by the Government from the mat (interior of the lane) of each sublot, and one random core will be taken from the joint (immediately over joint) of each sublot. Each random core will be full thickness of the layer being placed. When the random core is less than 1 inch thick, it will not be included in the analysis. In this case, another random core will be taken. After air drying to a constant weight, cores obtained from the mat and from the joints will be used for in-place density determination.

### 1.1.6 Mat and Joint Densities

The average in-place mat and joint densities are expressed as a percentage of the average TMD for the lot. The TMD for each lot will be determined as the average TMD of the two random samples per lot. The average in-place mat density and joint density for a lot are determined and compared with Table 2 to calculate a single pay factor per lot based on in-place density, as described below. First, a pay factor for both mat density and joint density are determined from Table 2. The area associated with the joint is then determined and will be considered to be 5 feet wide times the length of completed longitudinal construction joint in the lot. This area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of hot-mix asphalt pavement, either an adjacent freshly paved lane or one paved at any time previously. The area associated with the joint is expressed as a percentage of the total lot area. A weighted pay factor for the joint is
determined based on this percentage (see example below). The pay factor for mat density and the weighted pay factor for joint density is compared and the lowest selected. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD will be used as the TMD needed to calculate the percent joint density. All density results for a lot will be completed and reported within 24 hours after the construction of that lot.

<table>
<thead>
<tr>
<th>Average Mat Density (4 Cores) (Percent of TMD)</th>
<th>Pay Factor, Percent</th>
<th>Average Joint Density (4 Cores) (Percent of TMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.0 - 96.0</td>
<td>100.0</td>
<td>92.5 or above</td>
</tr>
<tr>
<td>93.9</td>
<td>100.0</td>
<td>92.4</td>
</tr>
<tr>
<td>93.8 or 96.1</td>
<td>99.9</td>
<td>92.3</td>
</tr>
<tr>
<td>93.7</td>
<td>99.8</td>
<td>92.2</td>
</tr>
<tr>
<td>93.6 or 96.2</td>
<td>99.6</td>
<td>92.1</td>
</tr>
<tr>
<td>93.5</td>
<td>99.4</td>
<td>92.0</td>
</tr>
<tr>
<td>93.4 or 96.3</td>
<td>99.1</td>
<td>91.9</td>
</tr>
<tr>
<td>93.3</td>
<td>98.7</td>
<td>91.8</td>
</tr>
<tr>
<td>93.2 or 96.4</td>
<td>98.3</td>
<td>91.7</td>
</tr>
<tr>
<td>93.1</td>
<td>97.8</td>
<td>91.6</td>
</tr>
<tr>
<td>93.0 or 96.5</td>
<td>97.3</td>
<td>91.5</td>
</tr>
<tr>
<td>92.9</td>
<td>96.3</td>
<td>91.4</td>
</tr>
<tr>
<td>92.8 or 96.6</td>
<td>94.1</td>
<td>91.3</td>
</tr>
<tr>
<td>92.7</td>
<td>92.2</td>
<td>91.2</td>
</tr>
<tr>
<td>92.6 or 96.7</td>
<td>90.3</td>
<td>91.1</td>
</tr>
<tr>
<td>92.5</td>
<td>87.9</td>
<td>91.0</td>
</tr>
<tr>
<td>92.4 or 96.8</td>
<td>85.7</td>
<td>90.9</td>
</tr>
<tr>
<td>92.3</td>
<td>83.3</td>
<td>90.8</td>
</tr>
<tr>
<td>92.2 or 96.9</td>
<td>80.6</td>
<td>90.7</td>
</tr>
</tbody>
</table>
### Table 2. Pay Factor Based on In-place Density

<table>
<thead>
<tr>
<th>Average Mat Density (4 Cores) (Percent of TMD)</th>
<th>Pay Factor, Percent</th>
<th>Average Joint Density (4 Cores) (Percent of TMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>92.1</td>
<td>78.0</td>
<td>90.6</td>
</tr>
<tr>
<td>92.0 or 97.0</td>
<td>75.0</td>
<td>90.5</td>
</tr>
<tr>
<td>below 92.0 or above 97.0</td>
<td>0.0 (reject)</td>
<td>below 90.5</td>
</tr>
</tbody>
</table>

### 1.1.7 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 93.2 percent of TMD. (2) Average joint density = 91.5 percent of TMD. (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2000 feet.

1.1.7.1 Step 1

Determine pay factor based on mat density and on joint density, using Table 2:

<table>
<thead>
<tr>
<th>Mat Density</th>
<th>93.2 percent</th>
<th>equals</th>
<th>98.3 pay factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint Density</td>
<td>91.5 percent</td>
<td>equals</td>
<td>97.3 pay factor</td>
</tr>
</tbody>
</table>

1.1.7.2 Step 2

Determine ratio of joint area (length of longitudinal joint x 5 ft) to mat area (total paved area in the lot): Multiply the length of completed longitudinal construction joint by the specified 5 ft width and divide by the mat area (total paved area in the lot).

\[
\frac{2000 \text{ ft.} \times 5 \text{ ft.}}{30,000 \text{ sq.ft.}} = 0.3333 \text{ ratio of joint area to mat area (ratio).}
\]

1.1.7.3 Step 3

Weighted pay factor (wpf) for joint is determined as indicated below:

\[
wpf = \text{joint pay factor} + (100 - \text{joint pay factor}) \times (1 - \text{ratio})
\]

\[
wpf = 97.3 + (100-97.3) \times (1-0.3333) = 99.1 \text{ percent}
\]

1.1.7.4 Step 4

Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

a. Pay factor for mat density: 98.3 percent. Weighted pay factor for joint density: 99.1 percent.
b. Select the smaller of the two values as pay factor based on density:

98.3 percent.

1.1.8 Pay Factor for Grade

When more than 5 percent of all measurements made within a lot are outside the 0.05 foot tolerance, the pay factor based on grade for that lot will be 95 percent. In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth and replace the lift with hot-mix asphalt to meet specification requirements, at no additional cost to the Government.

1.1.9 Payment Adjustment for Smoothness

1.1.9.1 Straightedge Testing

Record location and deviation from straightedge for all measurements. When between 5.0 and 10.0 percent of all measurements made within a lot exceed the tolerance specified in paragraph Smoothness Requirements above, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness, will be 95 percent. When more than 10.0 percent of all measurements exceed the tolerance, the computed pay factor will be 90 percent. When between 15.0 and 20.0 percent of all measurements exceed the tolerance, the computed pay factor will be 75 percent. When 20.0 percent or more of the measurements exceed the tolerance, the lot shall be removed and replaced at no additional cost to the Government. Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 50 percent, shall be corrected by diamond grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government.

1.1.9.2 Profilograph Testing

Record location and data from all profilograph measurements. When the Profile Index of a 0.1 mile segment of a lot exceeds the tolerance specified in paragraph Smoothness Requirements above by 1.0 inch/mile, but less than 2.0 inches/mile, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 2.0 inches/mile, but less than 3.0 inches/mile, the computed pay factor will be 90 percent. When the Profile Index exceeds the tolerance by 3.0 inches/mile, but less than 4.0 inches/mile, the computed pay factor will be 75 percent. When the Profile Index exceeds the tolerance by 4.0 inches/mile or more, the lot shall be removed and replaced at no additional cost to the Government. Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 5.0 inches/mile or more, shall be corrected by grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government.

1.1.9.3 Bumps ("Must Grind" Areas)

Any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.3 inch in height shall be reduced by diamond grinding until they do not exceed 0.3 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding.
The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas, including ground areas, may be rechecked with the profilograph in order to record a lower Profile Index.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


AASHTO T 304 (2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate

ASPHALT INSTITUTE (AI)

AI MS-2 (2015) Asphalt Mix Design Methods

AI MS-22 (2001; 2nd Ed) Construction of Hot-Mix Asphalt Pavements

ASTM INTERNATIONAL (ASTM)


ASTM D1461 (2011) Moisture or Volatile Distillates in Bituminous Paving Mixtures

ASTM D2041 (2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

ASTM D2172 (2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures


ASTM D2726 (2014) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures

ASTM D2950 (2014) Density of Bituminous Concrete in Place by Nuclear Methods


ASTM D4125 (2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method

ASTM D4791 (2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

ASTM D4867 (2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures


U.S. ARMY CORPS OF ENGINEERS (USACE)


1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data
   Mix Design; G
   Quality Control; G
   Material Acceptance; G
   Percent Payment; G

SD-04 Samples
   Asphalt Cement Binder
   Aggregates

SD-06 Test Reports
   Aggregates; G
   QC Monitoring

SD-07 Certificates
   Asphalt Cement Binder; G
1.4 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, meet all other requirements, including compaction.

<table>
<thead>
<tr>
<th>Mat Thickness, inches</th>
<th>Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 or greater</td>
<td>40</td>
</tr>
<tr>
<td>Less than 3</td>
<td>45</td>
</tr>
</tbody>
</table>

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections indicated. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

2.1.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Testing Facilities

Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

2.1.1.3 Inspection of Plant

Provide the Contracting Officer with access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.
2.1.1.4 Storage bins

Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

a. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.

b. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

2.1.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.3.2 Automatic Grade Controls

Equip the paver with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. Provide controls capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.
d. Laser control.

2.1.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 200 lb of blended mixture for mix design verification. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit all aggregate test results and samples to the Contracting Officer at least 14 days prior to start of construction.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. All individual coarse aggregate sources shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131.

b. The percentage of loss shall not be greater than 18 percent after five cycles when tested in accordance with ASTM C88 using magnesium sulfate or 12 percent when using sodium sulfate.

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.

e. Slag shall be air-cooled, blast furnace slag, with a compacted weight of not less than 75 lb/cu ft when tested in accordance with ASTM C29.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142.

2.2.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls.
a. All individual fine aggregate sources shall have a sand equivalent value not less than 45 when tested in accordance with ASTM D2419.

b. The fine aggregate portion of the blended aggregate shall have an uncompacted void content not less than 45.0 percent when tested in accordance with AASHTO T 304 Method A.

c. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 25 percent by weight of total aggregate.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142.

2.2.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242.

2.2.4 Aggregate Gradation

The combined aggregate gradation shall conform to gradations specified in Table 4, when tested in accordance with ASTM C136 and ASTM C117, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

<table>
<thead>
<tr>
<th>Sieve Size, inch</th>
<th>Gradation 1 Percent Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>3/4</td>
<td>76-96</td>
</tr>
<tr>
<td>1/2</td>
<td>68-88</td>
</tr>
<tr>
<td>3/8</td>
<td>60-82</td>
</tr>
<tr>
<td>No. 4</td>
<td>45-67</td>
</tr>
<tr>
<td>No. 8</td>
<td>32-54</td>
</tr>
<tr>
<td>No. 16</td>
<td>22-44</td>
</tr>
<tr>
<td>No. 30</td>
<td>15-35</td>
</tr>
<tr>
<td>No. 50</td>
<td>9-25</td>
</tr>
<tr>
<td>No. 100</td>
<td>6-18</td>
</tr>
</tbody>
</table>
Table 4. Aggregate Gradations

<table>
<thead>
<tr>
<th>Sieve Size, inch</th>
<th>Gradation 1 Percent Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 200</td>
<td>3-6</td>
</tr>
</tbody>
</table>

2.3 ASPHALT CEMENT BINDER

Submit a 5 gallon sample for mix design verification. Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) 64-22. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with ASTM D140 and in the presence of the Contracting Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder.

2.4 MIX DESIGN

a. Develop the mix design. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF). Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. The hot-mix asphalt shall be designed in accordance with Marshall (MS-02), Superpave (SP-2), or Hveem (MS-02) procedures and the criteria shown in Table 5. Use the hand-held hammer to compact the specimens for Marshall mix design. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867 is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an approved anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Sufficient materials to produce 200 pound of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

2.4.1 JMF Requirements

Submit in writing the job mix formula for approval at least 14 days prior to the start of the test section including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.
c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave.)

f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design).

g. Laboratory mixing temperature.

h. Lab compaction temperature.

i. Temperature-viscosity relationship of the asphalt cement.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with 2 or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio (TSR).

r. Antistrip agent (if required) and amount.

s. List of all modifiers and amount.

t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).

u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

<table>
<thead>
<tr>
<th>Test Property</th>
<th>75 Blows or Mix Gyrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability, pounds, minimum (NA for Superpave)</td>
<td>*1800</td>
</tr>
<tr>
<td>Flow, 0.01 inch, (NA for Superpave)</td>
<td>8-18</td>
</tr>
</tbody>
</table>
2.4.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new Laboratory JMF design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

<table>
<thead>
<tr>
<th>TABLE 6. Field (Plant) Established JMF Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sieves</strong></td>
</tr>
<tr>
<td>1/2 inch</td>
</tr>
<tr>
<td>No. 4</td>
</tr>
<tr>
<td>No. 8</td>
</tr>
<tr>
<td>No. 200</td>
</tr>
<tr>
<td>Binder Content</td>
</tr>
</tbody>
</table>

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the No. 200 sieve, which shall remain within the aggregate grading of Table 4.
2.5 RECYCLED HOT MIX ASPHALT

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement to produce a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 inches. Design the recycled HMA mix using procedures contained in AI MS-2 and AI MS-22. The job mix shall meet the requirements of paragraph MIX DESIGN. The amount of RAP shall not exceed 30 percent.

2.5.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to ASTM D2172 or ASTM D6307 using the appropriate dust correction procedure.

2.5.2 RAP Mix

The blend of new asphalt cement and the RAP asphalt binder shall meet the dynamic shear rheometer at high temperature and bending beam at low temperature requirements in paragraph ASPHALT CEMENT BINDER. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph ASPHALT CEMENT BINDER.

PART 3 EXECUTION

3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 325 degrees F when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range of 265-320 degrees F when added to the aggregate.

3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the percentage of coated particles described in ASTM D2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least...
achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.4 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a prime coat and/or tack coat in accordance with the Contract Specifications.

3.5 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of ASTM D3666. The Government will inspect the laboratory equipment and test procedures prior to the start of hot mix operations for conformance to ASTM D3666. The laboratory shall maintain the Corps certification for the duration of the Project. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.6 TRANSPORTING AND PLACING

3.6.1 Transporting

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F. To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver.

3.6.2 Placing

Place and compact the mix at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips.
having a minimum width of 10 feet. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.7 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened but excessive water will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.8 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.8.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the Project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.8.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the Project. All contact surfaces shall be given a light tack coat of
asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

3.9 QUALITY CONTROL

3.9.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design;
b. Aggregate Grading;
c. Quality of Materials;
d. Stockpile Management;
e. Proportioning;
f. Mixing and Transportation;
g. Mixture Volumetrics;
h. Moisture Content of Mixtures;
i. Placing and Finishing;
j. Joints;
k. Compaction;
l. Surface Smoothness.

3.9.2 Testing Laboratory

Utilize a local commercial laboratory or provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.9.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt
content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.9.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE and PERCENT PAYMENT) by one of the following methods: The extraction method in accordance with ASTM D2172, Method A or B, the ignition method in accordance with ASTM D6307, or the nuclear method in accordance with ASTM D4125. Calibrate the ignition oven or the nuclear gauge for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.9.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444. When asphalt content is determined by the ignition oven or nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with ASTM C136 using actual batch weights to determine the combined aggregate gradation of the mixture.

3.9.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.9.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.9.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with ASTM D1461 or an approved alternate procedure.

3.9.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using 75 blows per side with the hand-held Marshall hammer as described in ASTM D6926. When the Superpave gyratory compactor is used, mixes will be compacted to 75 gyrations in accordance with ASTM D6925. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with ASTM D6927.
3.9.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with ASTM D2950.

3.9.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

3.9.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.9.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.9.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.9.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts
### 3.10 MATERIAL ACCEPTANCE

Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results and payment calculations daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 8 hours of production or one working day. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus grade and smoothness measurements for the entire lot...
cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

3.10.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

3.10.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the Specification Requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.10.3 Grade

The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 0.05 foot from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

3.10.4 Surface Smoothness

Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

3.10.4.1 Smoothness Requirements
3.10.4.1.1 Straightedge Testing

The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the tolerances of 1/4 inch in both the longitudinal and transverse directions, when tested with an approved 12 feet straightedge.

3.10.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lanes less than 20 feet wide and at the third points for lanes 20 feet or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.

3.10.4.2.1 Straightedge Testing

Hold the straightedge in contact with the surface and move it ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

-- End of Section --
SECTION 32 13 11
CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS
11/15

PART 1    GENERAL

1.1    UNIT PRICES

1.1.1    Measurements

The quantity of concrete to be paid for will be the volume of concrete in cubic yards including thickened edges, where required, placed in the completed and accepted pavement. Concrete will be measured in place in the completed and accepted pavement only within the neat line dimensions shown in the plan and cross section. No deductions will be made for rounded or beveled edges or the space occupied by pavement reinforcement, dowel bars, or electrical conduits, nor for any void, or other structure extending into or through the pavement slab, measuring 3 cubic feet or less in volume. No other allowance for concrete will be made unless placed in specified locations in accordance with the approved Contract Modification. The quantity of other materials specified herein, and used in the construction of the work covered by this Section, will not be measured for payment, but will be considered a subsidiary obligation, covered under the price per cubic yard for concrete. Joint sealing materials are covered in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.

1.1.2    Payments

1.1.2.1    Lump Sum

The quantity of concrete will be paid for and included in the Lump-Sum Contract Price. If less than 100 percent payment is due based on the pay factors stipulated below, a unit price of $200 per square yard will be used for purposes of calculating the payment reduction.

1.1.3    Payment of Lots

When a lot of material fails to meet the specification requirements, that lot will be accepted at a reduced price or be removed and replaced. The lowest computed percent payment determined for any pavement characteristic discussed below (for example, thickness, grade, and surface smoothness) becomes the actual percent payment for that lot. The actual percent payment will be applied to the unit price and the measured quantity of concrete in the lot to determine actual payment. Use results of strength tests to control concreting operations. Strength will be evaluated, but will not be considered for payment adjustment. Remove and replace any pavement not meeting the required 'Concrete Strength for Final Acceptance' at no additional cost to the Government.

1.1.4    Payment Adjustment for Smoothness

1.1.4.1    Straightedge Testing

Record location and deviation from straightedge for all measurements. When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot exceed the tolerance specified in Paragraph "Surface
Smoothness", after any reduction of high spots or removal and replacement, the computed percent payment based on surface smoothness will be 95 percent. When more than 10.0 percent and less than or equal to 15.0 percent of all measurements exceed the tolerance, the computed percent payment will be 90 percent. When more than 15.0 and less than or equal to 20.0 percent of all measurements exceed the tolerance, the computed percent payment will be 75 percent. Remove and replace the lot when more than 20.0 percent of the measurements exceed the tolerance, at no additional cost to the Government.

1.1.5 Payment Adjustment for Plan Grade

When more than 5.0 and less than or equal to 10.0 percent of all measurements made within a lot are outside the specified tolerance, the computed percent payment for that lot will be 95 percent. When more than 10.0 percent but less than 50 percent are outside the specified tolerances, the computed percent payment for the lot will be 75 percent. Remove and replace the deficient area where the deviation from grade exceeds the specified tolerances by 50 percent or more, at no additional cost to the Government.

1.1.6 Payment Adjustment for Thickness

Using the Average Thickness of the lot, determine the computed percent payment for thickness by entering the following table:

<table>
<thead>
<tr>
<th>Deficiency in Thickness Determined by cores inches</th>
<th>Pavements Equal To or Greater Than 8 inches Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 to 0.24</td>
<td>100</td>
</tr>
<tr>
<td>0.25 to 0.49</td>
<td>75</td>
</tr>
<tr>
<td>0.50 to 0.74</td>
<td>50</td>
</tr>
<tr>
<td>0.75 or greater</td>
<td>0</td>
</tr>
</tbody>
</table>

Where 0 percent payment is indicated, remove the entire lot and replace at no additional cost to the Government. Where either of the two cores from a subplot show a thickness deficiency of 0.75 inch or greater, drill two more cores in the subplot and compute the average thickness of the four cores. If this average shows a thickness deficiency of 0.75 inch or more remove the entire subplot.

1.2 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.
<table>
<thead>
<tr>
<th>AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO M 182</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACI 214R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ASTM INTERNATIONAL (ASTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A1064</td>
</tr>
<tr>
<td>ASTM A615</td>
</tr>
<tr>
<td>ASTM A996</td>
</tr>
<tr>
<td>ASTM C1077</td>
</tr>
</tbody>
</table>
for Use in Construction and Criteria for Laboratory Evaluation

ASTM C117

ASTM C123

ASTM C1260

ASTM C131

ASTM C136

ASTM C138
(2016a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

ASTM C142

ASTM C143

ASTM C150

ASTM C1567

ASTM C1602

ASTM C1646

ASTM C172
(2010) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C174
(2016) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores

ASTM C192
(2016a) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231 (2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method


ASTM C294 (2012) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates

ASTM C295 (2012) Petrographic Examination of Aggregates for Concrete

ASTM C31 (2015a; E 2016) Standard Practice for Making and Curing Concrete Test Specimens in the Field


ASTM C618 (2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C666 (2015) Resistance of Concrete to Rapid Freezing and Thawing

ASTM C78 (2016) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)


ASTM D1751 (2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and
Structural Construction (Nonextruding and Resilient Bituminous Types)

ASTM D2995 (1999; R 2009) Determining Application Rate of Bituminous Distributors


ASTM D4791 (2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate


NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)


U.S. AIR FORCE (USAF)

AF ETL 97-5 (1997) Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)


COE CRD-C 300 (1990) Specifications for Membrane-Forming Compounds for Curing Concrete


COE CRD-C 55 (1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete


1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:
SD-03 Product Data
Diamond Grinding Plan; G
Dowels; G
Dowel Bar Assemblies; G
Equipment
Proposed Techniques; G

SD-05 Design Data
Preliminary Proposed Proportioning; G
Proportioning Studies; G

SD-06 Test Reports
Batch Plant Manufacturer's Inspection Report; G
Slipform Paver Manufacturer's Inspection Report; G
Sampling and Testing; G
Diamond Grinding of PCC Surfaces; G
Mixer Performance (Uniformity) Testing; G
Repair Recommendations Plan; G

SD-07 Certificates
Contractor Quality Control Staff; G
Laboratory Accreditation and Validation
Commercial Laboratory; G
NRMCA Certificate of Conformance

1.4 QUALITY CONTROL

1.4.1 Contractor Quality Control Staff

Reference Section 01 45 00.00 10 QUALITY CONTROL for Contractor personnel qualification requirements. Submit American Concrete Institute certification for Contractor Quality Control staff. Qualifications and resumes for petrographer, surveyor, concrete batch plant operator, and profilographe operator. All Contractor Quality Control personnel assigned to concrete construction are required to be American Concrete Institute (ACI) certified in the following grade:

a. The minimum requirements for the CQC System Manager consist of being a graduate engineer or a graduate of construction management, with a minimum of 5 years airfield construction experience and a minimum of 1 year experience as a CQC System Manager on an airfield construction project.
b. CQC personnel responsible for inspection of concrete paving operations: ACI Concrete Transportation Inspector. The ACI Concrete Transportation Inspector is required to be present at the paving site during all paving operations, with the exception of the initial saw cutting operation. The QC manager is required to be present during initial saw cutting operations.

c. CQC staff is required to oversee all aspects of sawing operations (sawing, flushing, vacuuming, checking for random cracking, lighting).

d. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Concrete Flatwork Technician/Finisher.

e. Batch Plant Manufacturer's Representative: A representative from the batch plant manufacturer is required to be on site to inspect and make necessary adjustments to all components of the batch plant including but not limited to aggregate bin weighing operations, water metering, cement and fly ash weighing devices. All necessary inspections and adjustments by the manufacturer representative is required to be performed prior to uniformity testing. Submit a written Batch Plant Manufacturer's Inspection Report signed by the representative noting all inspection items and corrections and stating the batch plant is capable of producing the volume of concrete as required herein.

f. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

g. Slipform Paving Equipment Manufacturer's Representative: A representative of the slipform paving equipment manufacturer is required to be on site to inspect and make corrections to the paving equipment to ensure proper operations. Perform a complete and full hydraulic flow test of the vibrator system prior to the test section being placed. Submit a written Slipform Paver Manufacturer's Inspection Report signed by the manufacturer's representative noting all inspections, corrections, and flow tests have been performed and the paver is in a condition to perform the required work.

h. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and Laboratory Testing Technician, Grade I or II.

1.4.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295 and trained in identification of the specific deleterious materials and tests identified in this Specification. Detail the education, training, and experience related to the project-specific test methods and deleterious materials in the Resume and submit at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: Perform all survey work under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification.
1.4.3 Laboratory Accreditation and Validation

Provide laboratory and testing facilities. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures. The laboratories performing the tests are required to be accredited in accordance with ASTM C1077, including ASTM C78 and ASTM C1260. Provide current accreditation and include the required and optional test methods, as specified. In addition, all contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at http://www.erdc.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Articl for costs and scheduling. Provide onsite temperature-controlled concrete curing facilities.

1.4.3.1 Aggregate Testing and Mix Proportioning

Aggregate testing and mixture proportioning studies are required to be performed by a commercial laboratory.

1.4.3.2 Acceptance Testing

Provide all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the paving site and in the laboratory. Provide steel molds for molding the beam specimens. Provide and maintain boxes or other facilities suitable for storing and curing the specimens at the paving site while in the mold within the temperature range stipulated by ASTM C31. Provide flexural loading equipment in accordance with ASTM C78.

1.4.3.3 Contractor Quality Control

All sampling and testing is required to be performed by an approved, onsite, independent, commercial laboratory, or for cementitious materials and admixtures, the manufacturer's laboratory.

1.4.3.4 Laboratory Inspection

The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any concreting operations for conformance to ASTM C1077. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. The laboratory is to maintain this certification for the duration of the Project.

1.4.4 Preconstruction Testing of Materials

All sampling and testing is required to be performed. Use an approved commercial laboratory or, for cementitious materials and chemical admixtures, a laboratory maintained by the manufacturer of the material. Materials are not allowed to be used until notice of acceptance has been given. Additional payment or extension of time due to failure of any material to meet Project Requirements, or for any additional sampling or testing required is not allowed. Additional tests may be performed by the Government; such Government testing does not relieve any required testing
responsibilities.

1.4.4.1 Aggregates

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75 and be representative of the materials to be used for the Project. Submit test results a minimum of 7 days before commencing mixture proportioning studies.

1.4.4.2 Chemical Admixtures, Curing Compounds and Epoxies

At least 30 days before the material is used, submit certified copies of test results for the specific lots or batches to be used on the Project. Provide test results less than 6 months old prior to use in the Work. Retest chemical admixtures that have been in storage at the Project Site for longer than 6 months or that have been subjected to freezing, and reject if test results do not meet manufacturer requirements.

1.4.4.3 Cementitious Materials

Cement, slag cement, and pozzolan will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the Specification under which it is provided. Provide mill test reports no more than 1 month old, prior to use in the work. Do not use cementitious materials until notice of acceptance has been given. Cementitious materials may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the Project Site. If tests prove that a cementitious material that has been delivered is unsatisfactory, promptly remove it from the Project Site. Retest cementitious material that has not been used within 6 months after testing, and reject if test results do not meet manufacturer requirements.

1.4.5 Testing During Construction

During construction, sample and test aggregates, cementitious materials, and concrete as specified herein. The Government will sample and test concrete and ingredient materials as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Testing by the Government does not relieve the specified testing requirements.

1.4.6 Test Section

Up to 10 days, but not more than 60 days, prior to construction of the concrete pavement, construct a test section near the job site, but not as part of the production pavement area. Construct test section of the same depth as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed is required to be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section is required to be the same equipment to be used on the remainder of the course represented by the test section. Use the test section to develop and demonstrate the proposed techniques of mixing, hauling, placing, consolidating, finishing, curing, initial saw cutting, start-up procedures, testing methods, plant operations, and the preparation of the construction joints. Perform variations in mixture proportions, other than water, if directed. Operate and calibrate the mixing plant prior to start of placing the test section. Use the same equipment, materials, and construction
techniques on the test section proposed for use in all subsequent work. Perform base course preparation, concrete production, placing, consolidating, curing, construction of joints, and all testing in accordance with applicable provisions of this Specification. Three days after completion of the test section, provide eight cores at least 6 inches in diameter by full depth cut from points selected in the test section by the Government. The cores will be evaluated for surface paste, uniformity of aggregate distribution, segregation, voids, and thickness. Construct the test section meeting all Specification Requirements and being acceptable in all aspects, including surface texture, thickness, grade, and longitudinal and transverse joint alignment. Failure to construct an acceptable test section necessitates construction of additional test sections at no additional cost to the Government. Remove test sections allowed to be constructed as part of the production pavement which do not meet specification requirements at no expense to the Government. If slipform paving is performed and is unable to construct an acceptable test section, repair or replace the slipform paving equipment, or paving completed using fixed-forms and equipment compatible with them and allowed by the Specification. Do not commence production paving until the results on aggregates and concrete, including evaluation of the cores, and all pavement measurements for edge slump, joint face deformation, actual plan grade, surface smoothness and thickness have been submitted and approved. Pavement accepted as a production lot will be evaluated and paid as specified in PART 1 GENERAL.

1.4.6.1 Pilot Lane

Construct the test section consisting of one paving lane at least 400 feet long and to the same thickness as the thickest portion of pavement shown on the Drawings. Construct at the same lane width as that required for use in the Project. Provide at least one transverse construction joint in the test section. If doweled longitudinal construction joints are required in any of the production pavements, install them full length along one side of the test lane throughout the test section. Construct the test section on two separate days.

1.4.6.2 Fill-In Lane

Consider the first 400 feet of the initial production fill-in lane as a fill-in lane test section for purposes of testing and evaluation. All requirements for the test section are applicable. Obtain cores from the fill-in lane side of the longitudinal construction joint with the pilot lane. The cores will be evaluated for homogeneity, consolidation, and segregation.

1.4.7 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests to validate the results of the production testing. If the results of the production testing vary by less than 2.0 percent of the Government’s test results, the results of the production testing will be used. If the results of the Government and production tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, carefully evaluate each sampling and testing procedure and obtain another series of Government and production tests on duplicate samples of material. If these vary by 4.0 percent or more, use the results of the tests made by the Government and the Government will continue check testing of this item on a continuous basis.
until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government does not relieve the specified testing requirements.

1.4.8 Acceptance Requirements

1.4.8.1 Pavement Lots

A lot is that quantity of construction to be evaluated for acceptance with Specification Requirements. A lot is equal to one shift of production not to exceed 1000 cubic yards. In order to evaluate thickness, divide each lot into four equal sublots. A sublot is equal to one shift of production not to exceed 250 cubic yards. Grade determinations will be made on the lot as a whole. Surface smoothness determinations will be made on every 0.1 mile segment in each lot. Select sample locations on a random basis in accordance with ASTM D3665. When operational conditions cause a lot to be terminated before the specified four sublots have been completed, use the following procedure to adjust the lot size and number of tests for the lot. Where three sublots have been completed, they constitute a lot. Where one or two sublots have been completed, incorporate them into the next lot (except for the last lot), and the total number of sublots used and acceptance criteria adjusted accordingly.

1.4.8.2 Evaluation

Provide all sampling and testing required for acceptance and payment adjustment, including batch tickets with all required acceptance testing. Individuals performing sampling, testing and inspection duties are required to meet the Qualifications. The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the Specification Requirements. Testing in these areas are in addition to the sublot or lot testing, and the requirements for these areas are the same as those for a sublot or lot. Provide facilities for and, where directed, personnel to assist in obtaining samples for any Government testing.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Bulk Cementitious Materials

Provide all cementitious materials in bulk at a temperature, as delivered to storage at the site, not exceeding 150 degrees F. Provide sufficient cementitious materials in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.5.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Store each size of aggregate from each source separately in free-draining stockpiles. Provide a minimum 24 inch thick sacrificial layer left undisturbed for each aggregate stored on ground. Provide free-draining storage for fine aggregate and the smallest size coarse aggregate for at least 24 hours immediately prior to use. Maintain sufficient aggregate at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Do not allow tracked equipment on coarse aggregate stockpiles.
1.5.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. Store all materials to avoid contamination and deterioration.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This Section is intended to stand alone for construction of concrete pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this Section and the other Section, including tolerances for both.

2.1.1 Surface Smoothness

Use the straightedge method for transverse testing and for longitudinal testing of each pavement lane, and at the ends of the paving limits for the Project. Smoothness requirements do not apply over crowns, drainage structures, or similar penetration. Maintain detailed notes of the testing results and provide a copy to the Government after each day's testing.

2.1.1.1 Straightedge Testing

Provide the finished surfaces of the pavements with no abrupt change of 1/4 inch or more, and all pavements within the limits specified when checked with an approved 12 foot straightedge. Provide all other airfield areas with a variation from a straight edge not greater than 1/4 inch in either the longitudinal or transverse direction. Provide roads, streets, tank hardstands, vehicular parking areas, and open storage areas with a variation from the specified straight edge not greater than 1/4 inch in either the longitudinal or transverse direction.

2.1.1.2 Bumps ("Must Grind" Areas)

Reduce any bumps ("must grind" areas) which exceed 0.4 inch in height by diamond grinding in accordance with Subparagraph "Diamond Grinding Of PCC Surfaces" below until they do not exceed 0.3 inch when retested. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding.

2.1.1.3 Testing Method

After the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement, test the entire surface of the pavement in each lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. If any pavement areas are diamond ground, retest these areas immediately after diamond grinding. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each paving lane shown on the drawings, regardless of whether multiple lanes are allowed to be paved at the same time, and at the 1/8th point in from each side of the lane. Also test other areas having obvious deviations. Perform longitudinal testing lines continuous across all joints. Perform transverse testing lines for pilot lanes carried to construction joint lines and for fill-in lanes carried 24 inches across construction joints, and the readings in this area applied to the fill-in lane. Perform straightedge testing of the longitudinal edges of slipformed
pilot lanes before paving fill-in lanes as specified below.

2.1.1.3.1 Straightedge Testing

Hold the straightedge in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along the entire length of the straight edge.

2.1.2 Edge Slump and Joint Face Deformation

2.1.2.1 Edge Slump

When slip-form paving is used, provide a maximum of 15.0 percent of the total free edge of each pavement panel with a maximum edge slump of 1/4 inch and none of the free edge of the pavement lot with an edge slump exceeding 3/8 inch. (A pavement panel is defined as a lane width by the length between two adjacent transverse contraction joints. The total free edge of the pavement is the cumulative total linear measurement of pavement panel edge originally constructed as non-adjacent to any existing pavement; for example, 100 feet of pilot lane originally constructed as a separate lane, would have 200 feet of free edge; 100 feet of fill-in lane would have no free edge.) The area affected by the downward movement of the concrete along the pavement edge is a maximum of 18 inches back from the edge.

2.1.2.2 Joint Face Deformation

In addition to the edge slump limits specified above, provide a vertical joint face with a surface within the maximum limits shown below:

<table>
<thead>
<tr>
<th>Offset from Straightedge</th>
<th>Offset from Straightedge</th>
<th>Offset from Straightedge</th>
<th>Abrupt Offset in Any Direction (d)</th>
<th>Offset of Joint Face from True Vertical (e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Longitudinally</td>
<td>Applied Longitudinally</td>
<td>Applied Longitudinally</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to Pavement Surface (a)</td>
<td>to Vertical Face (b)</td>
<td>to Bottom Against the Joint Face (c)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Airfield Pavement

<table>
<thead>
<tr>
<th>1/8 inch</th>
<th>1/4 inch</th>
<th>3/8 inch</th>
<th>1/8 inch</th>
<th>1 inch per 12 inches</th>
</tr>
</thead>
</table>

All Other Pavement

<table>
<thead>
<tr>
<th>1/4 inch</th>
<th>All other items same as airfield pavement</th>
</tr>
</thead>
</table>

(a) Measurement is taken by placing the straightedge longitudinally on the pavement surface 1 inch from the free edge.

(b) Measurement is taken by applying the straightedge longitudinally along the vertical joint face.
2.1.2.3 Slump Determination

Test the pavement surface to determine edge slump immediately after the concrete has hardened sufficiently to permit walking thereon. Perform testing with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified above. Determine the vertical edge slump at each free edge of each slipformed paving lane constructed. Place the straightedge transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Record measurements at 5 to 10 foot spacings, as directed, commencing at the header where paving was started. Initially record measurements at 5 foot intervals in each lane. When no deficiencies are present after 5 measurements, the interval may be increased. The maximum interval is 10 feet. When any deficiencies exist, return the interval to 5 feet. In addition to the transverse edge slump determination above, at the same time, record the longitudinal surface smoothness of the joint on a continuous line 1 inch back from the joint line using the 12 foot straightedge advanced one-half its length for each reading. Perform other tests of the exposed joint face to ensure that a uniform, true vertical joint face is attained. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and a report submitted within 24 hours after measurement is made. Identify areas requiring replacement within the report.

2.1.2.4 Excessive Edge Slump

When edge slump exceeding the limits specified above is encountered on either side of the paving lane, record additional straightedge measurements to define the linear limits of the excessive slump. Remove and replace concrete slabs having excessive edge slump or joint deformation to the next transverse joint in conformance with Paragraph "Repair, Removal, And Replacement Of Newly Constructed Slabs". Discontinue use of slip-form paving equipment and procedures that fail to consistently provide edges within the specified tolerances on edge slump and joint face deformation construct by means of standard paving procedures using fixed forms.
2.1.3 Plan Grade

Within 5 days after paving of each lot, test the finished surface of the pavement area by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and provide a copy to the Government at the completion of the survey of each lot. Provide finished surfaces of all airfield pavements that vary less than 1/2 inch above or below the plan grade line or elevation indicated. The above deviations from the approved grade line and elevation are not permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenant structures. Provide finished surfaces of new abutting pavements that coincide at their juncture. Provide horizontal control of the finished surfaces of all airfield pavements that vary not more than 1/2 inch from the plan alignment indicated.

2.1.4 Flexural Strength

Submit certified copies of laboratory test reports and sources for cement, supplementary cementitious materials (SCM), aggregates, admixtures, curing compound, epoxy, and proprietary patching materials proposed for use on this Project. Perform all aggregate tests no earlier than 6 months prior to Contract Award. Each lot of pavement will be evaluated for acceptance in accordance with the following procedures.

2.1.4.1 Sampling and Testing

For acceptance, obtain one composite sample of concrete from each sublot in accordance with ASTM C172 from one batch or truckload. Fabricate and cure test cylinders 6 by 12 inches in accordance with ASTM C31, and tested in accordance with ASTM C39. Test two test cylinders per sublot (8 per lot) at 14 days.

2.1.4.2 Computations

Average the eight 14-day strength tests for the lot. Use the average strength in accordance with Paragraph "Concrete Strength For Final Acceptance" in PART 2.

2.1.5 Thickness

Each lot of pavement will be evaluated for acceptance and payment adjustment in accordance with the following procedure. Drill two cores, between 4 and 6 inches in diameter, from the pavement, per sublot (8 per lot). Drill the cores within 3 days after lot placement, filling the core holes with an approved non-shrink concrete, respraying the cored areas with curing compound, and for measuring the cores. Inspect each core for voids, thickness of paste on the surface, and depth of reinforcement (if required). Provide the results with the thickness measurement data. Record eight measurements of thickness around the circumference of each core and one in the center, in accordance with ASTM C174. Average the pavement thickness from the 8 cores for the lot and evaluate as described in Paragraph "Payment Adjustment For Thickness" above.

2.1.6 Diamond Grinding of PCC Surfaces

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield pavements. In areas not
meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 ft wide. Diamond grinding equipment that causes raveling, aggregate fractures, spalls or disturbance to the joints is not permitted. The maximum area corrected by diamond grinding the surface of the hardened concrete is 10 percent of the total area of any subplot. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above in conformance with Paragraph "Repair, Removal And Replacement Of Newly Constructed Slabs". All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in Paragraph "Thickness", above.

Prior to production diamond grinding operations, perform a test section at the approved location. Perform a test section that consists of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish, transition between adjacent passes, and the results of crossing a transverse joint. Production diamond grinding operations are not to be performed prior to approval.

2.2 CEMENTITIOUS MATERIALS

Provide cementitious materials consisting of portland cement, blended cement or only portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.2.1 Portland Cement

Provide portland cement conforming to ASTM C150, Type II, low alkali including false set requirements.

2.2.2 Blended Cements

Provide blended cement conforms to ASTM C595, Type IP or IS, including the optional requirement for mortar expansion and sulfate soundness. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend are not allowed to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of Table 2 in Paragraph "Supplementary Cementitious Materials..."
(SCM) Content" do not apply to the SCM content of blended cement.

2.2.3 Pozzolan

2.2.3.1 Fly Ash

Provide fly ash that conforms to ASTM C618, Class F, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction with a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

2.2.3.2 Raw or Calcined Natural Pozzolan

Provide natural pozzolan that is raw or calcined and conforms to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction with a loss on ignition not exceeding 3 percent. Provide Class N pozzolan for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

2.2.3.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Provide Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) that conforms to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age of at least 95 percent of the control specimens.

b. The average particle size not exceeding 6 microns.

2.2.4 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) that conforms to ASTM C989, Grade 100 or Grade 120.

2.2.5 Supplementary Cementitious Materials (SCM) Content

Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR. The use of SCMs is encouraged in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

<table>
<thead>
<tr>
<th>Supplementary Cementitious Material</th>
<th>Minimum Content (percent)</th>
<th>Maximum Content (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class N Pozzolan and Class F Fly Ash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Si02 + Al2O3 + Fe2O3 &gt; 70 percent</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>Si02 + Al2O3 + Fe2O3 &gt; 80 percent</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Si02 + Al2O3 + Fe2O3 &gt; 90 percent</td>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>
2.3 AGGREGATES

2.3.1 Aggregate Sources

2.3.1.1 Durability of Coarse Aggregate

Provide aggregate with a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. Include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse aggregates, cement, and mineral admixtures in the service record. Consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio) in the review. Provide service record performed by an independent third party professional engineer, petrographer, or concrete materials engineer along with their resume. Include photographs and a written report addressing D-cracks and popouts in accordance with ACI 201.1R in the service record. Provide coarse aggregate with a durability factor of 80 or more when subjected to freezing and thawing of specimens prepared in accordance with ASTM C1646 and tested in accordance with ASTM C666, Procedure A, when a coarse aggregate size group or source proposed for use does not have a satisfactory demonstrable service record. Test all coarse aggregate size groups and sources proposed for use individually.

2.3.1.2 Alkali-Silica Reactivity

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all size groups and sources proposed for use.

a. Evaluate the fine and coarse aggregates separately, using ASTM C1260. Reject individual aggregates with test results that indicate an expansion of greater than 0.08 percent after 28 days of immersion in 1N NaOH solution, or perform additional testing as follows: Utilize the proposed low alkali portland cement, blended cement, and SCM, or Lithium Nitrate in combination with each individual aggregate. If only SCMs are being evaluated, test in accordance with ASTM C1567. If Lithium Nitrate is being evaluated, with or without SCMs, test in accordance with COE CRD-C 662. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity.

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.
2.3.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, provide the combined aggregate grading meeting the following requirements:

a. Provide materials selected and the proportions used such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point and its associated production tolerance thus determined falls within the parallelogram described therein. Refer to AF ETL 97-5 for combined aggregate plot area recommendations for the intended placement technique(s).

b. Determine the Coarseness Factor (CF) from the following equation:

\[
CF = \frac{100}{(\text{cumulative percent retained on the 3/8 inch sieve})} \cdot \frac{\text{cumulative percent retained on the No. 8 sieve}}{100}
\]

c. The Workability Factor (WF) is defined as the percent passing the No. 8 sieve based on the combined gradation. Adjust the WF, prorated upwards only, by 2.5 percentage points for each 94 pounds of cementitious material per cubic yard greater than 564 pounds per cubic yard.

d. Plot a diagram using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram, plot a parallelogram with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, revise the grading of each size of aggregate used and the proportions selected as necessary.

e. Plot the associated production tolerance limits, identified in Table 6, around the CF and adjusted WF point.

2.3.2 Coarse Aggregate

2.3.2.1 Material Composition

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof. Provide aggregates, as delivered to the mixers, consisting of clean, hard, uncoated particles meeting the requirements of ASTM C33 except as specified herein. Provide coarse aggregate that has been washed sufficient to remove dust and other coatings. Provide coarse aggregate with no more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131. Provide coarse aggregates with a maximum sodium sulfate soundness loss of 12 percent, or with a magnesium sulfate soundness loss of 18 percent after five cycles when tested in accordance with ASTM C88.

2.3.2.2 Particle Shape Characteristics

Provide particles of the coarse aggregate that are generally spherical or cubical in shape. The quantity of flat particles and elongated particles in any size group coarser than the 3/8 inch sieve are not allowed to exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.
2.3.2.3 Size and Grading

Provide coarse aggregate with a nominal maximum size of 1.5 inches. Grade and provide the individual aggregates in two size groups meeting the individual grading requirements of ASTM C33, Size No. 4 (1.5 to 0.75 inch) and Size No. 67 (0.75 inch to No. 4) to meet the coarseness and workability factor criteria for the proposed combined gradation. A third aggregate size group may be required to meet the above mentioned coarseness and workability criteria of Paragraph "Combined Aggregate Gradation".

2.3.2.4 Deleterious Materials - Airfield Pavements

The amount of deleterious material in each size group of coarse aggregate is not allowed to exceed the limits shown in Table 5 below, determined in accordance with the test methods shown.

| TABLE 5 |
|---------------------|---------------------|
| LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS |

<table>
<thead>
<tr>
<th>Percentage by Mass</th>
<th>Severe Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials (h)</td>
<td></td>
</tr>
<tr>
<td>Clay lumps and friable particles (ASTM C142)</td>
<td>0.2</td>
</tr>
<tr>
<td>Shale (a) (ASTM C295)</td>
<td>0.1</td>
</tr>
<tr>
<td>Material finer than No. 200 sieve (b) (ASTM C117)</td>
<td>0.5</td>
</tr>
<tr>
<td>Lightweight particles (c) (ASTM C123)</td>
<td>0.2</td>
</tr>
<tr>
<td>Clay ironstone (d) (ASTM C295)</td>
<td>0.1</td>
</tr>
<tr>
<td>Chert and cherty stone (less than 2.40 Sp. Gr.) (e) (ASTM C123 and ASTM C295)</td>
<td>0.1</td>
</tr>
<tr>
<td>Claystone, mudstone, and siltstone (f) (ASTM C295)</td>
<td>0.1</td>
</tr>
<tr>
<td>Shaly and argillaceous limestone (g) (ASTM C295)</td>
<td>0.2</td>
</tr>
<tr>
<td>Other soft particles (COE CRD-C 130)</td>
<td>1.0</td>
</tr>
<tr>
<td>Total of all deleterious substances exclusive of material finer than No. 200 sieve</td>
<td>1.0</td>
</tr>
</tbody>
</table>
TABLE 5

LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS

<table>
<thead>
<tr>
<th>Percentage by Mass</th>
<th>Severe Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials (h)</td>
<td></td>
</tr>
</tbody>
</table>

(a) Shale is defined as a fine-grained, thinly laminated or fissile sedimentary rock. It is commonly composed of clay or silt or both. It has been indurated by compaction or by cementation, but not so much as to have become slate.

(b) Limit for material finer than No. 200 sieve is allowed to be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale. Use XRD or other appropriate techniques as determined by petrographer to quantify amount and justify increase.

(c) Test with a separation medium with a density of Sp. Gr. of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

(d) Clay ironstone is defined as an impure variety of iron carbonate, iron oxide, hydrous iron oxide, or combinations thereof, commonly mixed with clay, silt, or sand. It commonly occurs as dull, earthy particles, homogeneous concretionary masses, or hard-shell particles with soft interiors. Other names commonly used for clay ironstone are "chocolate bars" and limonite concretions.

(e) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone.

(f) Claystone, mudstone, or siltstone, is defined as a massive fine-grained sedimentary rock that consists predominantly of indurated clay or silt without laminations or fissility. It may be indurated either by compaction or by cementation.

(g) Shaly limestone is defined as limestone in which shale occurs as one or more thin beds or laminae. These laminae may be regular or very irregular and may be spaced from a few inches down to minute fractions of an inch. Argillaceous limestone is defined as a limestone in which clay minerals occur disseminated in the stone in the amount of 10 to 50 percent by weight of the rock; when these make up from 50 to 90 percent, the rock is known as calcareous (or dolomitic) shale (or claystone, mudstone, or siltstone).
**TABLE 5**

<table>
<thead>
<tr>
<th>Material by Mass</th>
<th>Severe Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>(h) Performance testing in accordance with the referenced test methods, except use the minimum sample size specified below.</td>
<td></td>
</tr>
</tbody>
</table>

### 2.3.2.5 Testing Sequence for Deleterious Materials in Coarse Aggregate - Airfields Only

No extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements is allowed. The minimum test sample size of the coarse aggregate is 200 pounds for the 3/4 inch and larger maximum size and 25 pounds for the No. 4 to 3/4 inch coarse aggregate. Provide facilities for the ready procurement of representative test samples. The testing procedure on each sample of coarse aggregate for compliance with limits on deleterious materials is as follows:

**Step 1:** Wash each full sample of coarse aggregate for material finer than the No. 200 sieve. Discard material finer than the No. 200 sieve.

**Step 2:** Test remaining full sample for clay lumps and friable particles and remove.

**Step 3:** Test remaining full sample for chert and cherty stone with SSD density of less than 2.40 specific gravity. Remove lightweight chert and cherty stone. Restore other materials less than 2.40 specific gravity to the sample.

**Step 4:** Test remaining full sample for lightweight particles (Sp. Gr. 2.0) and remove.

**Step 5:** Test remaining sample for clay-ironstone, shale, claystone, mudstone, siltstone, shaly and argillaceous limestone, and remove.

**Step 6:** Test approximately one-fifth of remaining full sample for other soft particles.

### 2.3.2.6 Deleterious Material - Road Pavements

The amount of deleterious material in each size group of coarse aggregate is not to exceed the limits in the following table when tested as indicated.

<table>
<thead>
<tr>
<th>Material by Mass</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay lumps and friable particles (ASTM C142)</td>
<td>2.0</td>
</tr>
<tr>
<td>Material finer than No. 200 sieve (ASTM C117)</td>
<td>1.0</td>
</tr>
<tr>
<td>Lightweight particles (ASTM C123)</td>
<td>1.0</td>
</tr>
</tbody>
</table>
The limit for material finer than the No. 200 sieve is allowed to be increased to 1.5 percent for crushed aggregates consisting of crusher dust that is essentially free from clay or shale. Use a separation medium for lightweight particles with a density of 2.0 specific gravity. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.

2.3.3 Fine Aggregate

2.3.3.1 Composition

Provide fine aggregate consisting of natural sand, manufactured sand, or a combination of the two, and composed of clean, hard, durable particles meeting the requirements of ASTM C33. Stockpile and batch each type of fine aggregate separately. Provide fine aggregate with particles that are generally spherical or cubical in shape.

2.3.3.2 Grading

Provide fine aggregate, as delivered to the mixer, with a grading that conforms to the requirements of ASTM C33 and having a fineness modulus of not less than 2.50 nor more than 3.40.

2.3.3.3 Deleterious Material

The minimum test sample size for fine aggregate proposed for use in airfield paving is 10 pounds. The amount of deleterious material in the fine aggregate is not to exceed the following limits by mass:

<table>
<thead>
<tr>
<th>Material</th>
<th>Percentage by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay lumps and friable particles ASTM C142</td>
<td>1.0</td>
</tr>
<tr>
<td>Material finer than No. 200 sieve ASTM C117</td>
<td>3.0</td>
</tr>
<tr>
<td>Lightweight particles ASTM C123 using a medium with a density of Sp. Gr. of 2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Total of all above</td>
<td>3.0</td>
</tr>
</tbody>
</table>

2.4 CHEMICAL ADMIXTURES

2.4.1 General Requirements

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. Provide air-entraining admixture conforming to ASTM C260. An accelerating admixture conforming to ASTM C494, Type C, may be used only when specified in Paragraph "Mixture Proportions" below provided it is not
used to reduce the amount of cementitious material. Calcium chloride and admixtures containing calcium chloride are not allowed. Provide retarding or water-reducing admixture that meet the requirements of ASTM C494, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. ASTM C494, Type F and G high range water reducing admixtures and Type S specific performance admixtures are not allowed. ASTM C1017 flowable admixtures are not allowed.

2.4.2 Lithium Nitrate

Provide lithium admixture that consists of a nominal 30 percent aqueous solution of Lithium Nitrate, with a density of 10 pounds per gallon, with the approximate chemical form as shown below:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Limit (Percent by Mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiNO₃ (Lithium Nitrate)</td>
<td>30 plus or minus 0.5</td>
</tr>
<tr>
<td>SO₄⁻² (Sulfate Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>Cl⁻ (Chloride Ion)</td>
<td>0.2 (max)</td>
</tr>
<tr>
<td>Na⁺ (Sodium Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>K⁺ (Potassium Ion)</td>
<td>0.1 (max)</td>
</tr>
</tbody>
</table>

Provide the services of a manufacturer's technical representative experienced in dispensing, mixing, proportioning, placement procedures and curing of concrete containing lithium nitrate, at no expense to the Government. This representative is required to be present on the Project prior to and during at least the first two days of placement using lithium nitrate.

2.5 MEMBRANE FORMING CURING COMPOUND

Provide membrane forming curing compound that conforms to COE CRD-C 300 and is white pigmented.

2.6 WATER

Provide water for mixing and curing that is fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602.

2.7 JOINT MATERIALS

2.7.1 Expansion Joint Material

Provide preformed expansion joint filler material conforming to ASTM D1751.

Provide expansion joint filler that is 3/4 inch thick, unless otherwise indicated, and provided in a single full depth piece.

2.7.2 Slip Joint Material

Provide slip joint material that is 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to Paragraph "Expansion Joint Material".
2.8 **REINFORCING**

Provide reinforcement that is free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties is not allowed to be used.

2.8.1 Reinforcing Bars and Bar Mats

Provide reinforcing bars conforming to ASTM A615, billet-steel, Grade 60. Provide bar mats conforming to ASTM A184. The bar members may be billet rail or axle steel.

2.8.2 Welded Wire Reinforcement

Provide welded wire reinforcement that is deformed or smooth, conforming to ASTM A1064 or ASTM A185, and is provided in flat sheets.

2.9 **DOWELS**

2.9.1 Dowels

Provide dowels in single piece bars fabricated or cut to length at the shop or mill before delivery to the Site. Dowels are to be free of loose, flaky rust and loose scale and be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels are required to be plain (non-deformed) steel bars conforming to ASTM A615, Grade 40 or 60; ASTM A996, Grade 50 or 60. Dowel bars are required to be epoxy coated in conformance with ASTM A775, to include the ends. Provide grout retention rings that are fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.9.2 Dowel Bar Assemblies

Provide dowel bar assemblies that consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. Provide dowels that are welded to the assembly or held firmly by mechanical locking arrangements that prevent them from rising, sliding out, or becoming distorted during paving operations.

2.10 **EPOXY RESIN**

Provide epoxy-resin materials that consist of two-component materials conforming to the requirements of ASTM C881, Class as appropriate for each application temperature to be encountered, except that in addition, the materials meet the following requirements:

a. Material for use for embedding dowels and anchor bolts be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar be Type
III, Grade as approved.

c. Material for use for injecting cracks be Type IV, Grade 1.

d. Material for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete be Type V, Grade as approved.

2.11 EQUIPMENT

All plant, equipment, tools, and machines used in the work are required to be maintained in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant, at no expense to the Government. Provide inspection report of the concrete plant by an engineer approved by the NRMCA. A list of NRMCA approved engineers is available on the NRMCA website at http://www.nrmca.org. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist, NRMCA Certificate of Conformance, and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature is required to show that the equipment meets all details of these specifications. Include detailed information on automatic laser controlled systems if proposed for use.

2.11.1 Batching and Mixing Plant

2.11.1.1 Location

Locate the batching and mixing plant off Government premises no more than 15 minutes haul time from the placing site. Water and electrical power are not available on the Project Site. Provide operable telephonic or radio communication between the plant and the placing site at all times concreting is taking place.

2.11.1.2 Type and Capacity

Provide a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of 250 cubic yards per hour, that conforms to the requirements of NRMCA QC 3 including provisions addressing:

a. Material Storage and Handling.
b. Batching Equipment.

c. Central Mixer.

d. Ticketing System.

e. Delivery System.

2.11.1.3 Tolerances

<table>
<thead>
<tr>
<th>Materials</th>
<th>Percentage of Required Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cementitious Materials</td>
<td>plus or minus 1</td>
</tr>
<tr>
<td>Aggregate</td>
<td>plus or minus 2</td>
</tr>
<tr>
<td>Water</td>
<td>plus or minus 1</td>
</tr>
<tr>
<td>Admixture</td>
<td>plus or minus 3</td>
</tr>
</tbody>
</table>

For volumetric batching equipment for water and admixtures, the above numeric tolerances apply to the required volume of material being batched. Dilute concentrated admixtures uniformly, if necessary, to provide sufficient volume per batch to ensure that the batchers consistently operate within the above tolerance.

2.11.1.4 Moisture Control

Provide a plant capable of ready adjustment to compensate for the varying moisture contents of the aggregates and to change the quantities of the materials being batched.

2.11.2 Concrete Mixers

Provide stationary or truck mixers that are capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. Do not charge the mixers in excess of the capacity recommended by the manufacturer. Operate the mixers at the drum or mixing blade speed designated by the manufacturer. Maintain the mixers in satisfactory operating condition, with the mixer drums kept free of hardened concrete. Replace mixer blades or paddles when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades or paddles.

2.11.2.1 Stationary

Stationary mixers are required to be drum or pan mixers. Provide mixers with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed.

2.11.2.2 Mixing Time and Uniformity for Stationary Mixers

For stationary mixers, before uniformity data are available, the minimum mixing time for each batch after all solid materials are in the mixer, provided that all of the mixing water is introduced before one-fourth of the mixing time has elapsed, is 1 minute for mixers having a capacity of 1 cubic yard. For mixers of greater capacity, increase this minimum time by 20 seconds for each additional 1.33 cubic yard or fraction thereof. After
results of uniformity tests are available, the mixing time may be reduced to the minimum time required to meet uniformity requirements; but if uniformity requirements are not being met, increase the mixing time as directed. Perform mixer performance tests at new mixing times immediately after any change in mixing time or volume. Conduct the Regular Test sequence for initial determination of the mixing time or as directed. When regular testing is performed, the concrete is required to meet the limits of any five of the six uniformity requirements listed in Table 1 below.

2.11.2.3 Abbreviated Test

Conduct the Abbreviated Test sequence for production concrete verification at the frequency specified in Table 6. When abbreviated testing is performed, the concrete is required to meet only those requirements listed for abbreviated testing. Use the projects approved mix design proportions for uniformity testing. For regular testing perform all six tests on three batches of concrete. The range for regular testing is the average of the ranges of the three batches. Abbreviated testing consists of performing the three required tests on a single batch of concrete. The range for abbreviated testing is the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, the results of tests on one of the mixers apply to the others, subject to the approval. Perform all mixer performance (uniformity) testing in accordance with COE CRD-C 55 and with Paragraph "Testing And Inspection For Contractor Quality Control During Construction" in PART 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Regular Tests Allowable Maximum Range for Average of 3 Batches</th>
<th>Abbreviated Tests Allowable Maximum Range for 1 Batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit weight of air-free mortar</td>
<td>2.0 pounds per cubic foot</td>
<td>2.0 pounds per cubic foot</td>
</tr>
<tr>
<td>Air content</td>
<td>1.0 percent</td>
<td>--</td>
</tr>
<tr>
<td>Slump</td>
<td>1.0 inch</td>
<td>1.0 inch</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>6.0 percent</td>
<td>6.0 percent</td>
</tr>
<tr>
<td>Compressive strength at 7 days</td>
<td>10.0 percent</td>
<td>10.0 percent</td>
</tr>
<tr>
<td>Water content</td>
<td>1.5 percent</td>
<td></td>
</tr>
</tbody>
</table>

2.11.2.4 Truck

Truck mixers are not allowed for mixing or transporting slipformed paving concrete. Provide only truck mixers designed for mixing or transporting paving concrete with extra large blading and rear opening specifically for low-slump paving concrete. Provide truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof that conform to the requirements of ASTM C94. Determine the number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete by uniformity tests as specified in ASTM C94 and in requirements for mixer performance stated in Paragraph "Testing and Inspection for Contractor Quality Control During Construction" in PART 3.
If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, discontinue use of the mixer until the condition is corrected. Water is not allowed to be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Inject water into the head of the mixer (end opposite the discharge opening) drum under pressure, and turn the drum or blades a minimum of 30 additional revolutions at mixing speed. The addition of water to the batch at any later time is not allowed. Perform mixer performance (uniformity) tests for truck mixers in accordance with ASTM C94.

2.11.3 Transporting Equipment

Transport slipform concrete to the paving site in non-agitating equipment conforming to ASTM C94 or in approved agitators. Transport fixed form concrete in approved truck mixers designed with extra large blading and rear opening specifically for low slump concrete. Provide transporting equipment designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.11.4 Transfer and Spreading Equipment

Provide equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver that is specially manufactured, self-propelled transfer equipment which accepts the concrete outside the paving lane, transfers, and spreads it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

2.11.5 Paver-Finisher

Provide paver-finisher consisting of a heavy-duty, self-propelled machine designed specifically for paving and finishing high quality pavement, with a minimum weight of 2200 pounds per foot of lane width, and powered by an engine having a minimum 6.0 horsepower per foot of lane width. The paver-finisher is required to spread, consolidate, and shape the plastic concrete to the desired cross section in one pass. The mechanisms for forming the pavement are required to be easily adjustable in width and thickness and for required crown. In addition to other spreaders required by paragraph above, the paver-finisher equipped with a full width knock-down auger or paddle mechanism, capable of operating in both directions, which evenly spreads the fresh concrete in front of the screed or extrusion plate.

2.11.5.1 Vibrators

Provide gang mounted immersion vibrators at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete, as required. Provide vibrators that are automatically controlled to immediately stop as forward motion of the paver ceases. Equipped the paver-finisher with an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator with a readout display visible to the paver operator that operates continuously while paving, and displays all vibrator frequencies with manual or automatic
sequencing among all individual vibrators. Discontinue paving if the vibrator monitoring system fails to operate properly during the paving operation. Provide the spacing of the immersion vibrators across the paving lane as necessary to properly consolidate the concrete, with a maximum clear distance between vibrators of 30 inches and outside vibrators a maximum of 12 inches from the lane edge. Operate spud vibrators at a minimum frequency of 8000 impulses per minute and a minimum amplitude of 0.03 inch, as determined by COE CRD-C 521.

2.11.5.2 Screed or Extrusion Plate

Equipped the paver-finisher with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface and finish the surface that no significant amount of hand finishing, except use of cutting straightedges, is required. Provide a screed or extrusion plate constructed to adjust for crown in the pavement. Provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed or extrusion plate extending over previously placed concrete on either end when paving fill-in lanes. Repair or replace machines that cause displacement of properly installed forms or cause ruts or indentations in the prepared underlying materials and machines that cause frequent delays due to mechanical failures as directed.

2.11.5.3 Longitudinal Mechanical Float

A longitudinal mechanical float may be used. If used, provide a float that is specially designed and manufactured to smooth and finish the pavement surface without working excess paste to the surface that is rigidly attached to the rear of the paver-finisher or to a separate self-propelled frame spanning the paving lane. Provide float plate at least 5 feet long by 8 inches wide and automatically be oscillated in the longitudinal direction while slowly moving from edge to edge of the paving lane, with the float plate in contact with the surface at all times.

2.11.5.4 Other Types of Finishing Equipment

Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to approval. Provide bridge deck finishers with a minimum operating weight of 7500 pounds that have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Only use vibrating screeds or pans for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

2.11.5.5 Fixed Forms

Provide paver-finisher equipped with wheels designed to ride the forms, keep it aligned with the forms, and spread the load so as to prevent deformation of the forms. Provide paver-finishers traveling on guide rails located outside the paving lane that are equipped with wheels when traveling on new or existing concrete to remain. Alternatively, a modified slipform paver that straddles the forms may be used. Provide a modified slipform paver which has the side conforming plates removed or rendered ineffective and travels over or along pre-placed fixed forms.

2.11.5.6 Slipform

The slipform paver-finisher is required to be automatically controlled and
crawlers mounted with padded tracks so as to be completely stable under all operating conditions and provide a finish to the surface and edges so that no edge slump beyond allowable tolerance occurs. Provide suitable moving side forms that are adjustable and produce smooth, even edges, perpendicular to the top surface and meeting Specification Requirements for alignment and freedom from edge slump.

2.11.6 Curing Equipment

Provide equipment for applying membrane-forming curing compound mounted on a self-propelled frame that spans the paving lane. Constantly agitate the curing compound reservoir mechanically (not air) during operation and provide a means for completely draining the reservoir. Provide a spraying system that consists of a mechanically powered pump which maintains constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to provide uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. Protect all spray nozzles with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in Paragraph "Membrane Curing". Provide hand-operated sprayers allowed by that paragraph with compressed air supplied by a mechanical air compressor. Immediately replace curing equipment if it fails to apply an even coating of compound at the specified rate.

2.11.7 Texturing Equipment

Provide texturing equipment as specified below. Before use, demonstrate the texturing equipment on a test section, and modify the equipment as necessary to produce the texture directed.

2.11.7.1 Burlap Drag

Securely attach a burlap drag to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Provide length of the material between 24 to 36 inches dragging flat on the pavement surface. Provide burlap drag with a width at least equal to the width of the slab. Provide clean, reasonably new burlap material, completely saturated with water before attachment to the frame, always resaturated before start of use, and kept clean and saturated during use. Provide burlap conforming to AASHTO M 182, Class 3 or 4.

2.11.7.2 Broom

Apply surface texture using an approved mechanical stiff bristle broom drag of a type that provides a uniformly scored surface transverse to the pavement center line. Provide broom capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure that results in scores uniform in appearance and approximately 1/16 inch in depth but not more than 1/8 inch in depth.

2.11.8 Sawing Equipment

Provide equipment for sawing joints and for other similar sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to
maintain the required sawing rate. Provide wheel saws used in the removal of concrete with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which produce a saw kerf at least 1-1/2 inches wide. Provide saws capable of sawing to the full depth required. Early-entry saws may be used, subject to demonstration and approval. No change to the initial sawcut depth is permitted.

2.11.9 Straightedge

Provide and maintain at the job site, in good condition, a minimum 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. Provide straightedges constructed of aluminum or magnesium alloy and blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide straightedges with handles for operation on the pavement.

2.11.10 Work Bridge

Provide a self-propelled working bridge capable of spanning the required paving lane width where workmen can efficiently and adequately reach the pavement surface.

2.12 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.12.1 Specified Flexural Strength

Specified flexural strength, R, for concrete is 650 psi at 28 days, as determined by equivalent flexural strength, as specified in Paragraph "Mixture Proportioning For Flexural Strength" below.

2.12.2 Water-Cementitious Materials Ratio

Maximum allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio is the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1.

2.12.3 Air Content

Provide concrete that is air-entrained with a total air content of 6.0 plus or minus 1.5 percentage points, at the point of placement. Determine air content in accordance with ASTM C231.

2.12.4 Slump

The maximum allowable slump of the concrete at the point of placement is 2 inches for pavement constructed with fixed forms. For slipformed pavement, at the start of the project, select a slump which produces in-place pavement meeting the specified tolerances for control of edge slump. The selected slump is applicable to both pilot and fill-in lanes.

2.12.5 Concrete Temperature

The temperature of the concrete as delivered is required to conform to the requirements of Paragraphs "Paving In Hot Weather and Paving In Cold Weather", in PART 3. Determine the temperature of concrete in accordance with ASTM C1064.
2.12.6 Concrete Strength for Final Acceptance

The strength of the concrete will be considered acceptable when the equivalent 28-day flexural strengths for each lot are above the 'Specified Flexural Strength' as determined by correlation with 14-day flexural strength tests specified in Paragraph "Mixture Proportioning for Flexural Strength" below, and no individual set (2 specimens per subplot) in the lot are 25 psi or more below the equivalent 'Specified Flexural Strength'. If any lot or subplot, respectively, fails to meet the above criteria, remove and replace the lot or subplot at no additional cost to the Government. This is in addition to and does not replace the average strength required for day-to-day CQC operations as specified in Paragraph "Average CQC Flexural Strength Required for Mixtures", below.

2.13 MIXTURE PROPORTIONS

2.13.1 Composition

Provide concrete composed of cementitious material, water, fine and coarse aggregates, and admixtures. Include supplementary Cementitious Materials (SCM) choice and usage in accordance with Paragraph "Supplementary Cementitious Materials (SCM) Content". Provide a minimum total cementitious materials content of 517 pounds per cubic yard. Acceptable admixtures consist of air entraining admixture and may also include, as approved, water-reducing and retarding admixtures.

2.13.2 Proportioning Studies

Perform trial design batches, mixture proportioning studies, and testing, at no expense to the Government. Submit for approval the Preliminary Proposed Proportioning to include items a., b., and i., below a minimum of 7 days prior to beginning the mixture proportioning study. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. Include a statement summarizing the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard basis. Base aggregate quantities on the mass in a saturated surface dry condition. Provide test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. Base methodology for trial mixtures having proportions, slumps, and air content suitable for the work as described in ACI 211.1, modified as necessary to accommodate flexural strength. Submit test results including:

a. Coarse and fine aggregate gradations and plots.

b. Combined aggregate gradation and coarseness vs. workability plots.

c. Coarse aggregate quality test results, include deleterious materials.

d. Fine aggregate quality test results.

e. Mill certificates for cement and supplemental cementitious materials.

f. Certified test results for air entraining, water reducing, retarding, non-chloride accelerating admixtures.

g. Specified flexural strength, slump, and air content.
h. Documentation of required average CQC flexural strength, Ra.

i. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios.

j. Individual beam and cylinder breaks.

k. Flexural and compressive strength summaries and plots.

l. Correlation ratios for acceptance testing and CQC testing.

m. Historical record of test results, documenting production standard deviation (if available).

n. Narrative discussing methodology on how the mix design was developed.

o. Alternative aggregate blending to be used during the test section if necessary to meet the required surface and consolidation requirements.

2.13.2.1 Water-Cementitious Materials Ratio

Perform at least three different water-cementitious materials ratios, which produce a range of strength encompassing that required on the Project. The maximum allowable water-cementitious material ratio required in Paragraph "Specified Flexural Strength", above is the equivalent water-cementitious materials ratio. The maximum water-cementitious materials ratio of the approved mix design becomes the maximum water-cementitious materials ratio for the Project, and in no case exceeds 0.45.

2.13.2.2 Trial Mixture Studies

Perform separate sets of trial mixture studies made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either are to be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerating or retarding admixture may be used without separate trial mixture study. Perform separate trial mixture studies for each placing method (slip form, fixed form, or hand placement) proposed. Report the temperature of concrete in each trial batch. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding. Proportion laboratory trial mixtures for maximum permitted slump and air content.

2.13.2.3 Mixture Proportioning for Flexural Strength

Follow the step by step procedure below:

a. Fabricate all beams and cylinders for each mixture from the same batch or blend of batches. Fabricate and cure all beams and cylinders in accordance with ASTM C192, using 6 by 6 inches steel beam forms and 6 by 12 inches single-use cylinder forms.

b. Cure test beams from each mixture for 3, 7, 14, and 28-day flexural tests; 6 beams to be tested per age.

c. Cure test cylinders from each mixture for 3, 7, 14, and 28-day compressive strength tests; 6 cylinders to be tested per age.
d. Test beams in accordance with ASTM C78, cylinders in accordance with ASTM C39.

e. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:

3-day flexural strength
7-day flexural strength
14-day flexural strength
28-day flexural strength

3-day compressive strength
7-day compressive strength
14-day compressive strength
28-day compressive strength

f. From these graphs select a w/c that produces a mixture giving a 28-day flexural strength equal to the required strength determined in accordance with the next paragraph.

g. Using the above selected w/c, select from the graphs the expected 3, 7, 14, 28-day flexural strengths and the expected 3, 7, 14, 28-day compressive strengths for the mixture.

h. From the above expected strengths for the selected mixture determine the following Correlation Ratios:

(1) Ratio of the 14-day compressive strength of the selected mixture to the 28-day flexural strength of the mixture (for acceptance).

(2) Ratio of the 7-day compressive strength of the selected mixture to the 28-day flexural strength of the mixture (for CQC control).

i. If there is a change in materials, perform additional mixture design studies using the new materials and new Correlation Ratios determined.

j. No concrete pavement placement is allowed until the mixture proportions are approved. The approved water-cementitious materials ratio is restricted to the maximum value specified in the next paragraph and not be increased without written approval.

2.13.3 Average CQC Flexural Strength Required for Mixtures

In order to ensure meeting the strength requirements specified in Paragraph "Specified Concrete Strength and Other Properties" above, during production, the mixture proportions selected during mixture proportioning studies and used during construction requires an average CQC flexural strength exceeding the specified strength, R, by the amount indicated below. This required average CQC flexural strength, Ra, is used only for CQC operations as specified in Paragraph "Testing And Inspection for Contractor Quality Control During Construction" in PART 3 and as specified in the previous paragraph. During production, adjust the required Ra, as appropriate and as approved, based on the standard deviation of equivalent 28-day strengths being attained during paving.

2.13.3.1 From Previous Test Records

Where a concrete production facility has previous test records current to within 18 months, establish a standard deviation in accordance with the
applicable provisions of ACI 214R. Include test records from which a standard deviation is calculated that represent materials, quality control procedures, and conditions similar to those expected, that represent concrete produced to meet a specified flexural strength or strengths within 150 psi of the 28-day flexural strength specified for the proposed work, and that consist of at least 30 consecutive tests. Perform verification testing to document the current strength. A strength test is the average of the strengths of two specimens made from the same sample of concrete and tested at 28 days. Required average CQC flexural strength, Ra, used as the basis for selection of concrete proportions is the value from the equation that follows, using the standard deviation as determined above:

\[ Ra = R + 1.34S \]

Where:  
- \( S \) = standard deviation  
- \( R \) = specified flexural strength  
- Ra = required average flexural strength

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, establish a standard deviation as the product of the calculated standard deviation and a modification factor from the following table:

<table>
<thead>
<tr>
<th>NUMBER OF TESTS</th>
<th>MODIFICATION FACTOR FOR STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1.16</td>
</tr>
<tr>
<td>20</td>
<td>1.08</td>
</tr>
<tr>
<td>25</td>
<td>1.03</td>
</tr>
<tr>
<td>30 or more</td>
<td>1.00</td>
</tr>
</tbody>
</table>

2.13.3.2 Without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, determine the required average strength, Ra, by adding 15 percent to the specified flexural strength, R.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Before commencing paving, perform the following. If used, place cleaned, coated, and adequately supported forms. Have any reinforcing steel needed at the paving site; all transporting and transfer equipment ready for use, clean, and free of hardened concrete and foreign material; equipment for spreading, consolidating, screeding, finishing, and texturing concrete at the paving site, clean and in proper working order; and all equipment and material for curing and for protecting concrete from weather or mechanical damage at the paving site, in proper working condition, and in sufficient amount for the entire placement.

3.1.1 Weather Precaution

When windy conditions during paving appear probable, have equipment and
material at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment and profilographs; demolition of existing pavements, as specified; pavement diamond grinding equipment and procedures. Submit for approval the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints; transverse and longitudinal dowel bar spacing; and identifying pilot lanes and hand placement areas. Deviations from the jointing pattern shown on the Drawings are not allowed without written approval of the design engineer.

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Data on profilograph and methods to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Verify the underlying material, upon which concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, verify the underlying material is well drained and have been satisfactorily graded by string-line controlled, automated, trimming machine and uniformly compacted in accordance with the applicable Section of these Specifications. Test the surface of the underlying material to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. Trim high areas to proper elevation. Fill and compact low areas to a condition similar to that of surrounding grade, or filled with concrete monolithically with the pavement. Low areas filled with concrete are not to be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver. If a slipform paver is used, continue the same underlying material under the paving lane beyond the edge of the lane a sufficient distance that is thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.
3.2.2 Traffic on Underlying Material

After the underlying material has been prepared for concrete placement, equipment is not permitted thereon. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. Rework and repair the surface before concrete is placed. Transporting equipment is not to be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather. Completely remove any slab damaged by rain or other weather full depth, by full slab width, to the nearest original joint, and replaced as specified in Paragraph "Repair, Removal and Replacement of Newly Constructed Slabs" below, at no expense to the Government.

3.3.2 Paving in Hot Weather

When the ambient temperature during paving is expected to exceed 90 degrees F, properly place and finish the concrete in accordance with procedures previously submitted, approved, and as specified herein. Provide concrete that does not exceed the temperature shown in the table below when measured in accordance with ASTM C1064 at the time of delivery. Cooling of the mixing water or aggregates or placing in the cooler part of the day may be required to obtain an adequate placing temperature. Cool steel forms and reinforcing as needed to maintain steel temperatures below 120 degrees F. Cool or protect transporting and placing equipment if necessary to maintain proper concrete placing temperature. Keep the finished surfaces of the newly laid pavement damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

<table>
<thead>
<tr>
<th>Relative Humidity, Percent, During Time of Concrete Placement</th>
<th>Maximum Allowable Concrete Temperature in Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 60</td>
<td>90</td>
</tr>
<tr>
<td>40-60</td>
<td>85</td>
</tr>
<tr>
<td>Less than 40</td>
<td>80</td>
</tr>
</tbody>
</table>

3.3.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic

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shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement may be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. Immediately commence curing procedures when such water treatment is stopped. Repair plastic shrinkage cracks in accordance with Paragraph "Repair, Removal, and Replacement of Newly Constructed Slabs”. Never trowel over or fill plastic shrinkage cracks with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving is required to conform to ACI 306R. Use special protection measures, as specified herein, if freezing temperatures are anticipated or occur before the expiration of the specified curing period. Do not begin placement of concrete unless the ambient temperature is at least 35 degrees F and rising. Thereafter, halt placement of concrete whenever the ambient temperature drops below 40 degrees F. When the ambient temperature is less than 50 degrees F, the temperature of the concrete when placed is required to be not less than 50 degrees F nor more than 75 degrees F. Provide heating of the mixing water or aggregates as required to regulate the concrete placing temperature. Materials entering the mixer are required to be free from ice, snow, or frozen lumps. Do not incorporate salt, chemicals or other materials in the concrete to prevent freezing. Provide covering and other means for maintaining the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period. Remove pavement slabs, full depth by full width, damaged by freezing or falling below freezing temperature to the nearest planned joint, and replace as specified in Paragraph "Repair, Removal, and Replacement of Newly Constructed Slabs”, at no expense to the Government.

3.4 CONCRETE PRODUCTION

Provide batching, mixing, and transporting equipment with a capacity sufficient to maintain a continuous, uniform forward movement of the paver of not less than 2.5 feet per minute. Deposit concrete transported in non-agitating equipment in front of the paver within 45 minutes from the time cement has been charged into the mixing drum, except that if the ambient temperature is above 90 degrees F, the time is reduced to 30 minutes. Deposit concrete transported in truck mixers in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 90 degrees F, the time is reduced to 60 minutes. Accompany every load of concrete delivered to the paving site with a batch ticket from the operator of the batching plant. Provide batch ticket information required by ASTM C94 on approved forms. In addition provide design quantities in mass or volume for all materials, batching tolerances of all materials, and design and actual water cementitious materials ratio on each batch delivered, the water meter and revolution meter reading on truck mixers and the time of day. Provide batch tickets for each truck delivered as part of the lot acceptance package to the placing foreman to maintain on file and deliver them to the Government weekly.
3.4.1 Batch and Mix Concrete

Maintain scale pivots and bearings clean and free of rust. Remove any equipment which fails to perform as specified immediately from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Operate non-agitating equipment only on smooth roads and for haul time less than 15 minutes. Deposit concrete as close as possible to its final position in the paving lane. Operate all equipment to discharge and transfer concrete without segregation. Dumping of concrete in discrete piles is not permitted. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete are permitted.

3.5 PAVING

3.5.1 General Requirements

Construct pavement with paving and finishing equipment utilizing rigid fixed forms or by use of slipform paving equipment. Provide paving and finishing equipment and procedures capable of constructing paving lanes of the required width at a rate of at least 2.5 feet of paving lane per minute on a routine basis. Control paving equipment and its operation, and coordinated with all other operations, such that the paver-finisher has a continuous forward movement at a reasonably uniform speed from beginning to end of each paving lane, except for inadvertent equipment breakdown. Backing the paver and refinish of a lane is not permitted. Remove and replace concrete refinished in this manner. Failure to achieve a continuous forward motion requires halting operations, regrouping, and modifying operations to achieve this requirement. Personnel are not permitted to walk or operate in the plastic concrete at any time. Where an open-graded granular base is required under the concrete, select paving equipment and procedures which operate properly on the base course without causing displacement or other damage.

3.5.2 Consolidation

Consolidate concrete with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. Insert vibrators into the concrete to a depth that provides the best full-depth consolidation but not closer to the underlying material than 2 inches. Excessive vibration is not permitted. Discontinue paving operations if vibrators cause visible tracking in the paving lane, until equipment and operations have been modified to prevent it. Vibrate concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Do not use vibrators to transport or spread the concrete. Do not operate hand-operated vibrators in the concrete at one location for more than 20 seconds. Insert hand-operated vibrators between 6 to 15 inches on centers. For each paving train, provide at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) requires the immediate stopping of the paving operation and approved adjustment of the equipment or procedures.

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3.5.3 Operation

When the paver approaches a header at the end of a paving lane, maintain a sufficient amount of concrete ahead of the paver to provide a roll of concrete which spills over the header. Provide a sufficient amount of extra concrete to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. Maintain the spud vibrators in front of the paver at the desired depth as close to the header as possible before they are lifted. Provide additional consolidation adjacent to the headers by hand-manipulated vibrators. When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provide provisions to prevent damage to the previously constructed pavement. Electronically control screeds or extrusion plates from the previously placed pavement so as to prevent them from applying pressure to the existing pavement and to prevent abrasion of the pavement surface. Maintain the overlapping area of existing pavement surface completely free of any loose or bonded foreign material as the paver-finisher operates across it. When the paver travels on existing pavement, maintain approved provisions to prevent damage to the existing pavement. Pavers using transversely oscillating screeds are not allowed to form fill-in lanes that have widths less than a full width for which the paver was designed or adjusted.

3.5.4 Required Results

Adjust and operate the paver-finisher, its gang-mounted vibrators and operating procedures coordinated with the concrete mixture being used, to produce a thoroughly consolidated slab throughout that is true to line and grade within specified tolerances. Provide a paver-finishing operation that produces a surface finish free of irregularities, tears, voids of any kind, and any other discontinuities in a single pass across the pavement; multiple passes are not permitted. Provide equipment and its operation that produce a finished surface requiring no hand finishing other than the use of cutting straightedges, except in very infrequent instances. Stop paving if any equipment or operation fails to produce the above results. Prior to recommencing paving, properly adjust or replace the equipment, modify the operation, or modify the mixture proportions, in order to produce the required results. No water, other than fog sprays (mist) as specified in Paragraph "Prevention of Plastic Shrinkage Cracking" above, is allowed to be applied to the concrete or the concrete surface during paving and finishing.

3.5.5 Fixed Form Paving

Provide paving equipment for fixed-form paving and the operation that conforms to the requirements of Paragraph "Equipment", and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Provide straight forms made of steel and in sections not less than 10 feet in length that are clean and free of rust or other contaminants. Seal any holes or perforations in forms prior to paving unless otherwise permitted. Maintain forms in place and passable by all equipment necessary to complete the entire paving operation without need to remove horizontal form supports. Provide flexible or curved forms of proper radius for curves of 100-foot radius or less. Provide wood forms for curves and fillets made of well-seasoned, surfaced plank.

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or plywood, straight, and free from warp or bend that have adequate strength and are rigidly braced. Provide forms with a depth equal to the pavement thickness at the edge. Where the Project requires several different slab thicknesses, forms may be built up by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form and provide an increase in depth of not more than 25 percent. Provide forms with the base width of the one-piece or built-up form not less than eight-tenths of the vertical height of the form, except provide forms 8 inches or less in vertical height with a base width not less than the vertical height of the form. Provide forms with maximum vertical deviation of top of any side form, including joints, not varying from a true plane more than 1/8 inch in 10 feet, and the upstanding leg not varying more than 1/4 inch.

b. Provide form sections that are tightly locked and free from play or movement in any direction. Provide forms with adequate devices for secure settings so that when in place they withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms do not deviate vertically more than 0.01 foot from required grade and elevations indicated. Check conformity to the alignment and grade elevations shown on the drawings and make necessary corrections immediately prior to placing the concrete. Clean and oil the forms each time before concrete is placed. Concrete placement is not allowed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

e. Securely hold forms for overlay pavements and for other locations where forms set on existing pavements in place with stakes or by other approved methods. Carefully drill holes in existing pavements for form stakes by methods which do not crack or spall the existing pavement. After use, fill the holes flush with the surrounding surface using approved material, prior to overlying materials being placed. Immediately discontinue any method which does not hold the form securely or which damages the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location without proceeding further until the proposed method is approved.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time, as directed. Remove forms by procedures that do not damage the concrete. Do not use bars or heavy metal tools directly against the concrete in removing the forms. Promptly repair any concrete found to be defective after form removal, using procedures specified or as directed.
3.5.6 Slipform Paving

3.5.6.1 General

Provide paving equipment for slipform paving and the operation thereof that conforms to the requirement of Paragraph "Equipment", and all requirements specified herein. Provide a slipform paver capable of shaping the concrete to the specified and indicated cross section, meeting all tolerances, with a surface finish and edges that require only a very minimum isolated amount of hand finishing, in one pass. If the paving operation does not meet the above requirements and the specified tolerances, immediately stop the operation, and regroup and replace or modify any equipment as necessary, modify paving procedures or modify the concrete mix, in order to resolve the problem. Provide a slipform paver that is automatically electronically controlled from a taut wire guideline for horizontal alignment and on both sides from a taut wire guideline for vertical alignment, except that electronic control from a ski operating on a previously constructed adjoining lane is required where applicable for either or both sides. Automatic, electronic controls are required for vertical alignment on both sides of the lane. Control from a slope-adjustment control or control operating from the underlying material is not allowed. Properly adjust side forms on slipform pavers so that the finished edge of the paving lane meets all specified tolerances. Install dowels in longitudinal construction joints as specified below. The installation of these dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete is not permitted.

3.5.6.2 Guideline for Slipform Paving

Accurately and securely install guidelines well in advance of concrete placement. Provide supports at necessary intervals to eliminate all sag in the guideline when properly tightened. Provide guideline consisting of high strength wire set with sufficient tension to remove all sag between supports. Provide supports that are securely staked to the underlying material or other provisions made to ensure that the supports are not displaced when the guideline is tightened or when the guideline or supports are accidentally touched by workmen or equipment during construction. Provide appliances for attaching the guideline to the supports that are capable of easy adjustment in both the horizontal and vertical directions. When it is necessary to leave gaps in the guideline to permit equipment to use or cross underlying material, provide provisions for quickly and accurately replacing the guideline without any delay to the forward progress of the paver. Provide supports on either side of the gap that are secured in such a manner as to avoid disturbing the remainder of the guideline when the portion across the gap is positioned and tightened. Check the guideline across the gap and adjacent to the gap for a distance of 200 feet for horizontal and vertical alignment after the guideline across the gap is tightened. Provide vertical and horizontal positioning of the guideline such that the finished pavement conforms to the alignment and grade elevations shown on the drawings within the specified tolerances for grade and smoothness. The specified tolerances are intended to cover only the normal deviations in the finished pavement that may occur under good supervision and do not apply to setting of the guideline. Set the guideline true to line and grade.

3.5.6.3 Stringless Technology

If the use of any type of stringless technology is proposed, submit a detailed description of the system and perform a trial field demonstration
at least one week prior to start of paving. Approval of the control system will be based on the results of the demonstration and on continuing satisfactory operation during paving.

3.5.7 Placing Reinforcing Steel

Provide the type and amount of steel reinforcement indicated.

3.5.7.1 Pavement Thickness Greater Than 12 inches

For pavement thickness of 12 inches or more, install the reinforcement steel by the strike-off method wherein a layer of concrete is deposited on the underlying material, consolidated, and struck to the indicated elevation of the steel reinforcement. Place the reinforcement upon the pre-struck surface, followed by placement of the remaining concrete and finishing in the required manner. When placement of the second lift causes the steel to be displaced horizontally from its original position, provide provisions for increasing the thickness of the first lift and depressing the reinforcement into the unhardened concrete to the required elevation. Limit the increase in thickness only as necessary to permit correct horizontal alignment to be maintained. Remove and replace any portions of the bottom layer of concrete that have been placed more than 30 minutes without being covered with the top layer with newly mixed concrete without additional cost to the Government.

3.5.7.2 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, position the reinforcement on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Consolidate concrete after the steel has been placed. Regardless of placement procedure, provide reinforcing steel free from coatings which could impair bond between the steel and concrete, with reinforcement laps as indicated. Regardless of the equipment or procedures used for installing reinforcement, ensure that the entire depth of concrete is adequately consolidated.

3.5.8 Placing Dowels

Ensure the method used to install and hold dowels in position result in dowel alignment within the maximum allowed horizontal and vertical tolerance of 1/8 inch per foot after the pavement has been completed. Except as otherwise specified below, maintain the horizontal spacing of dowels within a tolerance of plus or minus 5/8 inch. Locate the dowel vertically on the face of the slab within a tolerance of plus or minus 1/2 inch). Measure the vertical alignment of the dowels parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Measure dowels across crowns and other joints at grade changes to a level surface. Check horizontal alignment perpendicular to the joint edge with a framing square. Do not place dowels closer than 0.6 times the dowel bar length to the planned joint line. If the last regularly spaced longitudinal dowel is closer than that dimension, move it away from the joint to a location 0.6 times the dowel bar length, but not closer than 6 inches to its nearest neighbor. Resolve dowel interference at a transverse joint-longitudinal joint intersection by deleting the closest transverse dowel. Do not position the end of a longitudinal dowel closer than 12 inches from the end of the nearest transverse dowel. Install dowels as specified in the following subparagraphs.
3.5.8.1 Contraction Joints

Securely hold dowels in longitudinal and transverse contraction joints within the paving lane in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. Securely hold the basket assemblies in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

3.5.8.2 Construction Joints-Fixed Form Paving

Install dowels by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes is not permitted. Prepare and place dowels across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. Provide the spacing of dowels in construction joints as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, provide closer spacing with additional dowels.

3.5.8.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. Before drilling commences, cure the concrete for 7 days or until it has reached a minimum compressive strength of 2500 psi. Drill holes 1/8 inch greater in diameter than the dowels into the hardened concrete using rotary-core drills. Rotary-percussion drills are permitted, provided that excessive spalling does not occur to the concrete joint face. Excessive spalling is defined as spalling deeper than 1/4 inch from the joint face or 1/2 inch radially from the outside of the drilled hole. Continuing damage requires modification of the equipment and operation. Drill depth of dowel hole within a tolerance of plus or minus 1/2 inch of the dimension shown on the Drawings. Upon completion of the drilling operation, blow out the dowel hole with oil-free, compressed air. Bond dowels in the drilled holes using epoxy resin. Inject epoxy resin at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. Hold the dowels in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Provide dowels required between new and existing concrete in holes drilled in the existing concrete, all as specified above.

3.5.8.4 Lubricating Dowel Bars

Wipe the portion of each dowel intended to move within the concrete clean and coat with a thin, even film of lubricating oil or light grease before the concrete is placed.

3.6 FINISHING

Provide finishing operations as a continuing part of placing operations starting immediately behind the strike-off of the paver. Provide initial finishing by the transverse screed or extrusion plate. Provide the sequence of operations consisting of transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Provide finishing by the machine method. Provide a work bridge as necessary for consolidation and hand finishing operations. Use
the hand method only on isolated areas of odd slab widths or shapes and in
the event of a breakdown of the mechanical finishing equipment. Keep
supplemental hand finishing for machine finished pavement to an absolute
minimum. Immediately stop any machine finishing operation which requires
appreciable hand finishing, other than a moderate amount of straightedge
finishing. Prior to recommencing machine finishing, properly adjust or
replace the equipment. Immediately halt any operations which produce more
than 1/8 inch of mortar-rich surface (defined as deficient in plus U.S. No.
4 sieve size aggregate) and the equipment, mixture, or procedures modified
as necessary. Compensate for surging behind the screeds or extrusion plate
and settlement during hardening and take care to ensure that paving and
finishing machines are properly adjusted so that the finished surface of
the concrete (not just the cutting edges of the screeds) is at the required
line and grade. Maintain finishing equipment and tools clean and in an
approved condition. Water is not allowed to be added to the surface of the
slab with the finishing equipment or tools, or in any other way, except for
fog (mist) sprays specified to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

Replace machines that cause displacement of the forms. Only one pass of
the finishing machine is allowed over each area of pavement. If the
equipment and procedures do not produce a surface of uniform texture, true
to grade, in one pass, immediately stop the operation and the equipment,
mixture, and procedures adjusted as necessary.

3.6.2 Machine Finishing with Slipform Pavers

Operate the slipform paver so that only a very minimum of additional
finishing work is required to produce pavement surfaces and edges meeting
the specified tolerances. Immediately modify or replace any equipment or
procedure that fails to meet these specified requirements as necessary. A
self-propelled non-rotating pipe float may be used while the concrete is
still plastic, to remove minor irregularities and score marks. Only one
pass of the pipe float is allowed. If there is concrete slurry or fluid
paste on the surface that runs over the edge of the pavement, immediately
stop the paving operation and the equipment, mixture, or operation modified
to prevent formation of such slurry. Immediately remove any slurry which
does run down the vertical edges by hand, using stiff brushes or scrapers.
Slurry, concrete or concrete mortar is not allowed to build up along the
edges of the pavement to compensate for excessive edge slump, either while
the concrete is plastic or after it hardens.

3.6.3 Surface Correction and Testing

After all other finishing is completed but while the concrete is still
plastic, eliminate minor irregularities and score marks in the pavement
surface by means of cutting straightedges. Provide cutting straightedges
with a minimum length of 12 feet that are operated from the sides of the
pavement or from bridges. Provide cutting straightedges operated from the
side of the pavement equipped with a handle 3 feet longer than one-half the
width of the pavement. Test the surface for trueness with a straightedge
held in successive positions parallel and at right angles to the center
line of the pavement, and the whole area covered as necessary to detect
variations. Advance the straightedge along the pavement in successive
stages of not more than one-half the length of the straightedge.
Immediately fill depressions with freshly mixed concrete, strike off,
consolidate with an internal vibrator, and refinish. Strike off
projections above the required elevation and refinish. Continue the
straightedge testing and finishing until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in Paragraph "Surface Smoothness". This straightedging is not allowed to be used as a replacement for the straightedge testing of Paragraph "Surface Smoothness" in PART 1. Use long-handled, flat bull floats very sparingly and only as necessary to correct minor, scattered surface defects. If frequent use of bull floats is necessary, stop the paving operation and the equipment, mixture or procedures adjusted to eliminate the surface defects. Keep finishing with hand floats and trowels to the absolute minimum necessary. Take extreme care to prevent over finishing joints and edges. Produce the surface finish of the pavement essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations are subject to approval.

3.6.4 Hand Finishing

Use hand finishing operations only as specified below. Provide a work bridge to be used as necessary for consolidation and placement operations to avoid standing in concrete.

3.6.4.1 Equipment and Template

In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping template and a longitudinal float for hand finishing. Provide a template at least 1 foot longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, that is constructed of metal or other suitable material shod with metal. Provide a longitudinal float at least 10 feet long, of approved design, is rigid and substantially braced, and maintain a plane surface on the bottom. Grate tampers (jitterbugs) are not allowed.

3.6.4.2 Finishing and Floating

As soon as placed and vibrated, strike off the concrete and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement is at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, tamp the entire surface with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, float the pavement longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, place additional concrete, consolidated and screeded, and the float operated until a satisfactory surface has been produced. Do not advance the floating operation more than half the length of the float and then continued over the new and previously floated surfaces.

3.6.5 Texturing

Before the surface sheen has disappeared and before the concrete hardens or curing compound is applied, texture the surface of the pavement as described herein. After curing is complete, thoroughly power broom all textured surfaces to remove all debris.
3.6.5.1 Burlap Drag Surface

Apply surface texture by dragging the surface of the pavement, in the direction of the concrete placement, with an approved burlap drag. Operate the drag with the fabric moist, and the fabric maintained clean or changed as required to keep clean. Perform the dragging so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.5.2 Broom Texturing

Complete brooming before the concrete has hardened to the point where the surface is unduly torn or roughened, but after hardening has progressed enough so that the mortar does not flow and reduce the sharpness of the scores. Overlap successive passes of the broom the minimum necessary to obtain a uniformly textured surface. Wash brooms thoroughly at frequent intervals during use. Remove worn or damaged brooms from the job site. Hand brooming is permitted only on isolated odd shaped slabs or slabs where hand finishing is permitted. For hand brooming, provide brooms with handles longer than half the width of slab to be finished. Transversely draw the hand brooms across the surface from the center line to each edge with slight overlapping strokes.

3.6.6 Edging

Before texturing has been completed, carefully finish the edge of the slabs along the forms, along the edges of slipformed lanes, and at the joints with an edging tool to form a smooth rounded surface of 1/8 inch radius. Eliminate tool marks, and provide edges that are smooth and true to line. Water is not allowed to be added to the surface during edging. Take extreme care to prevent overworking the concrete.

3.6.7 Outlets in Pavement

Construct recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement to conform to the details and dimensions shown. Carefully finish the concrete in these areas to provide a surface of the same texture as the surrounding area that is within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Continuously protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations. Have all equipment needed for adequate curing and protection of the concrete on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove or replace the damaged pavement, and provide another method of curing as directed. Accomplish curing by one of the following methods.

3.7.2 Membrane Curing

Apply a uniform coating of white-pigmented, membrane-forming, curing compound to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing. Apply immediately along the formed edge faces after the forms are removed. Do not allow the concrete to dry before the application of the membrane. If any drying has
occurred, moisten the surface of the concrete with a fine spray of water, and the curing compound applied as soon as the free water disappears. Apply the curing compound to the finished surfaces by means of an approved automatic spraying machine. Apply the curing compound with an overlapping coverage that provides a two-coat application at a coverage of 400 square feet per gallon, plus or minus 5.0 percent for each coat. A one-coat application is allowed provided it is applied in a uniform application and coverage of 200 square feet per gallon, plus or minus 5.0 percent is obtained. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, apply a second coat in a direction approximately at right angles to the direction of the first coat. If pinholes, abrasions, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray curing compound to concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray curing compound to areas where the curing compound is damaged by subsequent construction operations within the curing period immediately. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane.

3.8 JOINTS

3.8.1 General Requirements for Joints

Construct joints that conform to the locations and details indicated and are perpendicular to the finished grade of the pavement. Provide joints that are straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, remove and replace the slabs adjacent to the joint at no additional cost to the Government. Change from the jointing pattern shown on the drawings is not allowed without written approval. Seal joints immediately following curing of the concrete or as soon thereafter as weather conditions permit as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.

3.8.2 Longitudinal Construction Joints

Install dowels in the longitudinal construction joints, or thicken the edges as indicated. Install dowels as specified above. After the end of the curing period, saw longitudinal construction joints to provide a groove at the top for sealant conforming to the details and dimensions indicated.

3.8.3 Transverse Construction Joints

Install transverse construction joints at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for 30 minutes or longer. Install the transverse construction joint at a planned transverse joint. Provide transverse construction joints by utilizing headers or by paving through the joint, then full-depth sawcutting the excess concrete. Construct pavement with the paver as close to the header as possible, with the paver run out completely past the header. Provide transverse construction joints at a planned transverse joint constructed as shown or, if not shown otherwise, dowelled in accordance with Paragraph "Dowels Installed In Hardened

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3.8.4 Expansion Joints

Provide expansion joints where indicated, and about any structures and features that project through or into the pavement, using joint filler of the type, thickness, and width indicated, and installed to form a complete, uniform separation between the structure and the pavement or between two pavements. Attach the filler to the original concrete placement with adhesive and mechanical fasteners and extend the full slab depth. After placement and curing of the adjacent slab, sawcut the sealant reservoir depth from the filler. Tightly fit adjacent sections of filler together, with the filler extending across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Finish edges of the concrete at the joint face with an edger with a radius of 1/8 inch.

3.8.5 Slip Joints

Install slip joints where indicated using the specified materials. Attach preformed joint filler material to the face of the original concrete placement with adhesive and mechanical fasteners. Construct a 3/4 inch deep reservoir for joint sealant at the top of the joint. Finish edges of the joint face with an edger with a radius of 1/8 inch.

3.8.6 Contraction Joints

Construct transverse and longitudinal contraction joints by sawing an initial groove in the concrete with a 1/8 inch blade to the indicated depth. During sawing of joints, and again 24 hours later, the CQC team is required to inspect all exposed lane edges for development of cracks below the saw cut, and immediately report results. If there are more than six consecutive uncracked joints after 48 hours, saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. The time of initial sawing varies depending on existing and anticipated weather conditions and be such as to prevent uncontrolled cracking of the pavement. Commence sawing of the joints as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. The sawed faces of joints will be inspected for undercutting or washing of the concrete due to the early sawing, and sawing delayed if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. Continue the sawing operation as required during both day and night regardless of weather conditions. Saw the joints at the required spacing consecutively in the sequence of the concrete placement. Provide adequate lighting for night work. Illumination using vehicle headlights is not permitted. Provide a chalk line or other suitable guide to mark the alignment of the joint. Before sawing a joint, examine the concrete closely for cracks, and do not saw the joint if a crack has occurred near the planned joint location. Discontinue sawing when a crack develops ahead of the saw cut. Immediately after the joint is sawed, thoroughly flush the saw cut and adjacent concrete surface with water and vacuumed until all waste from sawing is removed from the joint and adjacent concrete surface. Respray the surface with curing compound as soon as free water disappears. Take necessary precautions to insure that the concrete is properly protected from damage and cured at sawed joints. Tightly seal the top of the joint opening and the joint groove at exposed edges with cord backer rod before the concrete in the region of the joint is resprayed with curing compound, and be maintained until removed immediately before sawing the joint sealant.
reservoir. Seal the exposed saw cuts on the faces of pilot lanes with bituminous mastic or masking tape. After expiration of the curing period, widen the upper portion of the groove by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. Center the reservoir over the initial sawcut.

3.8.7 Thickened Edge Joints

Construct thickened edge joints as indicated on the Drawings. Grade the underlying material in the transition area as shown and meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL, AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Repair or remove and replace new pavement slabs that have spalled edges or contain cracks, as specified at no cost to the Government. Removal of partial slabs is not permitted. Remove and replace slabs containing more than 15.0 percent of each of the longitudinal joint edge spalled. Prior to fill-in lane placement, saw full depth to remove the spalled face of pilot lane slabs exceeding this quantity, regardless of spall size. Remove all other slabs as directed. The Government will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores are to be drilled with a minimum diameter of 6 inches, and be backfilled with an approved non-shrink concrete. Perform drilling of cores and refilling holes at no expense to the Government. Prior to any repairs, submit a Repair Recommendations Plan detailing areas exceeding the specified limits as well as repair recommendations required to bring these areas within specified tolerances.

3.9.2 Slabs with Cracks

Clean cracks that do not exceed 2 inches in depth; then pressure injected full depth with epoxy resin, Type IV, Grade 1. Remove slabs containing cracks deeper than 2 inches.

3.9.3 Removal and Replacement of Full Slabs

Where it is necessary to remove full slabs, remove in accordance with Paragraph "Removal Of Existing Pavement Slab" below. Remove and replace full depth, by full width of the slab, and the limit of removal normal to the paving lane and extend to each original joint. Install dowels of the size and spacing as specified for other joints in similar pavement by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in Paragraph "Placing Dowels", above. Cut off original damaged dowels flush with the joint face. Paint protruding portions of dowels and lightly oil. Provide dowels for all four edges of the new slab. Place concrete as specified for original construction. Prior to placement of new concrete, recompact and shape the underlying material as specified in the appropriate section of these specifications, and clean the surfaces of all four joint faces of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Take care to prevent any curing compound from contacting dowels. Prepare and seal the resulting joints around the new slab as specified for original construction.
3.9.4 Repairing Spalls Along Joints

Repair spalls along joints to be sealed to a depth to restore the full joint-face support prior to placing adjacent pavement. Where directed, repair spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks by first making a vertical saw cut at least 3 inches outside the spalled area and to a depth of at least 2 inches. Provide saw cuts consisting of straight lines forming rectangular areas without sawing beyond the intersecting saw cut. Chip out the concrete between the saw cut and the joint, or crack, to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Thoroughly clean the cavity thus formed with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, apply a prime coat to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. Apply the prime coat in a thin coating and scrubbed into the surface with a stiff-bristle brush. Provide prime coat for portland cement repairs consisting of a neat cement grout and for epoxy resin repairs consisting of epoxy resin, Type III, Grade 1. Fill the prepared cavity with: Portland cement concrete or latex modified mortar for larger cavities, those more than 1/3 cubic foot in size after removal operations; Portland cement mortar for cavities between 0.03 cubic foot and 1/3 cubic foot; and epoxy resin mortar or epoxy resin or latex modified mortar for those cavities less than 0.03 cubic foot in size. Provide portland cement concretes and mortars that consist of very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Provide epoxy resin mortars made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved. Proprietary patching materials may be used, subject to approval. Place the epoxy resin materials in the cavity in layers with a maximum thickness of 2 inches. Provide adequate time between placement of additional layers such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening. Provide mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Where the spalled area abuts a joint, provide an insert or other bond-breaking medium to prevent bond at the joint face. Saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean the reservoir and then sealed with the sealer specified for the joints.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Diamond grind slabs containing weak surfaces less than 1/4 inch thick to remove the weak surface. Diamond grind in accordance with Paragraph "Diamond Grinding Of PCC Surfaces" in PART 1. All diamond ground areas are required to meet the thickness, smoothness and grade criteria specified in PART 1 GENERAL. Remove and replace slabs containing weak surfaces greater than 1/4 inch thick.

3.9.6 Repair of Pilot Lane Vertical Faces

Repair excessive edge slump and joint face deformation in accordance with Paragraph "Edge Slump and Joint Face Deformation" in PART 1. Repair inadequate consolidation (honeycombing or air voids) by saw cutting the face full depth along the entire lane length with a diamond blade. Obtain cores, as directed, to determine the depth of removal.
3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Remove existing concrete pavement at locations indicated on the Drawings. Prior to commencing pavement removal operations, inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain. After pavement removal, survey the remaining edge again to quantify any damage caused by removal operations. Perform both surveys in the presence of the Government. Perform repairs as indicated and as specified herein. Carefully control all operations to prevent damage to the concrete pavement and to the underlying material to remain in place. Perform all saw cuts perpendicular to the slab surface, forming rectangular areas. Perform all existing concrete pavement repairs prior to paving adjacent lanes.

3.10.1 Removal of Existing Pavement Slab

When existing concrete pavement is to be removed and adjacent concrete is to be left in place, perform the first full depth saw cut on the joint between the removal area and adjoining pavement to stay in place with a standard diamond-type concrete saw. Next, perform a full depth saw cut parallel to the joint that is at least 24 inches from the joint and at least 6 inches from the end of any dowels with a wheel saw as specified in Paragraph "Sawing Equipment". Remove all pavement beyond this last saw cut in accordance with the approved demolition work plan. Remove all pavement between this last saw cut and the joint line by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. In lieu of this method, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which does not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. In lieu of the above specified removal method, the slab may be sawcut full depth to divide it into several pieces and each piece lifted out and removed. Use suitable equipment to provide a truly vertical lift, and safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

Protect the edge of existing concrete pavement against which new pavement abuts from damage at all times. Remove and replace slabs which are damaged during construction as directed at no cost to the Government. Repair of previously existing damage areas is considered a subsidiary part of concrete pavement construction. Saw off all exposed keys and keyways full depth.

3.10.2.1 Spall Repair

Not more than 15.0 percent of each slab's edge is allowed to be spalled. Provide a full depth saw cut on the exposed face to remove the spalled face of damaged slabs with spalls exceeding this quantity, regardless of spall size. Provide repair materials and procedures as previously specified in Paragraph "Repairing Spalls Along Joints".

3.10.2.2 Underbreak and Underlying Material

Repair all underbreak by removal and replacement of the damaged slabs in accordance with Paragraph "Removal and Replacement Of Full Slabs" above. Protect the underlying material adjacent to the edge of and under the
existing pavement which is to remain in place from damage or disturbance during removal operations and until placement of new concrete, and be shaped as shown on the drawings or as directed. Maintain sufficient underlying material in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Remove and replace any slab with underlying material that is disturbed or loses its compaction.

3.11 PAVEMENT PROTECTION

Protect the pavement against all damage prior to final acceptance of the work by the Government. Placement of aggregates, rubble, or other similar construction materials on airfield pavements is not allowed. Exclude traffic from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or for a longer period if so directed. As a construction expedient in paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment is permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured flexural strength of 550 psi and approved means are provided to prevent damage to the slab edge. Continuously maintain all new and existing pavement carrying construction traffic or equipment completely clean, and spillage of concrete or other materials cleaned up immediately upon occurrence. Take special care in areas where traffic uses or crosses active airfield pavement. Power broom other existing pavements at least daily when traffic operates. For fill-in lanes, provide equipment that does not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION

3.12.1 Testing and Inspection by Contractor

During construction, perform sampling and testing of aggregates, cementitious materials (cement, slag cement, and pozzolan), and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative samples of aggregates from charging belts at the concrete plant. Obtain samples of concrete at the point of delivery to the paver. Testing by the Government in no way relieves the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. Perform this testing regardless of any other testing performed by the Government, either for pay adjustment purposes or for any other reason.

3.12.2 Testing and Inspection Requirements

Perform CQC sampling, testing, inspection and reporting in accordance with the following Table.
### TABLE 6
TESTING AND INSPECTION REQUIREMENTS

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test Method</th>
<th>Control Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate Gradation and Fineness Modulus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 per lot</td>
<td>ASTM C136 sample</td>
<td>9 of 10 tests must vary less than 0.15 from average</td>
<td>Retest, resolve, retest</td>
</tr>
<tr>
<td></td>
<td>at belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outside limits on any sieve</td>
<td>Retest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd gradation failure</td>
<td>Stop, resolve, retest</td>
</tr>
<tr>
<td>1 per 10 gradations</td>
<td>ASTM C117</td>
<td>Outside limits on any sieve</td>
<td>Retest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd gradation failure</td>
<td>Stop, repair, retest</td>
</tr>
<tr>
<td>Coarse Aggregate Gradation (each aggregate size)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 per lot</td>
<td>ASTM C136 sample</td>
<td>Outside limits on any sieve</td>
<td>Retest</td>
</tr>
<tr>
<td></td>
<td>at belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd gradation failure</td>
<td>report to COR, correct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 consecutive averages of 5 tests outside limits</td>
<td>report to COR, stop ops, repair, retest</td>
</tr>
<tr>
<td>1 per 10 gradations</td>
<td>ASTM C117</td>
<td>Outside limits on any sieve</td>
<td>Retest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd gradation failure</td>
<td>report to COR, correct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 consecutive averages of 5 tests outside limits</td>
<td>report to COR, stop ops, repair, reverify all operations</td>
</tr>
</tbody>
</table>

### Workability Factor and Coarseness Factor Computation

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test Method</th>
<th>Control Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same as C.A. and F.A.</td>
<td>see paragraph AGGREGATES</td>
<td>Use individual C.A. and F.A. gradations. Combine using batch ticket percentages. Tolerances: Plus or minus 3 points on WF; plus or minus 5 points on CF from approved adjusted mix design values</td>
<td>Check batching tolerances, recalibrate scales</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 consecutive averages of 5 tests outside limits</td>
<td>report to COR, stop ops, retest</td>
</tr>
</tbody>
</table>

### Aggregate Deleterious, Quality, and ASR Tests
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test Method</th>
<th>Control Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>First test no later than time of uniformity testing and then every 30 days of concrete production</td>
<td>see paragraph AGGREGATES</td>
<td></td>
<td>Stop production, retest, replace aggregate. Increase testing interval to 90 days if previous 2 tests pass</td>
</tr>
<tr>
<td>Plant - Scales, Weighing Accuracy</td>
<td>Monthly</td>
<td>NRMCA QC 3</td>
<td>Stop plant ops, repair, recalibrate</td>
</tr>
<tr>
<td>Plant - Batching and Recording Accuracy</td>
<td>Weekly</td>
<td>Record/Report</td>
<td></td>
</tr>
<tr>
<td>Plant - Batch Plant Control</td>
<td>Every lot</td>
<td>Record/Report</td>
<td>Record type and amount of each material per lot</td>
</tr>
<tr>
<td>Plant - Mixer Uniformity - Stationary Mixers</td>
<td>Every 4 months during paving</td>
<td>COE CRD-C 55</td>
<td>After initial approval, use abbreviated method</td>
</tr>
<tr>
<td>Plant - Mixer Uniformity - Truck Mixers</td>
<td>Every 4 months during paving</td>
<td>ASTM C94</td>
<td>Random selection of truck.</td>
</tr>
<tr>
<td>Concrete Mixture - Air Content</td>
<td>When test specimens prepared plus 2 random</td>
<td>ASTM C231 sample at point of discharge within the paving lane</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Individual test control chart: Warning plus or minus 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 6
TESTING AND INSPECTION REQUIREMENTS

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test Method</th>
<th>Control Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Mixture - Unit Weight and Yield</td>
<td>Same as Air Content</td>
<td>Individual test basis: Warning Yield minus 0 or plus 1 percent</td>
<td>Check batching tolerances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual test basis: Action Yield minus 0 or plus 5 percent</td>
<td>Halt operations</td>
</tr>
<tr>
<td>Concrete Mixture - Slump</td>
<td>When test specimens prepared plus 4 random</td>
<td>ASTM C143 sample at point of discharge within the paving lane</td>
<td>Adjust batch masses within max W/C ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual test control chart: Upper Warning minus 1/2 inch below max</td>
<td>Stop operations, adjust, retest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual test control chart: Upper Action at maximum allowable slump</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range between each consecutive test: 1-1/2 inches</td>
<td>Stop operations, repair, retest</td>
</tr>
<tr>
<td>Concrete Mixture - Temperature</td>
<td>When test specimens prepared</td>
<td>ASTM C1064 sample at point of discharge within the paving lane</td>
<td>See paragraph WEATHER LIMITATIONS</td>
</tr>
<tr>
<td>Concrete Mixture - Strength</td>
<td>8 per lot</td>
<td>ASTM C31 sample at point of discharge within the paving lane</td>
<td>See paragraph CONCRETE STRENGTH TESTING for CQC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perform fabrication of strength specimens and initial cure outside the paving lane and within 1,000 feet of the sampling point.</td>
<td></td>
</tr>
</tbody>
</table>

### Paving - Inspection Before Paving

| Prior to each paving operation | Report                  | Inspect underlying materials, construction joint faces, forms, reinforcing, dowels, and embedded items | |

### Paving - Inspection During Paving

| | | | |
### TABLE 6
**TESTING AND INSPECTION REQUIREMENTS**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test Method</th>
<th>Control Limit</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>During paving operation</td>
<td>Monitor and control paving operation, including placement, consolidation, finishing, texturing, curing, and joint sawing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paving - Vibrators</td>
<td>Weekly during paving</td>
<td>Test frequency (in concrete), and amplitude (in air), average measurement at tip and head.</td>
<td>Repair or replace defective vibrators.</td>
</tr>
<tr>
<td>Moist Curing</td>
<td>2 per lot, min 4 per day</td>
<td>Visual</td>
<td>Repair defects, extend curing by 1 day</td>
</tr>
<tr>
<td>Membrane Compound Curing</td>
<td>Daily</td>
<td>Visual</td>
<td>Calculate coverage based on quantity/area</td>
</tr>
<tr>
<td>Cold Weather Protection</td>
<td>Once per day</td>
<td>Visual</td>
<td>Repair defects, report conditions to COR</td>
</tr>
</tbody>
</table>

#### 3.12.3 Concrete Strength Testing for CQC

Perform Contractor Quality Control operations for concrete strength consisting of the following steps:

- **a.** Take samples for strength tests at the paving site. Fabricate and cure test cylinders in accordance with ASTM C31; test them in accordance with ASTM C39.

- **b.** Fabricate and cure 2 test cylinders per sublot from the same batch or truckload and at the same time acceptance cylinders are fabricated and test them for compressive strength at 7-day age.

- **c.** Average all 8 compressive tests per lot. Convert this average 7-day compressive strength per lot to equivalent 28-day flexural strength using the Correlation Ratio determined during mixture proportioning studies.

- **d.** Compare the equivalent 28-day flexural strength from the conversion to the Average Flexural Strength Required for Mixtures from paragraph of same title.
e. If the equivalent average 28-day strength for the lot is below the Average Flexural Strength Required for Mixtures by 20 psi flexural strength or more, at any time, adjust the mixture to increase the strength, as approved.

f. Fabricate and cure two beams for every 2000 cubic yards of concrete placed. Fabricate and cure in accordance with ASTM C31; test at 14-days of age in accordance with ASTM C78. Use the flexural strength results to verify the cylinder-beam acceptance correlation ratio.

g. Maintain up-to-date control charts for strength, showing the 7-day CQC compressive strength, the 14-day compressive strength (from acceptance tests) and the 28-day equivalent flexural strength of each of these for each lot.

3.12.4 Reports

Report all results of tests or inspections conducted informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Government has the right to examine all Contractor quality control records.

-- End of Section --
SECTION 32 16 13
CONCRETE SIDEWALKS AND CURBS AND GUTTERS
04/08

PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182  (2005; R 2012) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A1064  (2016b) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM A615  (2016) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement


ASTM C173  (2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

ASTM C231  (2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method


ASTM C31  (2015a; E 2016) Standard Practice for Making and Curing Concrete Test Specimens in the Field

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Provide plant, equipment, machines, and tools used in the work subject to approval and maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The Contracting Officer shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.2.2 Slip Form Equipment

Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in 1 pass.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data
Concrete
SD-06 Test Reports
Field Quality Control

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is
falling, or is already below that point. Placement may begin when the air
temperature reaches 35 degrees F and is rising, or is already above 40
degrees F. Make provisions to protect the concrete from freezing during
the specified curing period. If necessary to place concrete when the
temperature of the air, aggregates, or water is below 35 degrees F,
placement and protection shall be approved in writing. Approval will be
contingent upon full conformance with the following provisions. The
underlying material shall be prepared and protected so that it is entirely
free of frost when the concrete is deposited. Mixing water and aggregates
shall be heated as necessary to result in the temperature of the in-place
cement being between 50 and 85 degrees F. Methods and equipment for
heating shall be approved. The aggregates shall be free of ice, snow, and
frozen lumps before entering the mixer. Covering and other means shall be
provided for maintaining the concrete at a temperature of at least 50
degrees F for not less than 72 hours after placing, and at a temperature
above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed shall not exceed 85 degrees F
except where an approved retarder is used. The mixing water and/or
aggregates shall be cooled, if necessary, to maintain a satisfactory
placing temperature. The placing temperature shall not exceed 95 degrees F
at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section
32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS
except as otherwise specified. Concrete shall have a minimum compressive
strength of 3500 psi at 28 days. Maximum size of aggregate shall be 1-1/2
inches. Submit copies of certified delivery tickets for all concrete used
in the construction.

2.1.1 Air Content

Mixtures shall have air content by volume of concrete of 5 to 7 percent,
based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

The concrete slump shall be 2 inches plus or minus 1 inch where determined
in accordance with ASTM C143.

2.1.3 Reinforcement Steel

Reinforcement bars shall conform to ASTM A615. Wire mesh reinforcement
shall conform to ASTM A1064.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Impervious sheet materials shall conform to ASTM C171, type optional,
except that polyethylene film, if used, shall be white opaque.
2.2.2 Burlap

Burlap shall conform to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

White pigmented membrane-forming curing compound shall conform to ASTM C309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.4.2 Expansion Joint Filler, Premolded

Expansion joint filler, premolded, shall conform to ASTM D1751 or ASTM D1752, 1/2 inch thick, unless otherwise indicated.

2.5 JOINT SEALANTS

Joint sealant, cold-applied shall conform to ASTM C920 or ASTM D5893.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 10 feet with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.1 Sidewalk Forms

Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.
2.6.2 Curb and Gutter Forms

Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

The subgrade shall be constructed to the specified grade and cross section prior to concrete placement. Subgrade shall be placed and compacted in conformance with Section 32 11 23 GRADED-CRUSHED AGGREGATE BASE COURSE.

3.1.1 Sidewalk Subgrade

The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed. The subgrade shall be prepared and protected to produce a subgrade free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.
3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment shall be checked with a 10 foot straighedge. Forms shall have a transverse slope of 1/4 inch per foot with the low side adjacent to the roadway. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated by tamping and spading or with an approved vibrator, and the surface shall be finished to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

All slab edges, including those at formed joints, shall be finished with an edger having a radius of 1/8 inch. Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Concrete shall be placed to the section required in a single lift.
Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.4 Joint Finishing

Curb edges at formed joints shall be finished as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces shall not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 SIDEWALK JOINTS

Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 10 feet or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8 inch blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.
3.5.2 Sidewalk Expansion Joints

Expansion joints shall be formed with 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Joint filler shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 1/8 inch, and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be cleaned and filled with cold-applied joint sealant. Joint sealant shall be gray or stone in color. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.

3.5.3 Reinforcement Steel Placement

Reinforcement steel shall be accurately and securely fastened in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

a. Contraction joints (except for slip forming) shall be constructed by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

b. When slip forming is used, the contraction joints shall be cut in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. The depth of cut shall be at least one-fourth of the gutter/curb depth and 1/8 inch in width.

3.6.2 Expansion Joints

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 1/2 inch in width shall be provided at intervals not less than 30 feet nor greater than 120 feet. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Joints shall be sealed as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.
C-17 Type III Fuel System & Ramp Expansion
145th Airlift Wing, North Carolina Air National Guard

RIGID PAVEMENTS.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

The entire exposed surface shall be covered with 2 or more layers of burlap. Mats shall overlap each other at least 6 inches. The mat shall be thoroughly wetted with water prior to placing on concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Membrane Curing Method

A uniform coating of white-pigmented membrane-curing compound shall be applied to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Formed surfaces shall be coated immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Concrete shall not be allowed to dry before the application of the membrane. If any drying has occurred, the surface of the concrete shall be moistened with a fine spray of water and the curing compound applied as soon as the free water disappears. Curing compound shall be applied in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. The second coat shall be applied in a direction approximately at right angles to the direction of application of the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel and shall be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, an additional coat shall be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified above. Areas where the curing compound is damaged by subsequent construction operations within the curing period shall be resprayed. Necessary precautions shall be taken to insure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. The top of the joint opening and the joint groove at exposed edges shall be tightly sealed before the concrete in the region of the joint is resprayed with curing compound. The method used for sealing the joint groove shall prevent loss of moisture from the joint during the entire specified curing period. Approved standby facilities for curing concrete pavement shall be provided at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Concrete surfaces to which membrane-curing compounds have been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the
membrane.

3.7.2 Backfilling

After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Completed concrete shall be protected from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.7.4 Protective Coating

Protective coating, of linseed oil mixture, shall be applied to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Concrete to receive a protective coating shall be moist cured.

3.7.4.1 Application

Curing and backfilling operation shall be completed prior to applying two coats of protective coating. Concrete shall be surface dry and clean before each application. Coverage shall be by spray application at not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture shall be in accordance with the manufacturer's instructions. Coated surfaces shall be protected from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Protective coating shall not be heated by direct application of flame or electrical heaters and shall be protected from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Material shall not be applied at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.
3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken not less than once a day nor less than once for every 250 cubic yards of concrete. The samples for strength tests shall be taken in accordance with ASTM C172. Cylinders for acceptance shall be molded in conformance with ASTM C31 by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173 or ASTM C231. ASTM C231 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Two slump tests shall be made on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed,
between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 1/4 inch. Pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Government and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732  (1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)


U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595  (Rev C; Notice 1) Colors Used in Government Procurement

FS TT-B-1325  (Rev D; Notice 1) Beads (Glass Spheres) Retro-Reflective (Metric)

FS TT-P-1952  (2015; Rev F) Paint, Traffic and Airfield
1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data
   Surface Preparation Equipment List; G
   Application Equipment List; G
   Exterior Surface Preparation
   Material Safety Data Sheets (MSDS) for proposed materials; G
   Reflective media for airfields; G
   Reflective media for roads; G
   Waterborne Paint; G

SD-06 Test Reports
   Reflective Media for Airfields; G
   Reflective Media for Roads; G
   Waterborne Paint; G

Test Reports

SD-07 Certificates
   Qualifications; G
   Reflective Media for Airfields
   Reflective Media for Roads
   Waterborne Paint
   Volatile Organic Compound, (VOC); G

SD-08 Manufacturer's Instructions
   Waterborne Paint; G

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

Submit certificate stating that the proposed pavement marking paint meets the Volatile Organic Compound, (VOC) regulations of the local Air Pollution
Control District having jurisdiction over the geographical area in which the project is located. Submit Material Safety Data Sheets (MSDS) for each product.

1.3.2 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.3.3 Qualifications For Airfield Marking Personnel

Submit documentation of qualifications in resume format a minimum of 14 days before pavement marking work is to be performed showing personnel who will be performing the work have experience working on airfields, operating mobile self-powered marking, cleaning, and paint removal equipment and performing these tasks. Include with resume a list of references complete with points of contact and telephone numbers. Provide certification for pavement marking machine operator and Foreman demonstrating experience successfully completing a minimum of two airfield pavement marking projects of similar size and scope. Provide documentation demonstrating personnel have a minimum of four years of experience operating similar equipment and performing the same or similar work in similar environments, similar in size and scope of the planned project. The Contracting Officer reserves the right to require additional proof of competency or to reject proposed personnel.

1.4 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site, only in areas approved by the Contracting Officer, for maintaining materials at temperatures recommended by the manufacturer. Make available paint stored at the project site or segregated at the source for sampling not less than 30 days prior to date of required approval for use to allow sufficient time for testing. Notify the Contracting Officer when paint is available for sampling.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

1.5.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.
1.5.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Parking Areas

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.5.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.5.3 Airfield Traffic Control

Coordinate performance of all work in the controlled zones of the airfield with the Contracting Officer and with the Flight Operations Officer or Airfield Manager. Neither equipment nor personnel can use any portion of the airfield without permission of these officers unless the apron is closed.

1.5.4 Airfield Radio Communication

No personnel or equipment will be allowed in the controlled zones of the airfield until radio contact has been made with the control tower and permission is granted by the control tower. A radio for this purpose is to be provided by the Contractor as approved by the Contracting Officer. Maintain contact with the control tower at all times during work in vicinity of the airfield. Notify the control tower when work is completed and all personnel, equipment and materials have been removed from all aircraft operating surfaces.

1.5.5 Airfield Emergency Landing and Takeoff

Emergencies take precedence over all operations. Upon notification from the control tower of an emergency landing or imminent takeoff, stop all operations immediately and evacuate all personnel and equipment to an area not utilized for aircraft traffic which is at least 250 feet measured perpendicular to and away from the near edge of the runway unless otherwise authorized by the Contracting Officer. Equipment and chemicals or detergents as well as excess water must be able to clear the work area within 3 minutes.

1.5.6 Lighting

When night operations are necessary, provide all necessary lighting and
equipment. Direct or shade lighting to prevent interference with aircraft, the air traffic control tower, and other base operations. Provide lighting and related equipment capable of being removed from the runway within 15 minutes of notification of an emergency. Night work must be coordinated with the Flight Operations Manager or Airfield Manager and approved in advance by the Contracting Officer. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2  PRODUCTS

2.1  EQUIPMENT

2.1.1  Surface Preparation Equipment for Roads and Parking Areas

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant by the use of metal protective plates over all joints or approved equal by the Contracting Officer. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1.1  Waterblasting Equipment

Use mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order at all times.

2.1.2  Application Equipment

Submit application equipment list appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove them from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1  Paint Application Equipment

2.1.2.1.1  Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of water based paint or two-component, chemically curing paint, thermoplastic, or preformed tape, to pavement surfaces for small marking projects, such as legends and cross-walks, parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.
2.1.2.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

Provide self-propelled or mobile-drawn spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges.

2.1.2.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

2.1.2.1.2.2 Airfield Marking

Provide self-propelled or mobile-drawn spraying machine for applying the paint for airfield pavements with an arrangement of atomizing nozzles capable of applying the specified line width in a single pass. Provide paint applicator with paint reservoirs or tanks of sufficient capacity and suitable gages to apply paint in accordance with requirements specified. Equip tanks with suitable mechanical agitators. Equip spray mechanism with quick-action valves conveniently located, and include necessary pressure regulators and gages in full view and reach of the operator. Install paint strainers in paint supply lines to ensure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator must be readily adaptable for attachment of a dispenser for the reflective media approved for use.

2.1.2.1.2.3 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used. Spray guns may not be used on airfield pavement.

2.1.2.2 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the paint dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.2 MATERIALS

Use reflectorized waterborne or methacrylate paint for airfield markings. Use reflectorized waterborne paint for roads. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and parking areas and FED-STD-595 for airfields. Provide materials conforming to the requirements specified herein.

2.2.1 Waterborne Paint

FS TT-P-1952, Type III.
2.2.2 Reflective Media

2.2.2.1 Reflective Media for Airfields

FS TT-B-1325, Type I, Gradation A, Type III, Gradation A, or Type IV, Gradation A or B.

2.2.2.2 Reflective Media for Roads

FS TT-B-1325, Type I, Gradation A or Type IV, Gradation A or B.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine cleanliness adhesion of remaining coating and rate of cleaning. Perform a demonstration removal of pavement marking in an area designated by the Contracting Officer.

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take
a minimum of ten readings on each test stripe with a Retrospectometer with a direct readout in millicandela per square meter per lux (mcd/m2/ lx). Conform testing per ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

3.1.6 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove rubber deposits, existing paint markings, residual curing compounds, and other coatings adhering to the pavement by water blasting.

a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

b. Do not use shot blasting on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Paint

Apply paint pneumatically with approved equipment at rate of coverage...
specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic. If there is a deficiency in drying of the markings, painting operations must cease until the cause of the slow drying is determined and corrected.

3.3.1.1 Waterborne Paint

3.3.1.1.1 Airfields

For non-reflectorized and reflectorized markings, apply paint conforming to FS TT-P-1952 Type III at a rate of 121 plus or minus 6 square feet per gallon 108 plus or minus 8 square feet per gallon.

For reflectorized markings, apply paint and glass spheres at the following rates:

<table>
<thead>
<tr>
<th>Bead Type</th>
<th>Paint Type</th>
<th>Paint Application Rate</th>
<th>Bead Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I (Gradation A)</td>
<td>Type I, II, III</td>
<td>121 plus or minus 6 Sq Ft/Gallon</td>
<td>8 plus or minus 1 lb/gallon</td>
</tr>
<tr>
<td>Type III</td>
<td>Type I, II, III</td>
<td>121 plus or minus 6 Sq Ft/Gallon</td>
<td>10 plus or minus 1 lb/gallon</td>
</tr>
<tr>
<td>Type IV (Gradation A)</td>
<td>Type III</td>
<td>76 plus or minus 12 Sq Ft/Gallon</td>
<td>8 plus or minus 1 lb/gallon</td>
</tr>
<tr>
<td>Type IV (Gradation B)</td>
<td>Type III</td>
<td>98 plus or minus 9 Sq Ft/Gallon</td>
<td>8 plus or minus 1 lb/gallon</td>
</tr>
</tbody>
</table>

3.3.1.1.2 Roads

Apply paint at a rate of 105 plus or minus 5 square feet per gallon. Apply FS TT-B-1325 Type I (Gradation A) beads at a rate of 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.2 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations. Immediately clean up following removal operations in areas subject to aircraft traffic. Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

As soon as the paint materials and reflective media are available for sampling, obtain by random selection from the sealed containers, four quart samples of each batch in the presence of the Contracting Officer. Two quarts will be for sampling and testing by the Contractor and two quarts will be for retention by the Government. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated
name, specification number, batch number, project contract number, intended use, and quantity involved.

Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Include in the report of test results a listing of any specification requirements not verified by the test laboratory. At the discretion of the Contracting Officer, samples provided may be tested by the Government for verification.

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. A certificate of compliance shall be accompanied by test results substantiating conformance to the specified requirements.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

3.4.6 Retroreflective Markings

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m²/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m²/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

3.4.7 Material Bond Verification and Operations Area Cleanup for Airfields

Vacuum sweep the aircraft operating area before it is opened for aircraft operations to preclude potential foreign object damaged to aircraft engines. Visually inspect the pavement markings and the material captured by the vacuum. Verify that no significant loss of reflective media has occurred to the pavement marking due to the vacuum cleaning.
PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM F567 (2014a) Standard Practice for Installation of Chain Link Fence


U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191 (Rev K) Fencing, Wire and Post Metal (and Gates, Chain-Link Fence Fabric, and Accessories)

FS RR-F-191/1 (Rev F) Fencing, Wire and Post, Metal
1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Assembly; G
Location of Gate, Corner, End, and Pull Posts; G
Gate Assembly; G
Gate Hardware and Accessories; G
Erection/Installation Drawings; G

SD-03 Product Data

Fence Assembly; G
Gate Assembly; G
Gate Hardware and Accessories; G
Fabric; G
Stretcher Bars; G
Concrete; G

SD-04 Samples

Fabric; G
Posts; G
Braces; G
Line Posts; G
Sleeves; G
Top Rail; G
Bottom Rail; G
Tension Wire; G
Stretcher Bars; G
Gate Posts; G
Gate Hardware and Accessories; G
Wire Ties; G
SD-07 Certificates
Certificates of Compliance
SD-08 Manufacturer's Instructions
Fence Assembly
Gate Assembly
Hardware Assembly
Accessories
SD-11 Closeout Submittals
Recycled Material Content

1.3 QUALITY CONTROL

1.3.1 Certificates of Compliance

Submit certificates of compliance in accordance with the applicable reference standards and descriptions of this Section for the following:

a. Zinc coating.
b. Fabric.
c. Stretcher bars.
d. Gate hardware and accessories.
e. Concrete.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide fencing materials conforming to the requirements of ASTM A116,
Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly, and accessories.

2.2 COMPONENTS

2.2.1 Fabric

FS RR-F-191 and detailed specifications as referenced and other requirements as specified.

FS RR-F-191/1; Type I, zinc-coated steel, 9 gauge. Mesh size, 2 inches. Height of fabric, as indicated.

Provide fabric consisting of No. 9-gauge wires woven into a 2 inch diamond mesh, with dimensions of fabric and wire conforming to ASTM A116, ASTM A702, and ASTM F626, with 2.0 ounces per square foot zinc galvanizing.

Provide one-piece fabric widths for fence heights up to 12 feet.

2.2.1.1 Top and Bottom Selvages

Provide knuckled selvages at top and bottom for fabric with 2 inch mesh and up to 60 inches high, and if over 60 inches high, provide twisted and barbed top selvage and knuckled bottom selvage.

Knuckle top and bottom selvages for 1-3/4 inch and 1 inch mesh fabric.

2.2.2 Posts, Rails and Braces

FS RR-F-191/3 line posts; Class 1, steel pipe, Grade A. End, corner, and pull posts; Class 1, steel pipe, Grade A. Braces and rails; Class 1, steel pipe, Grade A, in minimum sizes listed in FS RR-F-191/3 for each class and grade.

2.2.3 Line Posts

Minimum acceptable line posts are as follows:

Up to 6 feet high:

Grade A: 1.900 inch O.D. pipe weighing 2.72 pounds per linear foot.

Over 6 feet high:

2.0 inch O.D. pipe weighing 3.65 pounds per linear foot.

2.2.4 End, Corner, and Pull Posts

Provide minimally acceptable end, corner, and pull posts as follows:

Up to 6 feet high:

Grade A: 2.375 inch O.D. pipe weighing 3.65 pounds per linear foot.
Over 6 feet high:

Grade A: 2.875 inch O.D. pipe weighing 5.79 pounds per linear foot.

2.2.5  Sleeves

Provide sleeves for setting into concrete construction of the same material as post sections, sized 1 inch greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.2.6  Top Rail

Provide top rails with a minimum of 1.660 inches O.D. pipe rails. Grade A weighing 2.27 pounds per linear foot. Provide expansion couplings 6 inches long at each joint in top rails.

2.2.7  Bottom Rail

Provide bottom rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized.

2.2.8  Post-Brace Assembly

Provide bracing consisting of 1.660 inches O.D. pipe Grade A weighing 2.27 pounds per linear foot and 3/8-inch adjustable truss rods and turnbuckles.

2.2.9  Stretcher Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 3/16 by 3/4 inch, in accordance with ASTM A116, ASTM A702, and ASTM F626.

2.2.10  Stretcher Bar Bands

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 15 inches on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.2.11  Post Tops

Provide tops that are steel, wrought iron, or malleable iron designed as a weathertight closure cap. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

2.2.12  Gate Posts

Provide a gate post for supporting each gate leaf as follows:

Up to 6-feet wide:

2.875 inch O.D. pipe Grade A weighing 5.79 pounds per linear foot.

Over 6 feet wide and up to 13 feet wide:

2.875 inch O.D. pipe Grade A weighing 5.79 pounds per linear foot.
2.2.13 Gates

FS RR-F-191/2; Type III, single cantilever sliding, wheel sliding gate. Shape and size of gate frame, as indicated. Framing and bracing members, round of steel alloy. Provide gate frames and braces of minimum sizes listed in FS RR-F-191/3 for each Class and Grade, except that steel pipe frames are a minimum of 1.90 inches o.d., 0.120 inches minimum wall thickness and aluminum pipe frames and intermediate braces are 1.869 inches o.d. minimum, 0.940 lb/ft of length. Gate fabric, is as specified for fencing fabric. Coating for steel latches, stops, hinges, keepers, and accessories, is galvanized. Provide intermediate members as necessary for gate leaves more than 8 feet wide, to provide rigid construction, free from sag or twist. Provide truss rods or intermediate braces for gate leaves less than 8 feet wide. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted. Arrange padlocking latches to be accessible from both sides of gate, regardless of latching arrangement.

For gate leaves over 6 feet high or 6 feet wide, provide perimeter gate frames of 1.90 inch O.D. pipe Grade A weighing 2.72 pounds per linear foot.

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 15 inches. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Provide diagonal cross-bracing, consisting of 3/8 inch diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.2.14 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to ASTM A116, ASTM A702, ASTM F626, and be as specified:

Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

2.2.15 Gate Operator

Provide electric gate operators for sliding gates as follows: Electrical gate operators shall have a right angle gearhead instantly reversing motor with solenoid-actuated brake, friction disc clutch, reversing starter with thermal overload protection, and automatic limit switch. Gate operators with V-belt pulleys are not allowed. Equip gate operators with an emergency release to allow the gate to be operated manually. The emergency release mechanism shall be capable of being locked in the engaged or disengaged position. Provide positive stops on the gate tracks as a backup to the limit switches. Gate operator shall be housed in a NEMA 3R enclosure and accept a minimum of three loop detector inputs. Operating voltage requirement is identified in the electrical drawing set.
2.2.16 Keypad

Provide dual pedestal mounted keypads for use with each gate operator, as indicated in electrical drawing set. Keypads shall be lighted and allow for local access code programming of up to 5 digits. Code databases shall be retained during system power loss and databases shall be password protected. Keypads shall be provided with built in transient voltage surge suppression.

2.2.17 Miscellaneous Hardware

Provide miscellaneous hot-dip galvanized hardware as required.

2.2.18 Wire Ties

Provide 16-gauge galvanized steel wire for tying fabric to line posts, spaced 12 inches on center. For tying fabric to rails and braces, space wire ties 24 inches on center. For tying fabric to tension wire, space 0.105-inch hog rings 24 inches on center.

Manufacturer's standard procedure will be accepted if of equal strength and durability.

FS RR-F-191/4. Provide wire ties constructed of the same material as the fencing fabric.

2.3 MATERIALS

2.3.1 Zinc Coating

Provide hot-dip galvanized (after fabrication) ferrous-metal components and accessories, except as otherwise specified.

Provide zinc coating of weight not less than 1.94 ounces per square foot, as determined from the average result of two specimens, when tested in accordance with ASTM A90.

Provide zinc coating conforming to the requirements of the following:

a. Pipe: FS RR-F-191/3 Class 1 Grade A in accordance with ASTM F1083.

b. Hardware and accessories: ASTM A153, Table 1.


d. External: Type B-B surface zinc with organic coating, 0.97 ounce per square foot minimum thickness of acrylated polymer.

e. Internal: Surface zinc coating of 0.97 ounce per square foot minimum.

Provide galvanizing repair material that is cold-applied zinc-rich coating conforming to ASTM A780.

2.3.2 Tension Wire

Provide galvanized, coiled spring wire, No. 7-gauge. Provide zinc coating that weighs not less than 2.0 ounces per square foot.
2.3.3 Concrete

Provide concrete conforming to ASTM C94, and obtaining a minimum 28-day compressive strength of 3,000 psi.

2.3.4 Grout

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

PART 3 EXECUTION

Submit manufacturer's erection/installation drawings and instructions that detail proper assembly and materials in the design for fence, gate, hardware, and accessories.

Provide complete installation conforming to ASTM F567.

3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.1.1 Clearing and Grading

Clear fence line of trees, brush, and other obstacles to install fencing.

3.2 INSTALLATION

3.2.1 Security

Install new chain link fencing, remove existing fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer and cognizant Security Officer.

3.2.2 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.2.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 10 feet on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 500 feet on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in grade. Submit drawings showing location of gate, corner, end, and pull posts.

3.2.2.2 Top and Bottom Tension Wire

Install top and/or bottom tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 8 inches of respective fabric line.
3.2.3 Excavation

Provide excavations for post footings which are in virgin or compacted soil, of minimum sizes as indicated.

Space footings for line posts 10 feet on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 3 inches below the bottoms of the posts. Set bottom of each post not less than 36 inches below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads.

Uniformly spread soil from excavations adjacent to the fence line or on areas of Government property, as directed or remove excavated soil from Government property as indicated.

When solid rock is encountered near the surface, drill into the rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gate posts. Drill holes at least 1 inch greater in diameter than the largest dimension of the placed post.

If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.2.4 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete.

Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved.

Grout all posts set into sleeved holes in concrete with an approved grouting material.

Maintain vertical alignment of posts in concrete construction until concrete has set.

3.2.4.1 Earth

Provide concrete bases of dimensions indicated on the manufactures installation drawings. Compact concrete to eliminate voids, and finish to a dome shape.

3.2.4.2 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence, and a diagonal tension rod.

a. Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the
established centerline between line posts. Repair defects as directed.

3.2.5 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

Take samples and test concrete to determine strength as specified.

3.2.6 Top Rails

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

3.2.7 Brace Assembly

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension.

Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.2.8 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gauge galvanized wire or by securing the wire to the fabric with 10-gauge ties or clips spaced 24 inches on center.

3.2.9 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 1-1/2 inches above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed.

Ensure fabric remains under tension after the pulling force is released.

3.2.10 Stretcher Bar Installation

Thread stretcher bars through or clamped to fabric 4 inches on center and secured to posts with metal bands spaced 15 inches on center.

3.2.11 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.
3.2.12 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.2.13 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.2.14 Zinc-Coating Repair

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.2.15 Accessories Installation

3.2.15.1 Post Caps

Install post caps as recommended by the manufacturer.

3.2.15.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

Submit manufacturer's data indicating percentage of recycled material content in protective fence materials, including chain link fence, fabric, and gates to verify affirmative procurement compliance.

-- End of Section --
PART 1 GENERAL

1.1 SUMMARY

Work shall consist of designing, furnishing all materials, labor, equipment, supervision and placement of mechanically stabilized earth (MSE) retaining wall systems in accordance with these Specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the plans.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


ASTM INTERNATIONAL (ASTM)

ASTM C1262 (2010) Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units


| ASTM D2487                          | (2011) Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D4355                          | (2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus |
| ASTM D448                           | (2012) Sizes of Aggregate for Road and Bridge Construction |
| ASTM D4632                          | (2015a) Grab Breaking Load and Elongation of Geotextiles |
| ASTM D4873                          | (2016) Identification, Storage, and Handling of Geosynthetic Rolls and Samples |
| ASTM D5321                          | (2014) Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method |
| ASTM D6638                          | (2011) Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks) |
| ASTM D698                           | (2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft.) |
| ASTM D1557                          | (2012; E 2015) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft.) |
1.3 DEFINITIONS

1.3.1 Blocks

Segmental concrete retaining wall units will be referred to as blocks.

1.3.2 Gabions

See Section 31 36 00 WIRE MESH GABIONS.

1.3.3 Drainage Aggregate

Granular soil or aggregate which is placed within, between, and/or immediately behind wall facing units.

1.3.4 Fill

Soil or aggregate placed in, behind, or below the wall will be referred to as fill.

1.3.5 Reinforced Fill

Soil which is placed and compacted within the neat line volume of reinforcement as outlined on the plans.

1.3.6 Retained Fill

Soil which is placed and compacted behind the reinforced fill. Elastic silts (MH) and/or highly plastic clays (CH) shall not be used.

1.3.7 Reinforcement

Reinforcement shall consist of a geogrid or a geotextile product manufactured for use as reinforcing. Reinforcement shall not include steel products.

1.3.8 Long Term Design Strength

The long term design strength (LTDS) is:

\[ \text{LTDS} = \frac{T_{\text{ult}}}{(R_{\text{FD}} \times R_{\text{ID}} \times R_{\text{CR}})}. \]

where:

- \( T_{\text{ult}} \) is the ultimate strength.
- \( R_{\text{FD}} \) is the reduction factor for chemical and biological durability.
RF$_{ID}$ is the reduction factor for installation damage.
RF$_{CR}$ is the reduction factor for creep.

1.4 Related Sections

   a. Section 31 24 00: SETTLEMENT MONITORING.
   b. Section 31 36 00: EARTHWORK.
   c. Section 31 36 00: WIRE MESH GABIONS.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

Fabrication and Installation Drawings. The shop drawings shall include all items described under Paragraph "System Requirements". If approved by the Contracting Officer, shop drawings may consist of marked up Contract Drawings showing exact dimensions for wall facing units supplied, required coping, and other minor revisions.

Alternate Wall System; G

If an alternative earth retention system is proposed, Contractor's Professional Engineer shall submit copies of all pertinent preliminary design notes and a sample installation construction specification. Final design notes shall be submitted a minimum of two (2) weeks prior to wall construction, including any required design verification field tests. Design shall be accordance with accepted government industry guidelines and building codes as applicable to all components of proposed wall system. Design shall indicate dimensions, location/spacing and elevations of all wall system components. Design shall include calculations showing strength of all incorporated materials and factors of safety against all potential modes of failure.

SD-03 Product Data

Components and Equipment

Descriptive technical data on the wall facing units, wall caps, masonry adhesive, reinforcement, geotextile filter materials and equipment to be used. The submittal shall include all material properties specified under PART 2 PRODUCTS. The submittal shall also include a copy of any standard manufacturer's warranties for the products.

Supplier Qualifications

Documentation showing that the installer and supplier meet the qualifications listed.
Manufacturer's Representative

Soil Testing; G

Reinforcement Testing; G

Testing data specific to the blocks and reinforcement to be supplied.

a. The shear strength between blocks, gabions mesh, or other approved facing unit shall be established in accordance with NCMA TR127B.

b. The connection strength between wall facing unit and reinforcement shall be established in accordance with ASTM D6638 or other approved testing methods.

c. The coefficient for direct shear of the reinforcement on a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone shall be established in accordance with ASTM D5321.

d. The coefficient of interaction for pull-out resistance of the reinforcement in a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone shall be established in accordance with GSI GRI GT6.

Calculations; G

Calculations of the long term design strength for the reinforcement in accordance the NCMA design method. The ultimate strength or index strength shall be based on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D4595. The calculation shall itemize each reduction factor and include backup data to justify each reduction factor.

Design calculations, including computer output data and program documentation. The calculations shall include all items described under Paragraph 2.1.2.

SD-04 Samples

Segmental Concrete Units; G

Two samples of each proposed block. Each sample shall be typical of the size, texture, color, and finish.

Gabions; G

See Section 31 36 00 WIRE MESH GABIONS.

Reinforcement; G

Samples of each type of reinforcement. The samples shall be labeled and have a minimum size 8 by 10 inches. Geogrid shall include at least 2 apertures (3 junctions) in each direction.
Reinforcement

Affidavit certifying that the reinforcement meets the Project Specifications. The affidavit shall be signed by an official authorized to certify on behalf of the manufacturer and shall be accompanied by a mill certificate that verifies physical properties were tested during manufacturing and lists the manufacturer's quality control testing. The documents shall include a statement confirming that all purchased resin used to produce reinforcement in virgin resin. The mill certificate shall include the tensile strength tested in accordance with ASTM D4595.

1.6 QUALITY ASSURANCE

1.6.1 Contractor Qualifications

Furnish Components and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. Submit descriptive technical data on wall facing units, wall caps, masonry adhesive, reinforcement, geotextile filter materials and equipment to be used. The submittal shall include all material properties specified under PART 2 PRODUCTS. The submittal shall also include a copy of any standard manufacturer's warranties for the products. The standard products shall have been in satisfactory commercial or industrial use for 2 years before award of this Contract. The job foreman or the company directly responsible for the wall installation shall have completed a minimum of 10 earth retention wall system projects and at least 2 years experience.

1.6.2 Supplier Qualifications

Submit documentation showing that the installer and supplier meet the qualifications listed.

1.6.3 Manufacturer's Representative

Provide a qualified and experienced representative from the wall facing unit or reinforcement manufacturer available on an as-needed basis during the wall construction. The representative shall visit the site for consultation at least once during construction and as requested by the Contracting Officer.

1.7 DELIVERY, STORAGE, AND HANDLING

Check products upon delivery to assure that the proper material has been received and is undamaged. For geosynthetics, the guidelines presented in ASTM D4873 shall be followed.

1.7.1 Segmental Concrete Units and Wall Caps

Protect blocks from damage and exposure to cement, paint, excessive mud, and like materials. Check materials upon delivery to assure that the block dimensions are within the tolerances specified.

1.7.2 Gabions

See Section 31 36 00 WIRE MESH GABIONS.
1.7.3 Geosynthetic Labeling

Each roll shall be labeled with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

1.7.4 Geosynthetic Handling

Geosynthetic rolls shall be handled and unloaded by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Geosynthetic rolls shall not be dragged, lifted by one end, lifted by cables or chains, or dropped to the ground.

1.7.5 Geosynthetic Storage

Protect geosynthetics from cement, paint, excessive mud, chemicals, sparks and flames, temperatures in excess of 160 degrees F, and any other environmental condition that may degrade the physical properties. If stored outdoors, the rolls shall be elevated from the ground surface. Geosynthetics, except for extruded grids, shall be protected with an opaque waterproof cover. Geosynthetics shall be delivered to the site in a dry and undamaged condition. Geotextiles shall not be exposed to direct sunlight for more than 7 days.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

This work element includes engineering services in addition to the construction requirements. The Contractor is responsible for engineering services that include design of the wall in accordance with the National Concrete Masonry Association design method, and providing shop drawings indicating all features of the complete design. This work element includes engineering in addition to the construction requirements. The NCMA design method for segmental retaining walls considers potential failure modes categorized by external, internal, local, compound, and global stability. The Government has considered the global stability and will provide the minimum design requirements. The Contractor is responsible for engineering services that include analysis of the wall for all modes of stability, and providing shop drawings indicating all features of the complete design.

2.1.1 Design Requirements

Complete all stability analyses in accordance with the NCMA TR127B. The methods described in NCMA TR127B shall be followed for the complete design, including reinforcement design strength, layout, stability calculations, and seismic effects. The earth retention wall systems shall be designed under the direction of, and be signed by, a professional engineer registered in the State of North Carolina. The engineer shall visit the job at least once during the construction. Coordinate design and construction of wall with all other site earthwork to avoid detrimental impacts to wall performance due to settlement of foundation or retained earth. As necessary, conduct geotechnical investigation to support design of the earth mechanically stabilized systems per standard industry practice to.

2.1.2 Design Parameters

Calculations shall include determination of long term design strength of
reinforcement specific to this Project in accordance with the NCMA TR127B. Submit calculations of the long term design strength for the reinforcement in accordance with the NCMA or FHWA design method. The ultimate strength or index strength shall be based on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D4595. Submit Design calculations, including computer output data and program documentation. The calculations shall include all items described under Paragraph "System Requirements". The calculation shall itemize each reduction factor and include backup data to justify each reduction factor. Calculations shall include analysis of all failure modes listed in the NCMA TR127B. Design calculations shall include a clear outline of material properties and assumptions. See the Report of Geotechnical Services C-17 Type II Hydrant Refueling System and Ramp Expansion, Summit Engineering, Inc., Charlotte, NC for recommended design parameters.

<table>
<thead>
<tr>
<th>Modes of Internal Wall Failure Minimum Factor of Safety</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geogrid Pullout (peak load criterion)</td>
<td>1.5</td>
</tr>
<tr>
<td>Geogrid Pullout (serviceability criterion)</td>
<td>1.0</td>
</tr>
<tr>
<td>Facing Shear (peak load criterion)</td>
<td>1.5</td>
</tr>
<tr>
<td>Facing Shear (serviceability criterion)</td>
<td>1.0</td>
</tr>
<tr>
<td>Connections (peak load criterion)</td>
<td>1.5</td>
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<tr>
<td>Connections (serviceability criterion)</td>
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<tr>
<td>Uncertainties</td>
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</table>

<table>
<thead>
<tr>
<th>Modes of External Failure Minimum Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Sliding</td>
</tr>
<tr>
<td>Overturning</td>
</tr>
<tr>
<td>Bearing Capacity</td>
</tr>
<tr>
<td>Global Stability</td>
</tr>
</tbody>
</table>

2.1.2.1 External Stability Design Requirements

As a minimum requirement, the length of the reinforcing at the base of the wall shall not be less than 0.7 times the total height of the wall.

2.1.2.2 Seismic Design Requirements

Complete the seismic stability analysis in accordance with NCMA TR127B. The pseudo-acceleration value with a 10 percent probability of exceedance in 50 years (referred to as the A value by NCMA) shall be assumed as 0.138g. The minimum factors of safety indicated above for all modes of external failure and for geogrid pullout (peak load criterion) shall be satisfied when analyzing the seismic stability.
2.1.2.3 Global Stability Design Requirements

The long term design strength of the lowest reinforcement layers shall equal or exceed the requirements included in the design calculations provided by the Contractor's Professional Engineer.

2.1.3 Layout

Shop drawings shall reflect all information needed to fabricate and erect the walls including the leveling pad elevations; the shape and dimensions of wall elements; the number, size, type, and details of the soil reinforcing system and anchorage; and identification of areas requiring coping. Submit Fabrication and Installation Drawings (Drawings). Include with the shop drawings all items described under Paragraph "System Requirements". If approved by the Contracting Officer:

a. All features indicated in the Contract Documents shall be incorporated in the final design and construction.

b. The leveling pad elevations may vary, but shall be no higher than the embedment depth profile shown.

c. Each reinforcement level shall run as continuous as practical throughout the profile. If a geotextile filter is present, the reinforcement shall be laid out so that interference with the geotextile is minimized.

d. Any reinforcement not placed with the machine direction as the design reinforcement direction shall be identified on the shop drawings.

e. Reinforcement attached to the wall facing shall not combine geogrid and geotextile, nor products from different manufacturers, within one wall. The number of reinforcement products shall be limited to avoid confusion in placement. For walls under 12 feet high, all reinforcement shall be the same grade and strength (i.e., design with one reinforcement strength).

2.2 BLOCK UNITS

Submit two samples of each proposed block. Each sample shall be typical of the size, texture, color, and finish.

2.2.1 Architectural requirements

2.2.1.1 Face color

To be determined by Government.

2.2.1.2 Face Texture

Split face typical of broken mortar/brick face.

2.2.1.3 Face Appearance

Segment block facing is required around the northern retaining wall surrounding the new tank containment area. All other wall facing shall be gabion mesh matching or similar to existing gabion structures. All gabion facing shall conform to Section 31 36 00 WIRE MESH GABIONS.
2.2.1.4 Batter

All earth retention system wall shall be designed and constructed to provide a consistent wall batter between 1H:6V and 1H:16V. Engage blocks to the block below by use of keys, lips, pins, clips, or other reliable mechanism.

2.2.1.5 Block Size

A minimum of 2/3 square feet of face area, and minimum 6 inch height.

2.2.1.6 Bond Configuration

No bond configuration is required for straight face blocks. Design beveled or sculptured face blocks to stack with a half-bond (joints located at midpoint of vertically adjacent blocks). Finish the block edges so that vertical joints are flush.

2.2.2 Structural requirements

The blocks must be manufactured to the requirements of ASTM C1372 or ASTM C94, except for the following modifications:

a. Minimum 28-day compressive strength of 4000 psi, based on net area in accordance with ASTM C140.

b. A maximum moisture absorption rate of 9 pcf, in accordance with ASTM C140.

c. The minimum oven dry density of concrete shall be 125 pcf.

d. The blocks shall provide a minimum of 80 psf of wall face area (determined without void filling).

e. For freeze-thaw durability tested in accordance with ASTM C1262, specimens shall comply with either of the following: (1) the weight loss of each of 5 specimens after 100 cycles shall not exceed 1 percent; or (2) the weight loss of each of 5 specimens after 150 cycles shall not exceed 1.5 percent.

2.2.3 Wall Caps

Segmental concrete block units shall be placed as caps on top of northern retaining wall surrounding the new tank where indicated. The cap blocks shall have a color and texture on exposed faces to match that of the other blocks and meet the requirements for the other blocks except that the minimum height shall be 3 inches. Each cap block shall have abutting edges saw cut or formed to provide tight, flush abutting joints with no gaps in the joints when placed end to end in the alignment shown on the Drawings.

2.2.4 Gabions

See Section 31 36 00 WIRE MESH GABIONS.

2.3 REINFORCEMENT

2.3.1 Geogrid Reinforcement

Geogrid shall be a geosynthetic manufactured for reinforcement
applications. The geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate, or other fill materials. The geogrid structure shall be dimensionally stable and able to retain its geometry under manufacture, transport and installation. The geogrid shall be manufactured with 100 percent virgin resin consisting of polyethylene, polypropylene, or polyester, and with a maximum of 5 percent in-plant regrind material. Polyester resin shall have a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Polyethylene and polypropylene shall be stabilized with long term antioxidants.

2.3.2 Geotextile Reinforcement

Geotextile shall be a pervious sheet of polymeric material and shall consist of long-chain synthetic polymers composed of at least 95 percent by weight polyethylene, polypropylene, or polyesters. The geotextile shall be manufactured with 100 percent virgin resin, and with a maximum of 5 percent in-plant regrind material. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Polyester resin shall have a minimum molecular weight of 20,000 and a carboxyl end group number less than 50. Polyethylene and polypropylene shall be stabilized with long term antioxidants. For survivability during installation, and in addition to installation damage used in calculating the long term design strength, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 1, and shall have a minimum mass per unit area of 8 oz/sy.

2.3.3 Reinforcement Properties

The reinforcement shown in the approved shop drawing submittal shall meet the long term design strength requirements used in the design, and shall meet the properties listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction. The reinforcement indicated must meet the property requirements listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction. Submit affidavit certifying that the reinforcement meets the Project Specifications. The affidavit must be signed by an official authorized to certify on behalf of the manufacturer and shall be accompanied by a mill certificate that verifies physical properties were tested during manufacturing and lists the manufacturer's quality control testing. Include in the documents a statement confirming that all purchased resin used to produce reinforcement is virgin resin. Include in the mill certificate the tensile strength tested in accordance with ASTM D4595. Reinforcement strength requirements represent minimum average roll values in the machine direction.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>REQUIREMENT</th>
<th>TEST DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permittivity (geotextiles)</td>
<td>0.5 per second</td>
<td>ASTM D4491</td>
</tr>
<tr>
<td>UV Resistance</td>
<td>70 percent after 500 HOURS</td>
<td>ASTM D4355</td>
</tr>
</tbody>
</table>
2.3.3.1 Long Term Design Strength

The long term design strength shall be based on reduction factors for installation damage and durability that are applicable to the fill that will be used. Minimum reduction factors for durability include: 1.1 for polyethylene and polypropylene geosynthetics, 1.15 for coated polyester geogrids, and 1.6 for polyester geotextiles. The creep reduction factor must be consistent with the test procedure used for determining the ultimate strength.

2.3.3.2 Connection Strength

The connection strength between the blocks and reinforcement determined in accordance with ASTM D6638 shall meet the connection strength requirements used in the design.

2.4 GEOTEXTILE FILTER

Geotextiles used as filters shall meet the requirements specified in Table 2. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction. For survivability during installation, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 2, and shall have a minimum mass per unit area of 8 oz/sy.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST REQUIREMENT</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Tensile, lbs.</td>
<td>160 nonwoven</td>
<td>ASTM D4632</td>
</tr>
<tr>
<td></td>
<td>250 woven</td>
<td></td>
</tr>
<tr>
<td>Apparent Opening Size (U.S. Sieve)</td>
<td>70 - 100</td>
<td>ASTM D4751</td>
</tr>
<tr>
<td>Permittivity, sec-1</td>
<td>0.5</td>
<td>ASTM D4491</td>
</tr>
</tbody>
</table>

2.5 SOILS AND AGGREGATES

All material placed as fill shall consist of material classified by ASTM D2487 as GW, GP, GC, GM, SP, SM, SC, CL, ML, or SW. The material shall be free of ice; snow; frozen earth; trash; debris; sod; roots; organic matter; contamination from hazardous, toxic or radiological substances; or stones larger than 3 inches in any dimension. Each material shall be obtained entirely from one borrow source, unless the Contracting Officer determines that quality control is adequate and the alternate source produces material that is similar in gradation, texture, and interaction with the reinforcement. Supply any testing required by the Contracting Officer to evaluate alternate sources. All materials shall be of a character and quality satisfactory for the purpose intended.

2.5.1 Drainage Aggregate

Meet the requirements of ASTM D448, size No. 7.
2.5.2 Aggregate Base Material

For the wall leveling pads meet the requirements of ASTM D1241, gradation C.

2.5.3 Reinforced Fill

Soil placed in the reinforced fill zone must consist of granular material with less than 5 percent passing the No. 200 sieve.

2.5.4 Retained Fill

Soil placed in the retained fill zone must meet the minimum requirements above.

2.6 MASONRY ADHESIVE

The masonry adhesive shall meet the following requirements:

a. ASTM C920, Type S, Grade NS, Class 25.

b. Expected 75 year life.

c. Recommendations of the block manufacturer.

2.7 DRAINAGE PIPE

Provide corrugated polyethylene pipe drainage pipe meeting requirements of AASHTO M 252.

PART 3 EXECUTION

3.1 CLASSIFICATION OF SOIL MATERIALS

Perform classification of soil materials in accordance with ASTM D2488. The Contracting Officer reserves the right to revise the Contractor classifications. In the case of disagreement, the Contracting Officer's classification will govern unless the soils are classified in accordance with ASTM D2487. All testing completed by the Contractor in conjunction with soil material classification will be considered incidental to the Contract Work.

3.2 EARTHWORK

The leveling pad and reinforced fill zone shall bear on undisturbed native soils, or acceptably placed and compacted fill. In the event that it is necessary to remove material to a depth greater than specified or to place fill below the leveling pad not otherwise provided for in the Contract, the Contracting Officer shall be notified prior to work and an adjustment in the contract price will be considered in accordance with the Contract. Additional work not authorized by the Contracting Officer shall be at the Contractor's expense.

3.2.1 Excavation

Foundation soil shall be excavated as required for leveling pad dimensions and reinforcement placement shown on the Drawings. Material for backfilling shall be stockpiled in a neat and orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent slides or caving. Excavation and fill shall be performed in
a manner and sequence that will provide proper drainage at all times. The Contractor is responsible for disposal of surplus material, waste material, and material that does not meet specifications, including any soil which is disturbed by the Contractor's operations or softened due to exposure to the elements and water.

3.2.2 Stockpiles

Stockpiles of all material to be incorporated into the work shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed. Topsoil shall be stockpiled separately from suitable backfill material. Stockpiles of aggregates and granular soils shall be protected from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes frozen, saturated, intermixed with other materials, or otherwise out of specification or unsatisfactory for the use intended, such material shall be removed and replaced with new material from approved sources at no additional cost to the Government.

3.3 LEVELING PAD

3.3.1 Aggregate Base Leveling Pad

The subgrade below the leveling pad shall be compacted with at least 3 passes with a vibratory plate compactor with an operating weight not less than 450 pounds. The aggregate base material shall be placed in lifts not exceeding 6 inches and compacted with at least 3 passes with a vibratory plate compactor. If the subgrade or aggregate base pumps, bleeds water, or cracks during compaction, the Contracting Officer shall be notified and, if no other changes are directed, the aggregate shall be replaced with a concrete leveling pad.

3.3.2 Concrete Leveling Pad

Tolerances in screeding shall be sufficient to place the wall facing units directly on the leveling pad without mortar, pointing, or leveling course between the wall facing units and leveling pad.

3.4 BLOCK INSTALLATION

The wall system components shall be constructed in accordance with the wall supplier's recommendations and construction manual. Damaged blocks shall not be incorporated in the retaining wall.

a. Block placement shall begin at the lowest leveling pad elevation. The blocks shall be in full contact with the leveling pad. Each course of block shall be placed sequentially for the entire wall alignment to maintain a level working platform for layout of reinforcement and placement of fill.

b. The grade and alignment of the first course shall be surveyed and the results furnished to the Contracting Officer prior to placing the second course. Survey control for alignment shall include a string line, offset from a base line, or suitable provisions that can be reproduced for quality assurance.

c. Place the blocks with the edges in tight contact. No gap are allowed for wall batter and curvature. Maintain the vertical joints with a
minimum 4 inch overlap on the underlying block. Do coping required to keep block alignment with a full depth saw cut. No splitting is allowed.

d. Stacking of blocks prior to filling any lower course of block with drainage aggregate will not be allowed.

e. Join cap units and the top two course of blocks using masonry adhesive. Take care to keep adhesive from coming into contact with the face of wall units.

3.5 GABION INSTALLATION

See Section 31 36 00 WIRE MESH GABIONS.

3.6 REINFORCEMENT INSTALLATION

a. Before placing reinforcement, compact the subgrade or subsequent lift of fill and grade level with the top of the wall facing units. The surface must be smooth and free of windrows, sheepsfoot impressions, and rocks.

b. Place reinforcement at the elevations and to the extent shown on the Drawings and the approved shop drawing submittal. Reinforcement shall be oriented with the design strength axis perpendicular to the wall face. Each segment of reinforcement shall be continuous. Spliced connections between shorter pieces of reinforcement will not be allowed. Place reinforcement strips immediately next to adjacent strips to provide 100 percent coverage.

c. Install the reinforcement in tension. Pull the reinforcement taut and anchor with staples or stakes prior to placing the overlying lift of fill. The tension must be uniform along the length of the wall and consistent between layers.

d. All reinforcement must be 100 percent covered by soil so that reinforcement panels do not contact in overlaps. Where the wall bends, place a veneer of fill to a nominal thickness of 3 inches to separate overlapping reinforcement.

3.7 FILL PLACEMENT

a. Fill placement, including drainage aggregate, shall be completed to the top of each course of wall facing units prior to stacking the subsequent course of wall facing units. Maximum loose lift thickness of reinforced material shall not exceed 8 inches.

b. Reinforced fill shall be placed from the wall back toward the fill area to ensure that the reinforcement remains taut. Fill shall be placed, spread, and compacted in such manner that minimizes the development of wrinkles in or movement of the reinforcement.

c. A minimum fill thickness of 6 inches is required prior to operation of vehicles over the reinforcement. Sudden braking and sharp turning shall be avoided. Tracked equipment shall not turn within the reinforced fill zone to prevent tracks from displacing the fill and damaging the reinforcement. Construction equipment shall not be operated directly upon the reinforcement as part of the planned construction sequence. Rubber tired equipment may operate directly on
the reinforcement if: The Contractor submits information documenting testing of equipment operating on a similar geogrid product on similar soils, the travel is infrequent, equipment travels slow, turning is minimized, and no damage or displacement to the reinforcement is observed.

d. Drainage aggregate shall be placed and tamped directly behind, between, and within the cells of the wall facing units (if applicable). Compaction of the drainage aggregate shall be achieved by at least two passes on each lift with a vibratory plate compactor. Care shall be taken not to contact or damage wall facing units with the compactor. Aggregate placed within wall facing units cores and recesses shall be compacted by hand tamping and rodding.

e. At the end of each day, slope the last lift of fill away from the wall in a manner that will allow drainage and direct runoff away from the wall face.

3.8 COMPACTION

Fill shall not be placed on surfaces that contain mud, frost, organic soils, fill soils that have not met compaction requirements, or where the Contracting Officer determines that unsatisfactory material remains in or under the fill. Fill shall be spread and compacted in lifts not exceeding the height of one course of wall facing units.

3.8.1 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557. The maximum density is hereafter abbreviated as the "Modified Proctor" value.

3.8.2 Moisture Control

Control of moisture in the fill shall be maintained to provide acceptable compaction. Disking and plowing will not be allowed in the reinforced fill zone. Moisture content of cohesive soils shall be adjusted at the borrow source before placement. Adding water directly to the reinforced fill zone shall only be conducted under conditions where the soil has sufficient porosity and capillarity to provide uniform moisture throughout the fill during compaction.

3.8.3 Compaction

Reinforced and retained fill shall be compacted to 95 percent of the modified proctor maximum dry density at near optimum moisture content (+/-2 percent). Care shall be exercised in the compaction process to avoid misalignment of the wall facing units. Heavy compaction equipment (including vibratory drum rollers) shall not be used within 3 feet from the wall face.

3.9 SOIL TESTING

All testing expenses shall be the Contractor's responsibility. The Contracting Officer reserves the right to direct the location and select the material for samples to be tested and to direct where and when moisture-density tests shall be performed. Use nuclear density testing equipment in general accordance with ASTM D6938.
3.9.1 Transmittal

The Contracting Officer shall be informed of test results daily for direction on corrective action required. Draft copies of field testing results shall be furnished to the Contracting Officer on a frequent and regular basis, as directed.

3.9.2 Corrective Action

Tests of materials which do not meet the contract requirements (failing test) will not be counted as part of the required testing. Each such failing test must be retaken at the same location as the failing test was taken. If testing indicates material does not meet the Contract Requirements, the material represented by the failing test shall not be placed in the contract work or shall be recompacted or removed. The quantity of material represented by the failing test shall be determined by the Contracting Officer to the quantity represented by the testing frequency. The Contractor may increase testing frequency in the vicinity of a failing test in order to reduce removal requirements, as approved by the Contracting Officer. Such increases in testing frequency shall be at the Contractor's expense and at no additional cost to the Government.

3.9.3 Testing Schedule

3.9.3.1 Moisture-Density Relations

ASTM D698. One test for each material variation, not less than 3 tests total.

3.9.3.2 In-Place Densities

ASTM D1556 or ASTM D6938. Not less than 1 test for each 2 vertical feet per 300 linear feet along wall face.

3.9.3.3 Sieve Analysis

ASTM C136. Drainage Aggregate, 1 test for each source.

3.10 REINFORCEMENT TESTING

All testing expenses shall be the Contractor's responsibility. Testing shall be performed by a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer or performed by the Contractor if approved by the Contracting Officer. The Contracting Officer reserves the right to direct the location and select the material for samples. Testing data specific to the wall facing units and reinforcement to be supplied shall be as follows:

a. The shear strength between wall facing units shall be established in accordance with NCMA TR127B.

b. The connection strength between wall facing unit and reinforcement shall be established in accordance with ASTM D6638. Other approved test methods shall include testing with reinforcement and full-scale wall facing units.

c. The coefficient for direct shear of the reinforcement on a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone shall be established in accordance with ASTM D5321.
d. The coefficient of interaction for pull-out resistance of the
reinforcement in a soil similar in gradation and texture to the
material that will be used for fill in the reinforced zone shall be
established in accordance with ASTM D6706.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST DESIGNATION</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Width Strip Tensile Strength</td>
<td>ASTM D4595</td>
<td>1 per every 10 rolls of geogrid product delivered</td>
</tr>
</tbody>
</table>

Modify ASTM D4595 for geogrids considering recommendations in GSI GRI GG6; and the tensile strength shall be expressed on a unit length basis by substituting \( n*a \) for \( W_s \), where:

\[
W_s = \text{specimen width, (inches)}.
\]

\[
n = \text{number of ribs in the sample (must be a whole number)}.
\]

\[
a = \text{nominal rib spacing for the product tested, (inches)}.\]

3.11 DRAINAGE PIPE

Drain pipe shall be placed as indicated on the Drawings. Drain lines shall be laid to true grades and alignment with a continuous fall in the direction of flow. The interior of the pipe shall be kept clean from soil and debris; and open ends shall be temporarily capped as necessary.

3.12 CONSTRUCTION TOLERANCES

3.12.1 Horizontal

The top of wall must be within 3 inches of the plan location.

3.12.2 Vertical

The top of wall elevations must be within 0.1 feet above to 0.1 feet below the prescribed top of wall elevations indicated.

3.12.3 Plumbness and Alignment

The wall batter and alignment offset measured as deviation from a straight edge must be within plus or minus 1.25 inches per 10 feet section. The batter measured from vertical must be within 2 degrees of the plan dimension.

3.12.4 Block Defects

The blocks will be accepted on the basis of tolerances specified in ASTM C1372.
3.12.5 Block Gaps

Gaps between adjacent blocks must not exceed 1/8 inches.

3.13 PROTECTION OF WORK

Protect work against damage from subsequent operations. Remove disturbed or displaced blocks and replace to conform to all requirements of this Section. Do not incorporate damaged material into the wall. Upon completion of wall erection, clean the wall face to remove any loose soil deposits or stains.

-- End of Section --
SECTION 32 92 19

SEEDING
10/06

PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2013a) Agricultural Liming Materials
ASTM D4972 (2013) pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this Section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch
Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports
Topsoil Composition Tests (reports and recommendations)

SD-07 Certificates
State certification and approval for seed

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed Protection
Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer and Lime Delivery
Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Seed, Fertilizer and Lime Storage
Store in cool, dry locations away from contaminants.

1.5.2.2 Topsoil
Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling
Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions
Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed
Apply seed within twenty four hours after seed bed preparation.
PART 2  PRODUCTS

2.1  SEED

2.1.1  Classification

Provide State-certified and State-approved seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2  Planting Dates

<table>
<thead>
<tr>
<th>Planting Season</th>
<th>Planting Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season 1</td>
<td>April 1st - June 31st</td>
</tr>
<tr>
<td>Temporary Seeding 1</td>
<td>Jan 1st - March 31st</td>
</tr>
<tr>
<td>Temporary Seeding 2</td>
<td>July 1st - Dec 30th</td>
</tr>
</tbody>
</table>

2.1.3  Seed Purity

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Minimum Percent Pure Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cynodon Dactylon</td>
<td>Bermuda Grass</td>
<td>100%</td>
</tr>
<tr>
<td>Secale Cereale</td>
<td>Rye (grain)</td>
<td>100%</td>
</tr>
<tr>
<td>Kummerowia Striata</td>
<td>Kobe Lespedeza</td>
<td>100%</td>
</tr>
</tbody>
</table>

Approved Bermuda cultivars: Riviera and Yukon or approved equal.

2.1.4  Seed Mixture

<table>
<thead>
<tr>
<th>Planting Season</th>
<th>Variety</th>
<th>Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season 1</td>
<td>Bermuda Grass</td>
<td>2PLS/1000 SF</td>
</tr>
<tr>
<td>Planting Season</td>
<td>Variety</td>
<td>Application Rate</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Temporary Seeding 1</td>
<td>Kobe Lespedeza</td>
<td>120 PLS/Ac</td>
</tr>
<tr>
<td></td>
<td>Rye (grain)</td>
<td>50 PLS/Ac</td>
</tr>
<tr>
<td>Temporary Seeding 2</td>
<td>Rye (grain)</td>
<td>120 PLS/Ac</td>
</tr>
</tbody>
</table>

Proportion seed mixtures by weight. Temporary seeding must later be replaced by Season 1 plantings for a permanent stand of grass. The same requirements of turf establishment for Season 1 apply for temporary seeding.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>25-50 percent</td>
</tr>
<tr>
<td>Clay</td>
<td>10-30 percent</td>
</tr>
<tr>
<td>Sand</td>
<td>20-35 percent</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 to 7.0</td>
</tr>
<tr>
<td>Soluble Salts</td>
<td>600 ppm maximum</td>
</tr>
</tbody>
</table>
2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 and as recommended per the soil analysis.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic, granular controlled release fertilizer consisting of nitrogen, phosphorus, potassium, and other nutrients in proportions and amounts recommended per the soil analysis.

2.5 MULCH

Mulch shall be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw shall contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Hay shall be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent) or wood-based (100 percent) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material shall conform to the following:

2.7.1 Erosion Control Blanket

100 percent agricultural straw stitched with a degradable nettings, designed to degrade within 12 months.
2.7.2 Erosion Control Fabric

Fabric shall be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips shall have a minimum life of 6 months.

2.7.3 Erosion Control Material Anchors

Erosion control anchors shall be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation (including soil conditioners as required), fertilizing, seeding, and surface topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 4 inches of off-site topsoil or on-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters, soil conditioners into soil a minimum depth of 4 inches by diskimg, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy, frozen, snow covered, or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method shall be broadcasted and drop seeding or hydroseeding.
3.2.2.1 Broadcast and Drop Seeding

Seed shall be uniformly broadcast at the rate specified in 2.1.4 above. Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of 1/4 inch by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.2.2 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper shall be applied as part of the hydroseeding operation. Fiber shall be added at 1,000 pounds, dry weight, per acre. Then add and mix seed and fertilizer to produce a homogeneous slurry. Seed shall be mixed to ensure broadcasting at the rate of 2 pounds per 1000 square feet. When hydraulically sprayed on the ground, material shall form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.4 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.5 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --
SECTION 33 08 53

AVIATION FUEL DISTRIBUTION SYSTEM START-UP
02/10

PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this section to the extent referenced. The publications are referred to within the text by the basic designation only.

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

AFLP-3747 (2013; Rev 9) Guide Specifications
(Minimum Quality Standards) for Aviation
Turbine Fuels (F-24, F-27, F-34, F-35,
F-37, F-40 And F-44)

1.2 ADMINISTRATIVE REQUIREMENTS

Utilize the Checklist for Equipment Test at the end of this section.
Request electronic format of the Checklist from the Contracting Officer.

1.2.1 System Start-up Plan

Submit a detailed written plan prepared by the system supplier for implementation of system start-up. Submit the plan shall 60 days prior to system start-up. Include a list of personnel by trade, list of key personnel, safety equipment, list of miscellaneous equipment such as two-way radios personnel transportation vehicles etc. and detailed procedures (Start-Up Commissioning example provided by the Contracting Officer) and schedules. The Contractor and system supplier are responsible for implementing system start-up in coordination with ongoing base operations.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
System Start-up Plan; G

SD-06 Test Reports
Test Reports
Final Reports
Equipment Tests; G

SD-11 Closeout Submittals
Certification of Entire System

1.4 CLOSEOUT SUBMITTALS

1.4.1 Final Reports

Submit a final report which includes the final settings of the valves and switches and a copy of the strip chart graphs and excel data and charts on CDR media with an explanation of what the graph indicates and what the system is doing.

1.5 QUALITY ASSURANCE

1.5.1 Test Reports

Submit written test reports to the Contracting Officer prior to the final acceptance procedure. Information reported shall include:

a. Elapsed operating time.
b. Tank liquid level readings.
c. System flow rate and meter readings.
d. System pressure gage readings.
e. Number identification of pumps running.
f. Pump RPM, amperage, and voltage.
g. Condition of fuel samples.
h. Hydrant control valve performance (including flow rate and pressure) during emergency shutoff, downstream valve closure, and relief operation.

1.5.2 Certification of Entire System

Prior to the acceptance of the newly constructed system by the Government, all installed mechanical and electrical equipment shall be inspected and approved by the Contracting Officer. Provide the Contracting Officer 30 days notice in order to schedule the Government representatives for participation in the inspection and equipment tests and final acceptance procedures and approval. Any deficiencies observed shall be corrected by the Contractor without cost to the Government.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.
2.2 GOVERNMENT-FURNISHED MATERIAL AND EQUIPMENT

The Government will furnish the following materials, equipment and services during the performance of the work under this section.

2.2.1 Aircraft Turbine Fuel

The Government will provide the fuel necessary for system testing. Notify the Contracting Officer a minimum of 60 days in advance of the requirements. Additional fuel will be provided by the Government as required for satisfactory flushing of the system. Upon satisfactory completion of the flushing and cleaning operations, the Government will supply the additional quantities of fuel required to complete the other work under this section. Fuel will not be delivered to the system until the Contractor has satisfactorily completed all work and, in particular, the cleaning and coating of the interior surfaces of the operating storage tanks and the removal of preservatives and foreign matter from those portions coming in contact with the fuel valves, pumps, filter separators and other such equipment. Fuel delivered to the system shall remain the property of the Government and the Contractor shall reimburse the Government for shortages not attributable to normal handling losses. The Government shall be reimbursed for fuel lost as a result of defective materials or workmanship. An empty Operating Tank shall never be filled at a velocity greater than 3 feet per second in the fill line until fuel is 3 feet above the fill nozzle.

2.2.2 Tank Trucks

Refueler tank trucks and operation of same will be furnished by the Government.

2.2.3 Hydrant Hose Trucks

The Government will furnish and operate the hydrant hose trucks required for ground refueling and defueling of aircraft at hydrant pits.

2.2.4 Utilities

Electric power required for the performance of the work under this section will be furnished at no charge to the Contractor.

2.3 MATERIAL AND EQUIPMENT

2.3.1 Contractor Furnished

Provide material, equipment and labor not specified to be Government-furnished and required for proper start-up of the system. Equipment shall include but not be limited to the following:

a. Temporary strainers.

b. Pipe spools.

c. Flow meters.

d. Pressure gages.

e. Electronic sensors and recorders for pressure and flow recording are included in the PCP, except a sensor and cable or RF will need to be
provided by the Contractor for the data from the Hydrant Control Valve and plugged into the PCP. This equipment shall be used to monitor and record the system during the "Equipment Test" and "Performance Testing" portions of this Specification Section. Recorded data shall be used by the Contractor and equipment factory representatives to achieve final control valve and equipment adjustments. Recorded data shall include:

(1) Fueling pumps discharge pressures.
(2) Supply Venturi flow rates.
(3) Hydrant Control Valve pressures.
(4) Back Pressure Control Valve upstream pressures.
(5) Back Pressure Control Valve downstream pressures.
(6) Return Venturi flow rates.

f. The Contractor must have on hand sufficient filter elements and coalescer cartridges to adequately clean the system. During cleaning operation, provide a flow versus pressure drop graph for each filter separator. Graph format shall be as shown at end of this Section. Change coalescers and cartridges upon reaching a differential pressure of 15 psi or when pressure drop is less than previous graph or fails to increase properly. Isolate each filter separator, one at a time and use one fueling pump to obtain rated flow rate (600 GPM). A minimum of one complete set of coalescer elements and separator cartridges for each filter separator shall be turned over to the Government after new coalescer elements and separator cartridges are installed in each filter separator vessel after completion of acceptance testing.

g. Pigging equipment and services as called out in paragraph PIPELINE PIGGING VERIFICATION, Section 33 52 43.13 AVIATION FUELING PIPING.

2.3.2 Design Conditions

Use temporary flushing lines and equipment that are equal in strength, stability, and materials to the associated permanent components. However, spools may be carbon steel. Additional design conditions shall be as specified in Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT.

PART 3 EXECUTION

3.1 PREPARATIONS FOR FLUSHING

Upon completion of the system to the satisfaction of the Contracting Officer and the Command Fuel Facilities Engineer, make the following preparations for flushing the system.

3.1.1 Protection of Equipment

The following items shall be removed from the system prior to start of flushing operations and, where applicable, replaced with spools of pipe, diameter equal to the item removed.

a. Control valves, including hydrant pit control valves if flushing outlets into tank trucks.
b. Sensors which are exposed to the fluid.

c. Coalescer and separator elements in filter separators.

d. Venturi Tubes and Pressure Indicating Transmitters.

e. Meter.

After flushing, the above items shall be reinstalled in the system and the spool sections turned over to the Contracting Officer.

3.1.2 Strainers

Temporary 100 mesh cone type strainers with minimum 300 percent open area shall be installed in the suction line ahead of each fueling pump and will be left in place. Any damaged strainers shall be replaced by the Contractor at no additional cost to the Government.

3.1.3 Water Draw-off

Remove any accumulated water from Operating Tanks' sumps and bottoms.

3.2 FLUSHING

Flushing procedures shall precede cleaning procedures. The transfer line, pump house piping, apron loop, supply and return lines to the operating tanks, hydrant laterals, product recovery lines and hydrant hose truck lines shall be flushed with fuel until the fuel being delivered is free of construction debris to the satisfaction of the Contracting Officer. Samples of fuel shall be taken and tested by the designated government agency and shall be free of gross contamination, maximum of 8.0 mg/gallon solids and free water not to exceed 2 ml per quart.

3.2.1 Fueling System Piping

The flushing of apron system pipelines shall be accomplished by pumping fuel from one of the operating tanks through the fueling system piping and back to another tank. Air shall be bled from system high points. The procedure shall be continued until the fuel being delivered into the tanks is acceptable to the Contracting Officer. After the system has been flushed to the satisfaction of the Contracting Officer, remove any water remaining in the low point drains and remove any accumulated water from Operating Tank sumps and bottoms by means of the Water Draw-off systems. Cone strainers shall be kept clean in order to insure maximum flow rate. In addition, baskets from all strainers shall be removed and cleaned.

3.2.1.1 Transfer Line

Flushing of the transfer line shall occur during the filling operations. Samples of the incoming fuel shall be taken at the point of connection with bulk storage supply line. These samples shall be taken at one hour intervals and shall be tested by the designated government agency and turned over to the Contracting Officer.

3.2.1.2 Pump House Piping

Remove equipment as specified in paragraph Protection of Equipment. Perform the following flushing operations by withdrawing fuel from one operating tank and returning it to another tank. Circulate a sufficient
amount of fuel for each operation. Bleed air from high points.

a. Position manual valves to circulate fuel through one pump, filter separator combination.

b. Provide a temporary connection between the hydrant hose truck checkout connection and the single point receptacle. Position manual valves to circulate fuel through the checkout connection and back to the transfer line. Flush the checkout lines using one fueling pump.

c. Position manual valves to circulate fuel through the bypass line. Flush this line using two fueling pumps.

3.2.1.3 Apron Loop Piping

Remove equipment as specified in paragraph Protection of Equipment. Position manual valves to circulate fuel through the apron loop and back to the operating tank. Begin flushing the apron loop at a flow rate of 900 gpm. Increase flushing flow rate one pump at a time to the maximum available number of pumps for a minimum of 8 hours.

3.2.1.4 Hydrant Outlets

Position a tank truck at the hydrant outlet and flush each hydrant lateral. Sample the fuel at the connection to the truck.

3.2.1.5 Product Recovery Tank Lines

During the flushing of apron loop piping, operate all manual drain lines individually to flush their connection to the product recovery tank. Fill the tank a minimum three times, each time utilizing the fuel transfer pump to drain it by returning the fuel to storage.

3.3 CLEANING

After initial flushing is completed, clean the pump house and apron loop piping in accordance with the procedure specified hereafter. Isolate Operating Tanks from the system and clean as specified in Section 33 65 00 CLEANING PETROLEUM STORAGE TANKS.

3.3.1 Preparation for Cleaning

Filter elements shall be installed in the filter separators. Adjust filter separator flow control valve. Valves and equipment removed for flushing shall be reinstalled. Operating Tanks shall be drained, vapor freed and cleaned. Transfer the contents from one operating tank to the other for the purposes of cleaning.

3.3.2 Cleaning Requirements

Cleaning shall continue until the Contracting Officer certifies that the fuel passes the color and particle assessment method as defined in T.O. 42B-1-1 or contains 2 milligrams per gallon or less of particulate. Fuel shall also contain 10 parts per million or less of free water. Sampling shall be performed by the Government and testing shall be done by an approved independent testing laboratory. Also take samples at Hydrant Hose Truck Check-out Station.
3.3.3 Cleaning Procedure

During cleaning procedure periodically bleed air through high point vent and drain water through low point drains.

3.3.3.1 Transfer Line

Continue to receive fuel and circulate it until fuel samples taken at the tanks meet the requirements of paragraph Cleaning Requirements above.

3.3.3.2 Pump House Piping

Pump house piping shall be cleaned as follows:

a. Position manual valves so that fuel is withdrawn from one operating tank, circulated through one fueling pump and filter separator, then returned to the operating tank through the receiving filter separators.

b. Clean the piping system using one pump at a time. Alternate the fueling pumps and filter separators during the operation to clean the individual fueling pump suction and discharge lines.

c. Provide a temporary connection between the hydrant hose truck connection and the nozzle adaptor. Position valves to circulate fuel through the checkout connection and back to the return line. Clean the checkout lines using two fueling pumps.

d. Monitor pressure drop through the filter separators during each cleaning operation and provide flow vs. pressure drop graphs as specified herein before.

e. Periodically take samples from all sample connections. Cleaning shall continue until the fuel meets the specified requirements.

3.3.3.3 Apron Loop Piping

Apron loop piping shall be cleaned as follows:

a. Position manual valves to circulate fuel through the apron loop and back to the operating tank through the receiving filter separators.

a. First clean the pipe using pigs as called out in paragraph PIPELINE PIGGING VERIFICATION, Section 33 52 43.13 AVIATION FUEL PIPING. During this, low point drains and high point vents shall be blown clean. Monitor pressure drop through the filter separators during the cleaning operation.

b. Inspect the pipe as called out in paragraph PIPELINE PIGGING VERIFICATION, Section 33 52 43.13 AVIATION FUEL PIPING.

c. Initially pump fuel through the apron loop at a flow rate of 900 gpm, then increase flow rate up to the full capacity (all pumps running) starting manually one pump at a time. When pumping at a rate greater than 1200 gpm, by-pass receiving filter separators.

d. Monitor pressure drop through the filter separators during the cleaning operation and provide flow vs. pressure drop graphs as specified herein before.
e. Position a tank truck at the hydrant outlet and clean each hydrant lateral, one at a time.

f. Periodically take samples from all sample connections. Continue cleaning until the fuel meets specified requirements of paragraph CLEANING REQUIREMENTS.

3.3.3.4 Product Recovery Lines

Repeat the process described under initial flushing until samples taken at the connection of the pipe line back to storage meet the requirements.

3.4 CONTROL VALVE ADJUSTMENT

Check all control valve settings and field adjust from the factory settings at start-up as necessary to provide a smooth operation. Check the filter separator control valves and fueling pump non-surge check valve and needle valve on Pantograph venturi and adjust as follows:

3.4.1 Rate of Flow Control Feature on Fueling Pump Non-Surge Check Valve

Run one pump at a time and adjust rate of flow feature (950 gpm).

3.4.2 Control Valves on Issue Filter Separator Downstream Side

a. Position valves so that one fueling pump can pump through only one filter separator. Close the valve at the entrance of the apron loop, and open the bypass valve, allowing discharge into the circulating line.

b. Start the pump and adjust the filter separator control valve for the rated flow capacity of the filter separator (900 gpm).

c. Repeat above for each remaining filter separator.

3.4.3 Venturi Needle Valve

Venturi needle valve shall be adjusted to ensure a pressure equal to nozzle pressure at maximum flow possible. After initial setting, valve shall be locked in adjusted position.

3.5 EQUIPMENT TESTS

After completion of flushing, cleaning, and control valve and electrical components adjusting operations, the tests specified hereinafter shall be performed. After cleaning is complete and prior to performance testing, field adjustment of automatic control valves and automatic pump controls while in operation shall be made only by the valve manufacturer's authorized field test engineer. For final adjustment of installed electrical control equipment provide an experienced electrical engineer, factory representative of PCP manufacturer and factory representative of PIT and DPT manufacturers. Both the mechanical and electrical components shall be adjusted concurrently. Tests will be witnessed by the Contracting Officer, the Command Fuel Facilities Engineer and the Command Fuel Management Officer.

3.5.1 Check List For Equipment Tests

System Supplier shall complete and submit to the Check List For Equipment Test provided at the end of this Section.
3.5.2 Operating Tank Low Level Alarm

Position valves to transfer fuel between operating tanks. Start one fueling pump and pump sufficient fuel out of the first operating tank to allow the low level alarm (LLA) to stop the fueling pump. This procedure shall be repeated for each fueling pump and each tank until the low level alarm stops the fueling pump due to low liquid level in operating tank.

3.5.3 Fuel Delivery

Deliver fuel to each fueling point against a backpressure at the outlet of the hydrant control valve created by the tank trucks and hoses used during the tests. The flow rate shall be not less than 900 gallons per minute for a 6-inch valve. Flow rates might be affected by aircraft capability.

3.5.4 Fueling Pump Operation

Demonstrate operation of all pressure and flow devices to start and stop the fueling pumps at the indicated pressure and flow rates in the presence of the Contracting Officer. Repeat the operating sequence with each of the pumps being selected as lead pump. For this test, measure the flow rates. Witness and record flow rates and test results.

3.5.5 Defueling Performance

To test the defueling operation in the "automatic" mode, the Government will furnish a defueling cart or a hydrant hose truck with a 300 gpm pump rated at 165 psi to pump fuel from a government furnished tank truck or bladder back into the system. While this defueling test is in operation, operate one 900 gpm transfer pump providing flow into a tank truck through one hydrant control valve. Demonstrate capability of defueling into the system at the same time a fueling operation is in progress. Also test the defuel capability while in the "Flush" mode.

3.5.6 Emergency Shutdown

With one fueling pump circulating fuel through the system, test each "Emergency Stop" pushbutton station to verify that the pump stops and the emergency shutoff solenoid activates and the control valve closes. Repeat above procedure for each fueling pump and "Emergency Stop" pushbutton station. Conduct tests for both the automatic and manual modes. With all the fueling pumps circulating fuel through the system, push an "Emergency Stop" pushbutton station.

3.5.7 Hydrant Control Valve

Each Hydrant Control Valve shall be operated to demonstrate the following:

3.5.7.1 Surge Shut-Down Capability

Surge from shut-off of on-board aircraft fill valve can be simulated by closing a fill line valve to the tank truck or bladder, use a 3 second closure.

3.5.7.2 Pressure Control at Setpoint Plus 2 psi

Requires use of a pressure gage at the pressure fueling nozzle.
3.5.8 Filter Separator Float Control Valves with Manual Tester

Using the manual float control test level on each Filter Separator, lift the weight from the float ball slowly and observe the Operation and closure of the water slug shut-off feature on the Filter Separator Control Valve.

3.5.9 Overfill Valve

Place fuel transfer pump in the "off" position. Delivery quantity of fuel to Product Recovery Tank to demonstrate capability of valve to close. Place Fuel Transfer Pump in the "Automatic" position to demonstrate capability of valve to open when fuel level drops below set point.

3.6 PERFORMANCE TESTING

Testing, as performed under the above paragraphs, shall be considered to be part of the performance testing after the Contractor has made the required adjustments to the various equipment and controls and demonstrates to the satisfaction of the Contracting Officer and the Command Fuel Facilities Engineer that these portions of the systems are working as specified. Notify the Contracting Officer 15 calendar days in advance of the test to permit arrangement for the use of Government-furnished items. During the time period of final performance testing, no construction activities will be allowed on the project site. The project site shall be considered an operational (fuel) zone (versus a construction zone) during this final performance testing period. Personnel, dressed for fuel’s operation, will be present to witness testing and participate in Contractor provided training.

3.6.1 Final Performance Test

The final performance test shall consist of performance of the fueling system during actual fueling and defueling of an aircraft. The maximum rated capacity of the system shall be tested by using several aircraft simultaneously. If it is not possible to use the number of aircraft required to receive the full flow, the test shall be supplemented through the use of refueling trucks or bladders. Record required data necessary to prepare Test Reports specified in paragraph TEST REPORTS.

3.6.1.1 Satisfactory Performance

In the event a portion of the system or any piece of equipment fails to meet the test, make the necessary repairs or adjustments and repeat the Performance Test until satisfactory performance is obtained. The determination of satisfactory performance shall be made by the Contracting Officer and the Command Fuel Facilities Engineer.

3.6.2 Control Valve Tagging

After the performance testing and system acceptance, tag the control valves with their final adjustments.

3.6.3 Final Acceptance

Fill the system with fuel and operate leak-free prior for acceptance. Anything wet with fuel is considered to be leaking.
3.6.3.1 Operating Tank High Liquid Level Shut-Off Valve Test and Adjustments

During the final filling of operating tanks, check the tank automatic high liquid level shut-off valve for proper functioning at least three times by lowering the fuel level and refilling again. Adjust valve to achieve a safe fill level.

3.6.3.2 Tank Level Indicator Adjustments

Also during the final filling of operating tanks, adjust and calibrate the tank level indicators including the final setting of the high high level (HHLA) and high level (HLA) alarms. Since the HHLA is at a point higher than the High Liquid Level Shut-Off Valve float set point, an artificial method of simulating HHL must be used.

3.6.3.3 Water Draw-Off System Test

During the performance testing, fill Water Draw-off Systems from Operating Tank sump to ensure proper operation. After filling system, allow time for fuel/water mixture to separate. Verify liquid separation through system's sight glasses. Proper operation includes capability to drain separated water and capability to pump separated fuel back to a full Operating Tank.

3.7 START-UP COMMISSIONING PROCEDURES FORMS

Use the forms provided by the Contracting Officer in the System Start-up Plan submittal. Generic templates of the forms (not specifically prepared for this project) are available at http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf. The Contractor and system supplier are responsible for implementing system start-up in coordination with ongoing base operations.

-- End of Section --
CHECK LIST FOR EQUIPMENT TEST
(To be completed after flushing, cleaning and control valve and electrical component adjustments)

PROJECT: 

LOCATION: 

ITEM 1 – OPERATING TANKS:

<table>
<thead>
<tr>
<th>FUEL PUMP NO.</th>
<th>OPERATING TANK NO. 1</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>SHUTDOWN ON LOW-LOW LEVEL</td>
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<tr>
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</tbody>
</table>

DATE: __________________________________________

TIME: __________________________________________

TEMPERATURE: __________________________________

TEST CONDUCTED BY: __________________________________
<table>
<thead>
<tr>
<th>FUEL PUMP NO.</th>
<th>OPERATING TANK NO. 2</th>
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</thead>
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<td>SHUTDOWN ON LOW-LOW LEVEL</td>
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<td></td>
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</tr>
</tbody>
</table>

**DATE:**

**TIME:**

**TEMPERATURE:**

**TEST CONDUCTED BY:**
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<thead>
<tr>
<th>FUEL PUMP NO.</th>
<th>OPERATING TANK NO. 3</th>
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</thead>
<tbody>
<tr>
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<td>SHUTDOWN ON LOW-LOW LEVEL</td>
</tr>
<tr>
<td></td>
<td>YES</td>
</tr>
</tbody>
</table>

**DATE:**

**TIME:**

**TEMPERATURE:**

**TEST CONDUCTED BY:**
ITEM 2 - FUEL DELIVERY - ONE FUELING PUMP RUNNING:

<table>
<thead>
<tr>
<th>Hydrant Control Valve No.</th>
<th>Size (Inch)</th>
<th>Delivery Pressure at Valve Inlet (PSIG)</th>
<th>Backpressure at Valve Outlet (PSIG)</th>
<th>Hydrant Control Valve Flow Rate (GPM)</th>
<th>Pressure Fueling Nozzle Pressure (PSIG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCV-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCV-2</td>
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</tr>
<tr>
<td>HCV-3</td>
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<td>HCV-4</td>
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</tr>
<tr>
<td>HCV-5</td>
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<tr>
<td>HCV-6</td>
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<td></td>
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</tbody>
</table>

DATE: __________________________________________

TIME: __________________________________________

TEMPERATURE: __________________________________

TEST CONDUCTED BY: ______________________________
ITEM 3 - FUELING PUMP OPERATION - AUTOMATIC MODE

SELECTED MICROPROCESSOR  1  

SELECTED LEAD PUMP  FP-1  

ACTUATION POINTS

<table>
<thead>
<tr>
<th>Measuring Device</th>
<th>Lead Pump Start</th>
<th>Second Pump Start</th>
<th>Second Pump Stop</th>
<th>Lead Pump Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT-151</td>
<td>[60][_____] PSIG</td>
<td>[_____] PSIG</td>
<td>[_____] PSIG</td>
<td>[_____] PSIG</td>
</tr>
<tr>
<td>Issue Venturi</td>
<td></td>
<td>[≥ 840][_____] GPM</td>
<td>[≥ 1800+] GPM</td>
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<tr>
<td>DPT-151</td>
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<td></td>
</tr>
<tr>
<td>Return Venturi</td>
<td></td>
<td>[≤ 60][_____] GPM</td>
<td>[≤ 1000][_____] GPM</td>
<td></td>
</tr>
<tr>
<td>DPT-153</td>
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<td></td>
</tr>
</tbody>
</table>

DATE: ________________________________________________________________

TIME: ________________________________________________________________

TEMPERATURE: _________________________________________________________

TEST CONDUCTED BY: _______________________________________________
ITEM 3 - FUELING PUMP OPERATION - AUTOMATIC MODE

SELECTED MICROPROCESSOR 1

SELECTED LEAD PUMP FP- [Contracting Officer Choice]

[ ] ACTUATION POINTS

<table>
<thead>
<tr>
<th>Measuring Device</th>
<th>Lead Pump Start</th>
<th>Second Pump Start</th>
<th>Second Pump Stop</th>
<th>Lead Pump Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT-151</td>
<td>[60][ ] PSIG</td>
<td>[ ] PSIG</td>
<td>[ ] PSIG</td>
<td>[ ] PSIG</td>
</tr>
<tr>
<td>Return Venturi DPT-153</td>
<td>[ ≤ 60][ ] GPM</td>
<td>[ ≤ 1000][ ] GPM</td>
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DATE: ____________________________

TIME: ____________________________

TEMPERATURE: ____________________________

TEST CONDUCTED BY: ____________________________
ITEM 3 - FUELING PUMP OPERATION - AUTOMATIC MODE

SELECTED MICROPROCESSOR 2

SELECTED LEAD PUMP FP - [Contracting Officer Choice]

[_____] ACTUATION POINTS

<table>
<thead>
<tr>
<th>Measuring Device</th>
<th>Lead Pump Start</th>
<th>Second Pump Start</th>
<th>Second Pump Stop</th>
<th>Lead Pump Stop</th>
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</thead>
<tbody>
<tr>
<td>PIT-151</td>
<td>[60][_____] PSIG</td>
<td>[_____] PSIG</td>
<td>[_____] PSIG</td>
<td>[_____] PSIG</td>
</tr>
<tr>
<td>Issue Venturi</td>
<td></td>
<td>[≥ 840][_____] GPM</td>
<td>[≥ 1800+] GPM</td>
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<tr>
<td>DPT-151</td>
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<td></td>
<td></td>
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<tr>
<td>Return Venturi</td>
<td></td>
<td>[≤ 60][_____] GPM</td>
<td>[≤ 1000][_____] GPM</td>
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<tr>
<td>DPT - 153</td>
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DATE: _______________________________________________________

TIME: ________________________________________________________

TEMPERATURE: _________________________________________________

TEST CONDUCTED BY: ____________________________________________
# ITEM 4 - DEFUELING PERFORMANCE

<table>
<thead>
<tr>
<th>FUELING PUMP NO.</th>
<th>AUTOMATIC MODE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>FLOW RATE THRU ISSUE VENTURI (GPM)</td>
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<tr>
<td>FP-1</td>
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<tr>
<td>FP-2</td>
<td></td>
</tr>
<tr>
<td>FP-3</td>
<td></td>
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</tbody>
</table>

**DATE:** ____________________________

**TIME:** ____________________________

**TEMPERATURE:** ____________________________

**TEST CONDUCTED BY:** ____________________________
## FLUSH MODE

<table>
<thead>
<tr>
<th>OPERATING TANK NO. 1 LEVEL-START</th>
<th>OPERATING TANK NO. 2 LEVEL-START</th>
<th>OPERATING TANK NO. 3 LEVEL-START</th>
<th>PRESSURE GAGE READING AT DEFUEL/FLUSH VALVE</th>
<th>HYDRANT CONTROL VALVE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td>HCV-1</td>
</tr>
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<td>HCV-2</td>
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<td>HCV-6</td>
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</table>

**DATE:**

**TIME:**

**TEMPERATURE:**

**TEST CONDUCTED BY:**

---

**SECTION 33 52 43.30**

**ATTACHMENT -9**
### ITEM 5 - EMERGENCY SHUTDOWN

#### AUTOMATIC MODE

<table>
<thead>
<tr>
<th>FUELING PUMP NO.</th>
<th>&quot;EMERGENCY STOP&quot; PUSHBUTTON NO.</th>
<th>EMERGENCY SHUT-OFF VALVE CLOSURE</th>
<th>FUELING PUMP STOP</th>
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</thead>
<tbody>
<tr>
<td>FP-[_____]</td>
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<tr>
<td>FP-[_____]</td>
<td></td>
<td>TIME (SEC)</td>
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<tr>
<td>FP-[_____]</td>
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<td>FP-[_____]</td>
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<td>FP-[_____]</td>
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<tr>
<td>FP-[_____]</td>
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<tr>
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</table>

**DATE:** __________________________

**TIME:** __________________________

**TEMPERATURE:** __________________________

**TEST CONDUCTED BY:** __________________________
ITEM 5 - EMERGENCY SHUTDOWN

<table>
<thead>
<tr>
<th>FUELING PUMP NO.</th>
<th>&quot;EMERGENCY STOP&quot; PUSHBUTTON NO.</th>
<th>EMERGENCY SHUT-OFF VALVE CLOSURE</th>
<th>FUELING PUMP STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP-[_____]</td>
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<td>YES</td>
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<tr>
<td>FP-[_____]</td>
<td></td>
<td>TIME (SEC)</td>
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</tr>
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<td>FP-[_____]</td>
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<td>FP-[_____]</td>
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<td>FP-[_____]</td>
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<tr>
<td>FP-[_____]</td>
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<tr>
<td>FP-[_____]</td>
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</table>

DATE: ____________________________________________

TIME: ____________________________________________

TEMPERATURE: ____________________________________

TEST CONDUCTED BY: __________________________________
## MANUAL MODE

<table>
<thead>
<tr>
<th>FUELING PUMP NO.</th>
<th>&quot;EMERGENCY STOP&quot; PUSHBUTTON NO.</th>
<th>EMERGENCY SHUT-OFF VALVE CLOSURE</th>
<th>FUELING PUMP STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP-[_____]</td>
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<td>YES</td>
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<tr>
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<td>FP-[_____]</td>
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**DATE:**

**TIME:**

**TEMPERATURE:**

**TEST CONDUCTED BY:**
## MANUAL MODE

<table>
<thead>
<tr>
<th>FUELING PUMP NO.</th>
<th>&quot;EMERGENCY STOP&quot; PUSHBUTTON NO.</th>
<th>EMERGENCY SHUT-OFF VALVE CLOSURE</th>
<th>FUELING PUMP STOP</th>
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<tbody>
<tr>
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<td>TIME (SEC)</td>
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<td>FP- [_____]</td>
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**DATE:**

**TIME:**

**TEMPERATURE:**

**TEST CONDUCTED BY:**
ITEM 6 - HYDRANT CONTROL VALVE/TRUCK FILL STAND VALVE TEST

<table>
<thead>
<tr>
<th>HYDRANT CONTROL VALVE NO.</th>
<th>SURGE SHUTDOWN CAPABILITY</th>
<th>PRESSURE CONTROL AT SETPOINT IS ± 2 PSI</th>
<th>DEADMAN CLOSURE WITHIN 2 SECONDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
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DATE: ____________________________
TIME: ___________________________
TEMPERATURE: _____________________
TEST CONDUCTED BY: _____________________________
ITEM 7 - FILTER SEPARATOR FLOW CONTROL VALVE MANUAL TEST

<table>
<thead>
<tr>
<th>FILTER SEPARATOR NO.</th>
<th>WATER SLUG FEATURE ON FILTER SEPARATOR CONTROL VALVE FUNCTIONED</th>
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DATE: ________________________________________________

TIME: ________________________________________________

TEMPERATURE: _________________________________________

TEST CONDUCTED BY: __________________________________
ITEM 8 - OVERFILL VALVE TEST

<table>
<thead>
<tr>
<th>PRODUCT RECOVERY TANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERFILL VALVE</td>
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<td>YES</td>
</tr>
</tbody>
</table>

DATE: __________________________

TIME: __________________________

TEMPERATURE: __________________________

TEST CONDUCTED BY: __________________________
I certify that the values recorded in Items 1-8 are accurate and correct.

<table>
<thead>
<tr>
<th>DATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNATURE:</td>
</tr>
<tr>
<td>ORGANIZATION:</td>
</tr>
</tbody>
</table>

I witnessed all tests required to produce values recorded in Items 1-8.

<table>
<thead>
<tr>
<th>DATE:</th>
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</thead>
<tbody>
<tr>
<td>SIGNATURE:</td>
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<tr>
<td>ORGANIZATION:</td>
</tr>
</tbody>
</table>
# PERSONNEL PRESENT DURING EQUIPMENT TEST

<table>
<thead>
<tr>
<th>NAME</th>
<th>ORGANIZATION</th>
<th>COMMERCIAL PHONE NO.</th>
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</tbody>
</table>

**REMARKS:**

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
### PRESSURE DROP IN POUNDS PER SQUARE IN (PSI)
CLEANING OPERATION DAILY FLOW VS. PRESSURE DROP GRAPH FOR FILTER SEPARATOR NO. FSI-1

* ELEMENT CHANGE CRITERIA:  
   1. When pressure drop across filter separator reaches 15 PSI  
   2. When pressure drop is less than previous plot or fails to increase properly

**STARTING DATE:** ___________________________  
**SIGNATURE:** ______________________________

---

**SECTION 33 52 43.30**  
**ATTACHMENT -19**
CLEANING DAY NUMBER

PRESSURE DROP IN POUNDS PER SQUARE IN (PSI)
CLEANING OPERATION DAILY FLOW VS. PRESSURE DROP GRAPH FOR FILTER SEPARATOR NO. FSI-2

* ELEMENT CHANGE CRITERIA: (1) When pressure drop across filter separator reaches 15 PSI
(2) When pressure drop is less than previous plot or fails to increase properly

STARTING DATE: ____________________________  SIGNATURE: ____________________________

SECTION 33 52 43.30  ATTACHMENT -20
CLEANING DAY NUMBER

PRESSURE DROP IN POUNDS PER SQUARE IN (PSI)
CLEANING OPERATION DAILY FLOW VS. PRESSURE DROP GRAPH FOR FILTER SEPARATOR NO. FSI-3

* ELEMENT CHANGE CRITERIA: (1) When pressure drop across filter separator reaches 15 PSI
(2) When pressure drop is less than previous plot or fails to increase properly

STARTING DATE: _____________________________ SIGNATURE: _____________________________

SECTION 33 52 43.30
ATTACHMENT -21
<table>
<thead>
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<th>10</th>
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PRESSURE DROP IN POUNDS PER SQUARE IN (PSI)
CLEANING OPERATION DAILY FLOW VS. PRESSURE DROP GRAPH FOR FILTER SEPARATOR NO. FSR-4

* ELEMENT CHANGE CRITERIA:  
(1) When pressure drop across filter separator reaches 15 PSI  
(2) When pressure drop is less than previous plot or fails to increase properly

STARTING DATE: ________________________________  SIGNATURE: ________________________________
### PRESSURE DROP IN POUNDS PER SQUARE IN (PSI)

**CLEANING OPERATION DAILY FLOW VS. PRESSURE DROP GRAPH FOR FILTER SEPARATOR NO. FSR-5**

*ELEMENT CHANGE CRITERIA:*
1. When pressure drop across filter separator reaches 15 PSI
2. When pressure drop is less than previous plot or fails to increase properly

**STARTING DATE:** ___________________________  **SIGNATURE:** ___________________________

---

**SECTION 33 52 43.30**  **ATTACHMENT -23**
PART 1  GENERAL

1.1 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 18.1  (1979; R 2004) Annunciator Sequences and Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250  (2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA IA 2  (2005) Programmable Controllers - Parts 1 thru 8


NEMA ICS 2  (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V


NEMA ICS 6  (1993; R 2011) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70  (2017) National Electrical Code

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

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1.2 ADMINISTRATIVE REQUIREMENTS

a. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this Section, with the additions and modifications specified herein. The Hydrant Fueling System consists of fueling pumps that pump fuel to a Hydrant Hose Truck Check-out Pad, Truck Fill Stands, and fuel pits located on the airfield apron. Automatic pump starts and stops are based on system pressure and flow.

b. Programmable Logic Controllers (PLCs) receive information from pressure transmitters and other devices to control the pumps and control valves. There are two PLCs that are connected in a redundant configuration, to assure continued operation of the Hydrant fueling System even if either PLC (but not both) fails. The Hydrant Fueling System also includes above ground fuel storage tanks and a product recovery tank.

c. The pump control panel, personal computer, graphic display panel, and annunciator are located in the Control Room of the Pumphouse. The control system shall be furnished by a single supplier. See Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT for other required components of the control system. The control system supplier shall be responsible for providing a fully functional control system, in accordance with the drawings and specifications, including the field devices. Installation shall be in accordance with NFPA 70.

d. Submit six copies of Operation and Maintenance Manuals, within 7 calendar days following the completion of factory tests. Installation, Operation, and Maintenance manuals for all equipment supplied shall be furnished following the completion of shop tests and shall include:


2. All documents previously submitted and approved with all comments and field changes annotated. Complete description of the sequence of operation including that described in PART 3 and any subsystems not controlled by the PLC (e.g., annunciator panel, EPDS, etc.).

3. Complete listing of all programming of the PLCs, laptop computer, and Personal Computer.

4. Complete relay ladder logic diagrams, PLC input/output diagrams, and control power distribution diagrams for the complete control system.

5. Complete troubleshooting guide, which lists possible operational
problems and corrective action to be taken, including all as-built conditions.

e. Submit documents demonstrating the accuracy and completeness of the list of material and components, that items proposed comply fully with Contract Requirements, and are otherwise suitable for the application indicated. Documents shall consist of all data or drawings published by the manufacturer of individual items listed including manufacturer's descriptive and technical literature, performance data, catalog cuts, and installation instructions. Submit additional material if the listed items are not adequate to identify intent or conformance to technical requirements. Provide typed and electronic copies of these lists for approval. Any delays associated with resubmittals of incomplete or ambiguous initial submittals will be the Contractor's responsibility.

f. Documents shall be bound in a suitable binder adequately marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEEDURES:

SD-02 Shop Drawings

   Shop Drawing; G

SD-03 Product Data

   Pump Control Panel (PCP) and Components; G
   Programmable Logical Controller (PLC) Hardware and Software; G
   Personal Computer (PC); G
   Laptop Computer; G
   FCC Computer; G
   Laser Printer; G
   Graphics Display Panel; G
   Graphics Display Screen; G
   Control Wiring Data Lists; G
   Tools and Spare Parts
SD-06 Test Reports
   Certified Pump Control Panel (PCP) Shop Test Report
   Record of Test

SD-07 Certificates
   Experience and Qualifications; G
   Training Plan for Instructing Personnel; G
   Testing Plan; G

SD-10 Operation and Maintenance Data
   Operation and Maintenance Manuals; G

1.4 TOOLS AND SPARE PARTS

Provide the following:

a. Any special tools necessary for operation and maintenance of the equipment providing supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked.

b. One spare set of fuses of each type and size.

c. Recommended manufacturer list of spare parts, including part number, current unit price, and source of supply.

d. One spare power supply module.

e. One spare I/O module for discrete devices and one for analog devices.

f. Two PLC RAM back-up batteries.

g. Two complete sets of ink cartridges for the laser printer.

h. Minimum of 10 spare lamps for the Alarm Annunciator.

i. Minimum of 10 spare lamps of each type of non-LED lamps used on the Pump Control Panel.

1.5 EXPERIENCE AND QUALIFICATIONS

Submit the following data for approval:

a. Certification stating that the manufacturer has manufactured, installed, and successfully completed at least five PLC-based systems for automatic cycling of pumps based upon varying dispensing demands ranging from 0 to 1,800 GPM utilizing multiple pumps. At least two of the five PLC-based systems shall be for dispensing jet fuel into a pressurized, constant pressure, flow demand aircraft hydrant system.

b. Certification that the control systems have successfully operated over the last 2 years and are currently in service.
c. Project names, locations, and system description of these installations. Include user point-of-contact and current telephone numbers.

1.6 WARRANTY

The Pump Control and Annunciation System including devices, hardware and software shall be warranted for a period of one year from the date of acceptance of the system by the Government. This warranty service shall include parts and labor service for equipment supplied under this Specification. Upon notification by the Government of system or component failure, respond at the site with necessary parts within 48 hours of notification.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Pump Control Panel (PCP) and Components

NEMA ICS 1, NEMA ICS 6, NEMA 250, and UL 508. The PCP enclosure shall be a freestanding NEMA Type 12, smooth, gasketed enclosure constructed of 12-gauge steel. All seams shall be continuously welded and there shall be no drilled holes or knockout prior to delivery to the job site. The pump control panel dimensions shall be a maximum of 90 inches high, maximum 72 inches wide, and a maximum of 24 inches deep and shall have removable lifting eyes. The interior surfaces of the panel shall be properly cleaned, primed, and spray painted with white high-gloss enamel. Exterior surfaces shall have standard factory finish. Access for the PCP shall be front only and shall consist of hinged doors having 3-point latching mechanisms. The doors shall open approximately 120 degrees. Rack mounting angles, swing-out panels and other component mounting hardware shall be installed such that servicing of one component shall not require removal or disconnection of other components. No clearance shall be required between the back of the panel and the room walls. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure.

2.1.2 Ventilation System

Provide two supply fans, single phase, 115 volt. Each fan must supply a minimum of 100 CFM. The supply and exhaust grill must contain a filter that is easily removed from the exterior of the enclosure. Also provide three thermostats with an adjustable set point range of 70 degrees F to 140 degrees F. Locate the thermostats near the top in the interior of the PCP.

2.1.3 Ground Bar

The control panel shall have a tin plated copper equipment ground bar. The bar shall have a minimum of twenty grounding screws.

2.1.4 Standard Indicator Lights

NEMA ICS 1, NEMA ICS 2, and UL 508. Lights shall be heavy duty, NEMA 13, 1 inch mounting hole, round indicating lights operating at 120 volts ac/dc or 24 volts ac/dc. Long life bulbs shall be used. Indicator lights shall have a legend plate with words as shown on drawings. Lens color as indicated on the drawings. Lights shall be "push to test (lamp)" type. LED type lamps of comparable size and color may be substituted for standard
indicator lights.

2.1.5 Selector Switches

NEMA ICS 1, NEMA ICS 2, and UL 508. Non-illuminated lever operated selector switches shall be heavy duty, NEMA 13, round, and utilize a 7/8 inches mounting hole. They shall have the number of positions as indicated on the drawings. Switches shall be rated 600 volt, 10 amperes continuous. Legend plates shall be provided with each switch with words as indicated on the Drawings.

2.1.6 Pushbuttons

NEMA ICS 1, NEMA ICS 2, and UL 508. Non-illuminated pushbuttons shall be heavy duty, NEMA 13, round, utilize a 7/8 inch mounting hole, and have the number and type of contacts as indicated on the Drawings or elsewhere in the Specifications. The emergency stop switch shall be a red mushroom head, 1.5 inch diameter, momentary contact type. Pushbuttons shall be rated 600 volt, 10 amperes continuous. Legend plates shall be provided with each switch with words as indicated on the Drawings.

2.1.7 Relays

IEEE C37.90, NEMA ICS 2, UL 508.

2.1.8 Nameplates

Nameplates shall be made of laminated plastic with black outer layers and a white core. Edges shall be chamfered. Nameplates shall be fastened with black-finished round-head drive screws or approved nonadhesive metal fasteners.

2.1.9 Transient Voltage Surge Suppression Devices

IEEE C62.41 for Category "B" transients, UL 1449.

2.1.10 Terminal Blocks

NEMA ICS 4. Terminal blocks for conductors exiting the PCP shall be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks shall be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip shall form part of the terminal block and each terminal shall be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

2.1.11 Circuit Breakers

UL 508. Individual, appropriately sized, terminal block mounted, circuit breakers shall be provided for all 120 volt PCP mounted equipment and for the 120 volt terminal boards shown on the Drawings.

2.1.12 Uninterruptible Power Supplies

UL 1012. Input voltage shall be 120 volts (nominal), 1 phase, 60 Hertz. Output voltage regulation shall be plus or minus 5.0 percent for the following conditions:
C-17 Type III Fuel System & Ramp Expansion  
145th Airlift Wing, North Carolina Air National Guard

- 20 to 100 percent load on output.
- Input voltage variation of minus 15 to plus 10 percent.
- Constant load power factor between 80 and 100 percent.

Response time shall be 1.5 cycles or less. Battery capacity shall be such as to provide an orderly shut down of operating programs or as a minimum 10 minutes.

2.1.13 Miscellaneous Power Supplies

UL 1012. Certain field devices may require power other than 120 VAC (i.e., 24 VDC). The power supplies shall be convection cooled, have fully isolated independent outputs, have constant voltage, have short circuit and overvoltage protection, and have automatic current limiting.

2.1.14 Alarm Annunciator

UL 508 and ISA 18.1. The Alarm Annunciator shall provide visual annunciation, local and remote monitoring, constant or flashing visual and audible alarm as specified herein. The annunciator shall be completely solid state with no moving parts. The annunciator shall be furnished with cabinet and hardware appropriate for flush mounting on the control panel. A power supply either integral or separately mounted shall operate on 120 volts, 60 Hertz. The annunciator shall have windows arranged in a matrix configuration (rows and columns). Each window shall be at least 15/16 inch high by 1-5/8 inches wide and shall have rear illuminated translucent engraved nameplate. Lettering shall be at least 5/32 inches high. System lamp voltage shall be 24 to 28 volts dc. The cells shall be individually addressable and not hardwired.

2.1.15 Alarm Horns

UL 508. The alarm horns shall consist of 3-vibrating horns and 2-resonating horns. One vibrating horn is to be mounted in the PCP, and two vibrating and two resonating horns shall be mounted outside of the pumphouse as shown on the Drawings. The exterior horns shall each produce 100 db at 10 feet and shall be provided in a weather proof housing. The PCP horn shall produce 70 db at 10 feet.

2.1.16 Laptop Computer

2.1.16.1 Hardware

The following are the minimum hardware requirements for the laptop computer:

- Latest Pentium CPU operating at 2 GHz or faster.
- 2 GB RAM.
- 100 GB hard drive.
- 16X Read Write DVD drive.
- Color XGA LCD screen 14 inches.
- Keyboard.

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g. Pointing device (e.g., mouse, track ball).

h. Parallel communication port.

i. Serial communication port compatible with PLC (e.g., RS-232-C, RS-485).

j. 120VAC and Battery power supply.

k. All cables and connectors for interfacing with PLC and personal computer.

l. Modem compatible for remote troubleshooting of the system.

m. Two USB 2.0 communications ports.

n. Provide a carrying case for the Laptop Computer.

2.1.16.2 Software

The following is the minimum software to be loaded on the laptop. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software needs to be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a hard drive crash.

a. Operating system (e.g., the latest commercially available MS Operating system).

b. Software for programming the PLCs.

c. Software for programming the personal computer.

2.1.17 Personal Computer (PC)

2.1.17.1 Hardware

The following are the minimum hardware requirements for the personal computer:

a. Latest Pentium CPU operating at 2.4 GHZ or faster.

b. 2 GB RAM.

c. 250 GB hard drive.

d. 16X Read Write DVD drive.

e. Color 17 inches flat screen monitor.

f. Keyboard.

g. Pointing device (e.g., mouse).

h. Parallel communication port.

i. Serial communication port compatible with PLC (e.g., RS-232-C, RS-485).

j. 120 VAC operating power.

k. All cables and connectors interfacing with PLC and Laser Printer.
l. Provide a modem capable of remote troubleshooting of the system. The modem will not be permanently connected to the System.

m. Two USB 2.0 communications ports.

2.1.17.2 Software

The following is the minimum software to be loaded on the personal computer. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software needs to be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a hard drive crash.

a. Operating system (e.g., the latest commercially available MS Operating System).

b. Software for programming the PLCs.

c. The personal computer shall communicate with the PLCs to display system status and change system set points. The personal computer shall have run-time graphical software to display the graphical screens described later and to change set points.

d. Software for recording, tracking, trending, and printing out the pressures, flows, and operational status of all monitored components of the fueling system on a real-time basis.

e. Provide MS Office Professional with Excel to allow the trending data described above to be imported to Excel where it can be studied, manipulated, graphed, and easily sent electronically.

2.1.18 Laser Printer

Provide color laser jet alarm/report printer. The unit must print in black at a minimum speed of twelve pages per minute. It must print in color at a minimum speed of ten pages per minute. As a minimum print color graphs of various system pressures, issue flow, and return flow vs. time in seven colors. Provide one set of spare replacement ink cartridges.

2.1.19 FCC Computer

2.1.19.1 Hardware

The FCC computer must be a copy of the personal computer so that upon failure of the personal computer it could be relocated to the pump house to assume the personal computers duties. The normal duties of the FCC computer shall be to serve as a remote monitor only of the screens that are available on the personal computer. The following are the minimum hardware requirements for the FCC computer:

a. Latest Pentium CPU operating at 2.4 GHZ or faster;

b. 2 GB RAM;

c. 250 GB hard drive;

d. 16X Read Write DVD drive;
e. Color 17 inch flat screen monitor;

f. Keyboard;

g. Pointing device (e.g., mouse);

h. Parallel communication port;

i. Serial communication port compatible with PLC (e.g., RS-232-C, RS-485);

j. 120 VAC operating power;

k. All cables and connectors interfacing with PLC and Laser Printer;

l. Provide a modem capable of remote troubleshooting of the system. The modem will not be permanently connected to the System;

m. Two USB 2.0 communications ports.

2.1.19.2 Software

The following is the minimum software to be loaded on the FCC computer. The FCC computer shall be capable of replacing the Personal computer in the pumphouse if the personal computer fails. It will be set up initially to serve only as a remote monitor of the system while located at the FCC. Should the personal computer fail, the FCC computer will be relocated to the pumphouse and then assume the role of the personal computer. The computer software shall have a built in command to tell the computer whether it is serving as the personal computer or as the remote monitor only. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software needs to be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a hard drive crash.

a. Operating system (the latest commercially available MS Operating System).

b. Software to tell the computer which mode it is to operate in, i.e., (personal computer or remote monitor).

c. Software to run as a remote monitor.

d. Software for programming the PLCs.

e. The personal computer shall communicate with the PLCs to display system status and change system set points. The personal computer shall have run-time graphical software to display the graphical screens described later and to change set points.

f. Software for recording, tracking, trending, and printing out the pressures, flows, and operational status of all monitored components of the fueling system, on a real time basis.

g. Provide MS Office Professional with Excel to allow the trending data described above to be imported to Excel where it can be studied, manipulated, graphed, and easily sent electronically.
2.2 PROGRAMMABLE LOGICAL CONTROLLER (PLC) HARDWARE AND SOFTWARE

2.2.1 General

a. NEMA IA 2. Each PLC must be able to receive discrete and analog inputs and through its programming it shall control discrete and analog output functions, perform data handling operations and communicate with external devices and remote I/O racks. The PLCs shall be a modular, field expandable design allowing the system to be tailored to the process control application. The capability shall exist to allow for expansion to the system by the addition of hardware and/or user software. At a minimum the PLCs shall include mounting backplanes, power supply modules, CPU module, communication modules, and I/O modules.

b. Design and test each PLC provided for use in the high electrical noise environment of an industrial plant. The PLC modules must comply with the FCC Part 15 Part A for radio noise emissions. The programmable controller processor must be able to withstand conducted susceptibility tests as outlined in NEMA ICS 2, IEEE C37.90.

c. The PLCs must function properly at temperatures between 32 and 122 degrees F, at 5 to 95 percent relative humidity non-condensing and have storage temperatures between minus 40 and plus 140 degrees F at 5 to 95 percent relative humidity non-condensing.

d. The PLCs must have manufacturer's standard system status indicators (e.g., power supply status, system fault, run mode status, back-up battery status).

2.2.2 Central Processing Unit Module

The CPU must be a modular self-contained unit that will provide time of day, scanning, application (ladder rung logic) program execution, storage of the application program, storage of numerical values related to the application process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics.

2.2.3 Power Supply Module

a. The power supply module shall be plugged into the backplane not separately mounted. The power supply shall be wired to utilize 120 VAC, 60 Hz power, the system shall function properly within the range of minus 10 to plus 15 percent of nominal voltage. The power supply shall provide an output to the backplane at a wattage and voltage necessary to support the attached modules. A single main power supply module shall have the capability of supplying power to the CPU module and local communication and I/O modules. Auxiliary power supplies shall provide power to remote racks.

b. Each power supply shall have an integral on/off disconnect switch to the module. If the manufacturers standard power supply does not have an on/off disconnect switch a miniature toggle type switch shall be installed near the PLC and clearly labeled as to its function.

c. The power supply shall monitor the incoming AC line voltage for proper levels and have provisions for both over current and over voltage protection. If the voltage level is detected as being out of range the system shall have adequate time to complete a safe and orderly shutdown.
2.2.4 Program Storage/Memory Requirements

a. The PLC shall have the manufacturers standard nonvolatile executive memory for the operating system. The PLC shall also have EEPROM (Electrically Erasable Programmable Read Only Memory) for storage of the user program and battery backup RAM for application memory. The EEPROM shall be loaded by use of the laptop computer or the personal computer.

b. Submit a calculation of the required amount of EEPROM and RAM (random access memory) needed for this application plus an extra 50 percent.

c. The number of times a normally open (N.O.) and/or normally closed (N.C.) contact of an internal output can be programmed shall be limited only by the memory capacity to store these instructions.

2.2.5 Input/Output (I/O) Modules

a. Provide all required I/O modules (analog input, analog output, discrete input, discrete output, and isolated discrete output) to manipulate the types of inputs and outputs as shown on the drawings and to comply with the sequence of operations. Also provide a minimum of 20 percent (round up for calculation) spare input and output points of each type provided, but not less than 2 of each type.

b. I/O modules shall be a self-contained unit housed within an enclosure to facilitate easy replacement. All user wiring to I/O modules shall be through a heavy-duty terminal strip. Pressure-type screw terminals shall be used to provide fast, secure wire connections. The terminal block shall be removable so it is possible to replace any input or output module without disturbing field wiring.

c. During normal operation, a malfunction in any remote input/output channel shall affect the operation of only that channel and not the operation of the CPU or any other channel.

d. Isolation shall be used between all internal logic and external power circuits. This isolation shall meet the minimum specification of 1500 VRMS. Provide optically isolated I/O components which are compatible with field devices.

e. Each I/O module shall contain visual indicators to display ON/OFF status of individual input or output points.

f. Discrete output modules shall be provided with self-contained fuses for overload and short circuit protection of the module.

g. All input/output modules shall be color coded and titled with a distinctive label.

2.2.6 Interfacing

The PLC shall have communication ports and communication modules using the manufacturers standard communication architecture for connections of the Personal computer, Laptop Computer, remote I/O racks and interconnections between SYS 1 PLC and SYS 2 PLC for the redundant backup system of the PLCs.
2.2.7 Program Requirements

a. The programming format shall be ladder diagram type as defined by NEMA IA 2.

b. There shall be a means to indicate contact or output status of the contact or output on the CRT (of the personal computer) or LCD screen (of the laptop computer). Each element's status shall be shown independently, regardless of circuit configuration.

c. The program shall be full featured in its editing capabilities (e.g., change a contact from normally open to normally closed, add instructions, change addresses, etc.).

2.2.8 Diagnostics

The CPU shall continuously perform self-diagnostic routines that will provide information on the configuration and status of the CPU, memory, communications and I/O. The diagnostic routines shall be regularly performed during normal system operation. A portion of the scan time of the controller should be dedicated to perform these housekeeping functions. In addition, a more extensive diagnostic routine should be performed at power up and during normal system shutdown. The CPU shall log I/O and system faults in fault tables, which shall be accessible for display. When a fault shuts down a CPU, a sequence shall be initiated that will automatically switch over to the other CPU. When a fault affects I/O or communication modules the CPU shall shut down only the hardware affected and continue operation by utilizing healthy system components. All faults shall be annunciated on the alarm annunciator.

2.3 GRAPHICS DISPLAY PANEL

2.3.1 Enclosure

The Graphics Display Panel (GDP) shall be a 42 inches LED Panel Display suitable for wall mounting and capable of accepting input from the Personal Computer. The Personal Computer shall be set up to normally display it's screen number four on the graphic Display Panel, but it shall be capable of sending any of its other screens to the display panel. Any combination of the screens shall be capable of being displayed on the Personal Computer Monitor and the Graphic Display Panel.

2.3.2 Display Presentation

The process schematic graphic representation shall be as shown on the drawings. Red, green, amber, etc., colors should display on the screen as indicated on the drawings. The indicated lights on the drawing shall display approximately 1/2 inch in diameter.

2.3.3 Digital Flow and Pressure Indicators

Digital indicators as shown on the drawings shall also be displayed on the Graphics Display Panel to provide flows in GPM and pressures in psig. The digital indicators shall display the indicated number of digits as shown on the drawings. Each digit shall be approximately 0.6 inches high.
PART 3 EXECUTION

3.1 PUMP CONTROL PANEL (PCP) AND COMPONENTS

3.1.1 General

a. Where two or more pieces of equipment performing the same function are required, they shall be exact duplicates produced by the same manufacturer. All display instruments of each type shall represent the same outward appearance, having the same physical size and shape, and the same size and style of numbers, characters, pointers, and lamp lenses.

b. The PCP shall include all required resident software programs and hardware to provide the specified sequence of operation. All software optical discs, including programming manuals, shall be turned over to the Government at the completion of start-up so modification can be done in the field with no outside assistance.

c. It is intended that process controlling devices except field devices, and motor controllers be attached to or mounted within the PCP enclosure and all interconnecting wiring installed prior to shipment to the job site. This is to allow shop testing of the system and to decrease field labor requirements.

d. The PCP shall be shipped fully assembled in one piece after the completion of the shop tests and all defects corrected.

3.1.2 Wiring

Wiring methods and practices shall be in conformance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 4, and NEMA ICS 6 recommendations as applicable. All wiring to instruments and control devices shall be made with stranded wire, and wiring shall be permanently labeled with conductor/wire numbers within 1 inch of termination points. Labels shall be tubular heat-shrinkable wire markers that remain legible after exposure to industrial fluids and abrasion. Position markers so that wire numbers can be read without disturbing or disconnecting wiring. Use of individual character-markers placed side-by-side is not acceptable. Numbers shall match approved shop drawings. All wiring shall be neatly laced from point of entry into enclosures to termination points with nylon lacing cord or plastic lacing ties. Lacing within wiring channels is not required. Provide typed Control Wiring Data Lists within each terminal cabinet and the PCP. The data lists shall include: Conductor identification number, wire gauge, wire insulation type, "FROM" terminal identification, "TO" terminal identification, and remarks. The preliminary lists generated by the Contractor will be submitted for approval to the Contracting Officer and will be updated to As-Built conditions by the Contractor. The As-Built data lists shall be placed in a document holder within each enclosure.

3.1.3 Certified Pump Control Panel (PCP) Shop Test Report

The manufacturer shall shop test the PCP, Personal computer, and lap top computer. The procedure shall include simulation of field components and shall provide for fully testing the pump control and annunciator system as a unit before delivery to the Project Site. The test shall, reveal system defects, including, but not limited to, functional deficiencies, operating program deficiencies, algorithm errors, timing problems, wiring errors, loose connections, short circuits, failed components and misapplication of
components. The test shall be performed prior to shipment to the site and problems detected shall be corrected. The final testing and correction sequence shall be repeated until no problems are revealed and then two additional successful tests shall be performed. Submit certified test report within 15 days after completion of the test. The report shall include a statement that the Pump Control Panel performs as specified. Notify the Contracting Officer and the Command Fuels Engineer 30 days prior to the final shop testing date. The Contracting Officer may require a Government witness at the final test before the PCP is shipped to the site.

3.1.4 Ventilation System

Thermostat T-1, shall control fan F-1 and thermostat T-2 shall control fan F-2. T-1 and T-2 shall be set at 80 degrees F to maintain interior air temperature to 20 degrees F above ambient. Thermostat T-3, set at 100 degrees F, shall provide a non-critical PCP HIGH TEMPERATURE alarm to the alarm annunciator.

3.1.5 Grounding

The PCP ground bar shall be connected to the building counterpoise via a #10 AWG conductor. Within the enclosure all I/O racks, processor racks, and power supplies, etc., shall be grounded to meet the manufacturer's specifications.

3.1.6 Indicator Lights, Switches, and Pushbuttons

Indicator lights, switches, and pushbuttons shall be mounted through the PCP enclosure and shall be arranged to allow easy vision and operation of each device. Each device shall have a nameplate and/or legend plate as indicated on the drawings. Nameplate wordings shall be as indicated on the Drawings.

3.1.7 Transient Voltage Surge Suppression Devices

Transient voltage surge suppression (TVSS) devices shall be installed in the PCP to minimize effects of nearby lightning strikes, switching on and off of motors and other inductive loads. TVSS shall be provided for each control circuit ladder. Each ladder may contain any combination of the following devices: PLCs, power supplies (e.g., 24 volt), fans, relays, lights, switches etc. TVSS shall also be provided for PLC I/O originating outside of the building.

3.1.8 Terminal Blocks

As a minimum, any PCP device that connects to a field device (devices not located in the PCP) shall be connected to a terminal block. A connection diagram similar to the drawings shall be provided to the field Contractor for field connections to the PCP.

3.1.9 Circuit Breakers

As a minimum, any 120 volt PCP device i.e., (fans, lights, power receptacles, 24 VDC power supplies, PLC CPUs, PLC I/O racks) shall be provided with an individual circuit breaker. Additionally 120 volt terminal boards connecting to field devices (devices not located in the PCP) shall be protected by a 120 volt circuit breaker.
3.1.10 Uninterruptible Power supplies

The PCP shall contain three uninterruptible power supplies (UPS) each connected to a dedicated circuit. As shown on the drawings one UPS shall supply PLC System 1, one UPS shall supply PLC System 2, and the third UPS shall supply the miscellaneous device power. The UPSs output capacity shall be sufficient to drive all the equipment connected plus 25 percent. The UPSs shall be mounted on shelves near the bottom of the PCP but not rest on the floor of the PCP.

3.1.11 Power Supplies

Provide and install all 120 VAC and 24 VDC power supply. Interconnecting wiring between UPSs and PLC power supplies shall be completely installed prior to shipment to the job site.

3.1.12 Alarm Annunciator and Horns

Signals shall be initiated by hardwired field contacts or by PCP outputs as required. The annunciator shall energize alarm horns, both an integral panel mounted vibrating horn and remote horns, and flash the appropriate annunciator lamp. The minimum number of windows shall correspond to the number of alarm points, plus 15 percent spare. The Drawings indicate panel layout and the alarms to be annunciated.

3.1.12.1 Non-critical Alarms

Non-critical alarm windows shall be white with black lettering and shall sound the PCP mounted vibrating horn and the exterior mounted vibrating horns.

3.1.12.2 Critical Alarms

Critical alarm windows shall be red with white lettering and shall sound the PCP mounted vibrating horn and the exterior mounted resonating horns. Critical alarms shall also cancel all automatic pump starts in the PLC.

3.1.12.3 Alarm Sequence

Alarm sequence for each alarm shall be as follows (ISA 18.1 sequence 'A').

a. For a normal condition, visual indicator and horns will be off.

b. For an alarm condition, visual indicator will flash and horns will sound (this condition will be locked in).

c. Upon acknowledgment of the alarm condition, visual indicator will be steady on and the horns will be off.

d. If, after acknowledgment of an alarm condition, another alarm condition is established, the new alarm will cause the appropriate window to flash and the horn to sound.

e. When condition returns to normal after acknowledgment, the visual indicator and the horn will be off.

3.1.13 Personal Computer

The personal computer shall be a stand alone, desk top mounted unit. The
personal computer shall download system parameters from the PLCs for display. The personal computer shall also upload new set point values that the operator has changed using the personal computer keyboard, after a password has been entered.

3.1.13.1 Screen Number 1

This shall be a general opening screen. As a minimum it shall display the name and location of the installation (e.g., Seymour Johnson Air Force Base, North Carolina), name of the project (e.g., Type III Hydrant Fueling System) and screen navigation information.

3.1.13.2 Screen Number 2

At a minimum the following items shall be displayed. The values shall be continuously updated, a 2 second delay maximum between updates will be acceptable.

<table>
<thead>
<tr>
<th>System Issue Rate</th>
<th>xxxx GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Return Rate</td>
<td>xxxx GPM</td>
</tr>
<tr>
<td>System Net Flow</td>
<td>xxxx GPM</td>
</tr>
<tr>
<td>System Pressure</td>
<td>xxxx PSI</td>
</tr>
<tr>
<td>System Operation Mode</td>
<td>Auto/Off/Flush/Tightness test</td>
</tr>
<tr>
<td>Active System</td>
<td>Sys-1/Sys-2</td>
</tr>
<tr>
<td>Lead Pump</td>
<td>1/2/3</td>
</tr>
</tbody>
</table>
| Fuel Pump #1      | On/Off   
|                   | xxxxx.x HOURS |
| Fuel Pump #2      | On/Off   
|                   | xxxxx.x HOURS |
| Fuel Pump #3      | On/Off   
|                   | xxxxx.x HOURS |
| Backpressure Control Valve | Closed/Enabled |
| Pressure Control Valve | Closed/Enabled |
| Defuel/Flush Valve | Closed/Enabled |
| Tank 1 Outlet Valve (I1) | Open/Closed |
| Tank 2 Outlet Valve (I2) | Open/Closed |
| Tank 3 Outlet Valve (I3) | Open/Closed |
| Tank 1 Low Suction Outlet Valve | Open/Closed |
| Tank 2 Low Suction Outlet Valve | Open/Closed |
| Tank 3 Low Suction Outlet Valve | Open/Closed |
| Tank 1 Inlet Valve (R11) | Open/Closed |
| Tank 2 Inlet Valve (R13) | Open/Closed |
| Tank 3 Inlet Valve (R12) | Open/Closed |
| Manifold Setup Valve (I28) | Open/Closed |
3.1.13.3 Screen Number 3

The following table shall be displayed. The table lists the set points that can be adjusted using the operator interface. A password shall be entered before the "current value" can be adjusted. The value entered can only be a number within the "set point range". The "default value" is the value held in the program that is loaded into EEPROM memory. (This screen may require more than one display screen.)

<table>
<thead>
<tr>
<th>SET POINT DESCRIPTION</th>
<th>SET POINT RANGE</th>
<th>DEFAULT VALUE</th>
<th>CURRENT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead pump starting pressure</td>
<td>30 to 150 psi</td>
<td>60 psi</td>
<td>xxx psi</td>
</tr>
<tr>
<td>Issue flow to start second pump in the sequence</td>
<td>750 to 950 gpm</td>
<td>840 gpm</td>
<td>xxx gpm</td>
</tr>
<tr>
<td>Return flow to enable next pump in sequence to start</td>
<td>10 to 100 gpm</td>
<td>60 gpm</td>
<td>xxx gpm</td>
</tr>
<tr>
<td>Return flow to stop second pump in the sequence (lag pump)</td>
<td>850 to 1100 gpm</td>
<td>1000 gpm</td>
<td>xxx gpm</td>
</tr>
<tr>
<td>Return flow to initiate lead pump shutdown sequence</td>
<td>750 to 950 gpm</td>
<td>840 gpm</td>
<td>xxx gpm</td>
</tr>
<tr>
<td>Timer to enable start-up of lead pump</td>
<td>0 to 120 seconds</td>
<td>0 seconds</td>
<td>xx seconds</td>
</tr>
<tr>
<td>Timer to enable second pump to start</td>
<td>0 to 120 seconds</td>
<td>10 seconds</td>
<td>xx seconds</td>
</tr>
<tr>
<td>Timer to stop second pump</td>
<td>0 to 120 seconds</td>
<td>15 seconds</td>
<td>xx seconds</td>
</tr>
<tr>
<td>Timer to stop first pump</td>
<td>0 to 60 seconds</td>
<td>2 seconds</td>
<td>xx seconds</td>
</tr>
<tr>
<td>Timer to disable Back Pressure Control Valve</td>
<td>0 to 360 seconds</td>
<td>60 seconds</td>
<td>xx seconds</td>
</tr>
<tr>
<td>Timer to establish fueling pump failure</td>
<td>5 to 30 seconds</td>
<td>15 seconds</td>
<td>xx seconds</td>
</tr>
</tbody>
</table>
### Screen Number 4

This screen shall be a duplicate of the Graphic Display Drawing showing a schematic of the process flow. This screen shall be referred to as the graphical display. Many operating parameters shall be displayed here as required in later paragraphs of this Specification.

### Screen Number 5

This screen shall be a duplicate of the Alarm Annunciator and it shall be superimposed over the current active screen on the personal computer monitor when an alarm is activated.

### Screen Number 6

This screen shall be a screen designed solely for assisting the testing team during initial start up to watch all of the significant parameters of the systems operation simultaneously on one screen. This screen shall include the system parameters i.e., (flows, pressures, and status) from screen 2, the set points from screen 3, and timers for all of the actions that will take place following a delay function.

### Screen Number 7

This screen shall be a screen designed solely for displaying the seven graphs as described in Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP. The following values shall be displayed concurrently against time: Issue flow, Issue pressure, Return flow, Pump #1 discharge pressure, Pressure upstream of BPCV, Pressure downstream of BPCV, and Hydrant Pit Pressure. The personal computer shall be capable of storing up to 1 week of data corresponding to the above values. The system will be able to produce graphs on the screen of this data and be able to print the data in seven colors on the laser printer.

### Screen Number 8

This screen shall be an alarm history screen. This screen shall be referred to as the Alarm History Display. This screen shall be capable of storing and displaying all alarms that have occurred in the system for at least a period of 30 days.

### Screen Number 9

This screen shall be a screen designed solely for displaying the parameters and process involved in the Tightness Test as described in this specification and on the drawings. The following values shall be displayed concurrently against time: Pressure (as sensed by PIT-153). The system will be able to produce graphs on the screen of this data and be able to print the data in color on the laser printer.

### Laptop Computer

The Laptop computer shall be used to create, edit, and load the ladder
logic program into the PLCs and the operator interface graphics control program into the personal computer. The Laptop shall also be used to monitor the PLCs memory and ladder logic program. The computer shall be stored in a lockable cabinet located within the Pump Control Panel.

3.2 PROGRAMMABLE LOGICAL CONTROLLER (PLC) HARDWARE AND SOFTWARE

3.2.1 General

The basic operation of the redundant PLC system is (Reference "Control System Block Diagram" on the Drawings):

a. CPU-1 and it's associated I/O rack (I/O-1) sends system outputs to appropriate devices and receive input signals from System-1 redundant field devices (PIT-151, DPT-151, DPT-153, flow switches, valve limit switches), System-2 redundant field devices (PIT-152, DPT-152, DPT-154, flow switches, valve limit switches), and all nonredundant field devices as listed on the Drawings.

b. CPU-2 and it's associated I/O rack (I/O-2) sends system outputs to appropriate devices and receive input signals from System-1 redundant field devices (PIT-151, DPT-151, DPT-153, flow switches, valve limit switches), System-2 redundant field devices (PIT-152, DPT-152, DPT-154, flow switches, valve limit switches), and all nonredundant field devices as listed on the Drawings.

c. Within each rack (I/O-1 and I/O-2) System-1, System-2, and nonredundant inputs and outputs shall not be mixed on the same input/output module.

d. Under normal operation: The system input select switch is in the "SYS-1" position. CPU-1 is controlling the system using System-1 and nonredundant inputs from I/O-1 and any set point changes from the personal computer. CPU-2 is being updated by CPU-1 or concurrently monitoring System-1 inputs from I/O-2.

e. If under normal operation CPU-1 recognizes that a System-1 input has failed (see note below) it shall change over to the System-2 redundant input on I/O-1 and report the failure to the personal computer alarm screen.

Note: The pressure indicating transmitters and the differential pressure transmitters are the only devices that the PLC can monitor for a possible failure. Failures shall be defined in the following manners: When the pressure indicating transmitters differ from each other by more than 10 psig after a ten second delay, assume the lower reading transmitter has failed. When the issue differential pressure transmitters differ from each other by more than 30 gpm after a ten second delay, assume the lower reading transmitter has failed. When the return differential pressure transmitters differ from each other by more than 20 gpm after a ten second delay, assume the lower reading transmitter has failed.

f. During normal operation there are two ways for CPU-2 to take control of the system: 1) CPU-1 identifies its own internal fault and hands over control to CPU-2. 2) CPU-2 identifies a fault in CPU-1 and takes control from CPU-1. When CPU-2 is in control of the system it shall annunciate the fault condition and shall be using any updated inputs from the personal computer and shall use System-1 inputs. If CPU-2 senses a fault on a System-1 input it shall then switch over to the appropriate System-2 input. If power is lost to System-1 inputs then
CPU-2 shall use all of the System-2 inputs.

g. CPU-2 shall also report any of its internal faults to CPU-1 and CPU-1 shall report any faults it detects in CPU-2.

h. When the operators think the system is not working and the PLCs do not detect any faults the operator can move the system input select switch from the "SYS-1" position to the "SYS-2" position. With the switch in the "SYS-2" position the PLCs are using System-2 inputs.

3.2.2 Programs

a. Provide two copies of all working programs (i.e., PLC logic, personal computer) on read only optical discs as well as a printed program listing.

b. Provide rung comments (documentation) in the ladder logic program. Each device, on the ladder, shall be identified as to the type of device, i.e., limit switch XX, flow indicator XX, motor starter XX, etc. Rung comments shall be provided for input and output rungs. The programmer shall also provide a comment describing the function of each rung or group of rungs that accomplish a specific function.

3.3 GRAPHICS DISPLAY PANEL

The graphic display panel shall be shipped fully assembled in one piece after it has been shop tested as an integral part of the pump control panel and all defects corrected. The graphic display panel shall be able to depict the same screens as the personal computer displays. The default screen on the GDP shall be the graphic display screen. The other screens that the personal computer can display will also be able to be chosen from the personal computer to be displayed here.

3.4 GRAPHICS DISPLAY SCREEN

3.4.1 General

The graphic display screen shall be capable of being displayed on the personal computer monitor and the GRAPHICS DISPLAY PANEL.

3.4.2 Display Presentation

The Graphic Display shall depict the process fuel flow schematically as indicated on the drawings. Red, green, and amber symbols shall be integrated with the process schematic to provide current equipment status graphically. The symbols shall be located immediately adjacent to related equipment symbol.

3.4.3 Process Schematic

The process schematic graphic representation shall utilize conventional symbols when possible. Symbols and flow lines shall be sized and spaced so as to provide a clear representation of the system process. The Graphic Display shall be suitable for supervised field modification when future items are added. Minor changes may be incorporated to allow proper line width and spacing. Component arrangement, piping routing, and location of valves shall match the flow diagram. The Graphic Display layout shall be approved by the Government.
3.4.4 Digital Flow and Pressure Indicators

The graphics display screen shall have digital displays for the flows and pressures as indicated on the Drawings.

3.5 INSTALLATION

Installation shall conform to the manufacturer's drawings, written recommendations, and directions.

3.5.1 Shop Drawing

The shop drawing shall be clear and readable and preferably drawn using a computer aided drafting package. At the conclusion of the Project the diagram drawings shall be redrafted to include all as-built conditions. These updated drawings shall be included in the O&M Manuals and appropriate section of the drawings placed in a data pocket located in each of the enclosures. The shop drawing at a minimum shall show:

a. Overall dimensions, front, side and interior elevation views of the PCP showing size, location, and labeling of each device.

b. Overall dimensions, front elevation of the GDP showing graphical layout and size, location, and labeling of each device.

c. Power ladder diagram indicating power connections between TVSS, power conditioners, PLCs, power supplies, and field and panel devices. Any terminal block connection numbers used shall be indicated.

d. Control ladder diagram indicating control connections between field and devices and PLC I/O modules. Terminal block connection numbers and PLC terminal numbers shall be indicated.

e. Communication connections between PLCs and I/O racks. Communication channel numbers shall be indicated.

f. Bill of materials.

g. Written control sequence covering all inputs, outputs, and control scheme.

3.5.2 System Start-Up and Testing

a. At PCP start-up and testing provide personnel, onsite, to provide technical assistance, program fine tuning, and to start-up and test the system. Start-up and testing shall be coordinated with the overall fueling system start-up test specified in Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP. Prior to this test, all connections shall have been made between the PCP, the personal computer, the motor control center, and all field devices. In addition, wiring shall have been checked for continuity and short circuits. Adjust set point values, timing values, and program logic as required to provide a functional hydrant fuel control system. Once the system has been fine tuned and passed the system test, the new system default values, shall be loaded into the PLC EEPROM and the personal computer screens adjusted to indicate the new values.

b. A step-by-step Testing Plan of the PCP shall be submitted. The test shall be designed to show that every device (lights, switches, personal
3.5.3 Training Plan for Instructing Personnel

a. Upon completion of the system start-up a competent technician regularly employed by the PCP manufacturer shall hold a training class for the instruction of Government personnel in the operation and maintenance of the system. Provide both classroom type theory instruction and hands-on instruction using operating equipment provided. The period of instruction shall be a minimum of three 8-hour working days. The training shall be designed to accommodate 8 operators, 4 maintenance personnel, and 2 programmers. The Contracting Officer shall receive written notice a minimum of 14 days prior to the date of the scheduled classes.

b. Furnish a written lesson plan and training schedule for Government approval at least 60 days prior to instructing operating, maintenance and programming personnel. Concurrently submit above to the MAJCOM for their input into the review process. Approval of lesson plan will be based on both Government and MAJCOM concurrence. This plan shall be tailored to suit the requirements of the Government. The training shall be divided into three separate classes. Each class shall be tailored to a specific group of personnel. The groups are: 1) Operators, those that will use the control system on a day to day basis; 2) Maintenance personnel, those that will perform routine and non-routine maintenance and trouble shooting of the control system; 3) Programmers, those that will make changes to and trouble shoot the PLC and personal computer programs. The training program shall provide:

1. A detailed overview of the control system including the complete step-by-step procedures for start-up, operation and shut-down of the control system.
2. A general overview of programmable logic controllers.
3. The maintenance of equipment installed.
4. The programming of the PLC and Personal Computer.
5. Trouble shooting of the system.

c. Complete approved Operation and Maintenance manuals for Specification 33 09 53 AVIATION PUMP CONTROL AND ANNUNCIATION SYSTEM and 26 20 00 INTERIOR DISTRIBUTION SYSTEM (specifically pertaining to the motor control center and its relay ladder diagrams) shall be used for instructing operating personnel. Training shall include both classroom and hands-on field instruction. The class shall be recorded in DVD format.

d. Provide training courses in DVD format covering system overview, operation, maintenance, trouble shooting, and programming. These DVDs shall be produced offsite by the Contractor using the supplied Pump
Control Panel as the teaching aid, or commercially produced DVDs by the PLC manufacturer or third party who specializes in training on PLC systems. Along with the DVDs, provide workbooks, which follow along with the DVDs.

3.6 PLC CONTROL SYSTEM SEQUENCE OF OPERATION

The following describes general functions of the fueling system components.

3.6.1 Abbreviations

a. SYS-1: Components of System #1 including UPS#1, power supplies, CPU-1, I/O-1, and system #1 input and outputs.

b. SYS-2: Components of System #2 including UPS#2, power supplies, CPU-2, I/O-2, and system #2 input and outputs.

c. CPU-1: SYS-1 PLC CPU.

d. CPU-2: SYS-2 PLC CPU.

e. I/O-1: SYS-1 PLC input/output modules.


g. PCP: Pump Control Panel.

h. PC: Personal Computer.

i. UPS: Uninterruptible Power Supply.

j. GDP: Graphic Display Panel.

3.6.2 Operating Tanks

3.6.2.1 Level Control

Each operating tank has four level float switches to measure low-low, low, high, and high-high levels. The switches are DPDT for the redundancy and each pole shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing.

3.6.2.1.1 Low-Low Level

When the low-low level float is activated the associated tank's graphic display low-low level light shall light up. If the tank's outlet valve is not fully closed the alarm annunciator's low-low level critical alarm sequence activates, fueling pumps running in automatic mode shall be disabled and no pump shall be allowed to start automatically. If all tanks are at low-low level, no fueling pumps shall start automatically.

3.6.2.1.2 Low Level

When the low level float is activated the associated tank's graphic display low level light shall light up and the alarm annunciator's non-critical low level alarm sequence activates.
3.6.2.1.3 High Level

When the high level float is activated the associated tank's graphic display high level light shall light up and the alarm annunciator's non-critical high level alarm sequence activates.

3.6.2.1.4 High-High Level

When the high-high level float is activated the associated tank's graphic display high-high level light shall light up, the alarm annunciator's critical high-high level alarm sequence activates, fueling pumps running in automatic mode shall be disabled and no pump shall be allowed to start automatically. Additionally the pump control panel shall de-energize the solenoid on the tank's high level shutoff valve to force it closed.

3.6.2.2 Outlet Valve

Each operating tank's outlet valve has two limit switches to indicate valve position. The closed limit switch is DPDT for redundancy and each pole shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The closed limit switch shall close when the valve is fully closed. When the closed limit switch is closed the associated tank's valve graphic display closed light shall activate. When the valve is fully open, the open limit switch is closed. At this time the associated tank's valve graphic display open light shall activate.

3.6.2.3 Low Suction Outlet Valve

Where indicated, operating tank's low suction outlet valve has two limit switches to indicate valve position. The limit switches are DPDT for redundancy. One pole on each limit switch shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The closed limit switch shall close when the valve is fully closed. When the closed limit switch is closed the associated tank's valve graphic display closed light shall activate. When the valve is fully open, the open limit switch is closed. At this time the associated tank's valve graphic display open light shall activate.

3.6.2.4 Inlet Valve

Each operating tank's inlet valve has two limit switches to indicate valve position. The limit switches are SPDT and the single pole shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The closed limit switch shall close when the valve is fully closed. When the closed limit switch is closed the associated tank's valve graphic display closed light shall activate. When the valve is fully open, the open limit switch is closed. At this time the associated tank's valve graphic display open light shall activate.

3.6.2.5 Tank Valve Interlocks for Pumping Systems

The issue pumps may not be operated, except in hand mode, while all the outlet and low suction close limit switches are closed.

3.6.3 Product Recovery Tank

3.6.3.1 Fuel Transfer Pump (FTP)

The pump's motor controller has a status relay to indicate the on/off
status of the pump. The status relay shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When status relay is open the pump's graphic display off light shall activate. When the status relay is closed the pump's graphic display on light shall light up. The status relay state shall also be used to start and stop the pumps elapsed run time timer.

3.6.3.2 Overfill Valve (OV)

The tank's overfill valve has a limit switch to indicate valve position. The switch is SPST and shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The switch shall close when the valve is fully closed. When the limit switch is closed, the tank's graphic display valve closed light shall light up and the alarm annunciator's non-critical alarm sequence activates. When the limit switch is open the tank's graphic display valve open light shall light up.

3.6.3.3 High Level Alarm

The tank has a high level alarm float switch. The switch is SPST and shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When the high level alarm float is activated the tank's graphic display high level light shall light up and the alarm annunciator's critical alarm sequence activates.

3.6.3.4 High-High Level Alarm

The tank has a high-high level alarm float switch. The switch is SPST and shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When the high-high level alarm float is activated the tank's graphic display high level light shall light up and the alarm annunciator's critical alarm sequence activates.

3.6.3.5 High Water Level Alarm

The tank has a high water level alarm float switch. The switch is SPST and shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When the high level alarm float is activated the tank's graphic display high level light shall light up and the alarm annunciator's non-critical alarm sequence activates. If the FTP motor controller is placed in automatic mode, high water level alarm will disable the run permissive.

3.6.3.6 Leak Detection

The tank has a leak detection system. The leak detection systems alarm relays shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When the leak alarm is activated the alarm annunciator's non-critical alarm sequence activates.

3.6.4 Fueling Pumps (FP)

There are three fueling pumps with a maximum of two pumps running at one time. The lead pump selector switch shall select the pump starting sequence. Each pump's motor controller has a status relay to indicate the on/off status of the pump. The status relay shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. When status relay is open the associated pump's graphic display off light shall activate and screen number 2 shall indicate on. When the status
relay is closed the associated pump's graphic display on light shall activate and screen number 2 shall indicate off. The status relay state shall also be used to start and stop the pumps elapsed run time timer and shall be displayed on screen number 2.

3.6.5 Flow Switch, Fueling Pump

On the discharge side of each pump is a flow switch to indicate positive flow (fail safe feature). The flow switch is DPDT for redundancy and each pole shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. If the PLC has given a signal to start a pump and the flow switch has not closed before the set point timer expires or if the flow switch opens after the pump has been running then the pump shall be in a failure state and it shall be disabled (taken out of the starting sequence), the alarm annunciator's non-critical alarm sequence shall also be activated, and the next pump in the start sequence started. After the PLC has stopped all of the pumps, any failed pump shall be added back into the start sequence.

3.6.6 Transmitters

3.6.6.1 Pressure Indicating Transmitter (PIT)

The PIT's measure system pressure in psi. There are two PITs connected to the PCP for redundancy. PIT-151 and PIT-152 are connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The system pressure is sent to personal computer display. PIT-153 is connected directly to the Tightness Test Panel.

3.6.6.2 Differential Pressure Transmitter (DPT)

The DPT's measure flow in gpm. There are two issue DPTs (DPT-151 and DPT-152) and two return DPTs (DPT-153 and DPT-154) for redundancy. The DPTs are connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection Drawing. The net flow is sent to the personal computer display. The issue rate, return rate and net flow shall be displayed on the personal computer.

3.6.6.3 Pressure Transmitters (PT)

The PTs measure system pressure in psi. There are three PTs installed on the system and there are PCP preparations made for a fourth PT to be temporarily wired in from a Hydrant Pit. PT-111, PT-151, PT-152, and PT-153 are connected to SYS-1 only as indicated on the Terminal Block Connection Drawing. These sensors will report various system pressures to the personal computer to be used for the creation of the system graphs as required for screen 7 and described in Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP.

3.6.7 Control Valves

3.6.7.1 Defuel/Flush Valve (D/FV)

The D/FV shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. The graphical display open and closed lights and screen number 2 status shall activate based on the PLC's output status for the valve. The valve status shall be based on the table listed below.
Defuel/Flush Valve Operation - Two Solenoids

<table>
<thead>
<tr>
<th>Fueling Mode per PCP Selector Switch</th>
<th>Valve Action</th>
<th>Solenoid A</th>
<th>Solenoid B</th>
<th>Graphical Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flush Mode</td>
<td>Open</td>
<td>De-energized</td>
<td>Energized</td>
<td>Open</td>
</tr>
<tr>
<td>Automatic Mode Pump(s) On</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Automatic Mode Pumps Off</td>
<td>Enabled</td>
<td>Energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Off Mode Pump(s) On</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Off Mode Pumps Off</td>
<td>Enabled</td>
<td>Energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Tightness Test</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
</tbody>
</table>

3.6.7.2 Pressure Control Valve (PCV)

The PCV shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. The graphical display enabled and closed lights and screen number 2 status shall activate based on the PLC's output status for the valve. The valve status shall be based on the table listed below.

<table>
<thead>
<tr>
<th>Pressure Control Valve Operation - Two Solenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fueling Mode per PCP Selector Switch</td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Automatic Mode Pumps Off</td>
</tr>
<tr>
<td>Automatic Mode Pump(s) On</td>
</tr>
<tr>
<td>Flush Mode Pumps On</td>
</tr>
<tr>
<td>Flush Mode Pumps Off</td>
</tr>
<tr>
<td>Off Mode Pump(s) On</td>
</tr>
<tr>
<td>Off Mode Pumps Off</td>
</tr>
<tr>
<td>Tight. Test-Hi Pres</td>
</tr>
<tr>
<td>Tight. Test-Static</td>
</tr>
<tr>
<td>Tight. Test-Low Pres</td>
</tr>
</tbody>
</table>

3.6.7.3 Backpressure Control Valve (BPCV)

The BPCV shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. The graphical display enabled and closed lights and screen number 2 status shall activate based on the PLC's output status for the valve. The valve status shall be based on the table listed below.
### Backpressure Control Valve Operation - Two Solenoids

<table>
<thead>
<tr>
<th>Fueling Mode per PCP Selector Switch</th>
<th>Valve Action</th>
<th>Solenoid A</th>
<th>Solenoid B</th>
<th>Graphical Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Mode Pump Start-Up</td>
<td>Enabled</td>
<td>Energized</td>
<td>De-energized</td>
<td>Enabled</td>
</tr>
<tr>
<td>Automatic Mode Prior to Lead Pump Shutoff</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Flush Mode</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Off Mode Pump(s) On</td>
<td>Enabled</td>
<td>Energized</td>
<td>De-energized</td>
<td>Enabled</td>
</tr>
<tr>
<td>Off Mode Pumps Off</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
<tr>
<td>Tight. Test-Hi Pres</td>
<td>Enabled</td>
<td>De-energized</td>
<td>Energized</td>
<td>Enabled</td>
</tr>
<tr>
<td>Tight. Test-Low Pres</td>
<td>Closed</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Closed</td>
</tr>
</tbody>
</table>

#### 3.6.8 Safety Circuit

##### 3.6.8.1 Emergency Stop Status

The emergency stop circuit status relay (ER1) N.O. contact shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. When the circuit is activated the alarm annunciator's critical alarm sequence is activated and any calls to start fueling pumps shall be canceled and no additional pump start signals shall be sent until the circuit has been reset. The fueling pumps will actually be stopped by a emergency stop circuit status relay (ER2) N.O. contact in the fuel pump motor control circuit located in the motor control center.

##### 3.6.8.2 Emergency Shutoff Valves (ESO) Status

The ESO status relay (ER2) N.O. contact shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. When the relay is closed the GDP valve open lights shall light up. When the relay is open the GDP valve closed lights shall activate.

##### 3.6.8.3 Circuit Power Status

The safety circuit power status relay (ER3) N.O. contact shall be connected to I/O-1, I/O-2, and UPS#3 as indicated on the Terminal Block Connection Drawing. When the relay is closed the PCP emergency circuit power on light shall light up.

#### 3.6.9 Pump Control Panel

##### 3.6.9.1 CPU Faults

The PCP mounted CPU-1 and CPU-2 on lights are connected to both SYS-1 and SYS-2. The associated CPU light shall light when no system faults are detected. When a fault is detected by the CPU or it's redundant CPU the faulted CPU's on light shall be turned off and the alarm annunciator's non-critical alarm sequence shall be activated.
3.6.9.2 Input Select Switch

The 2-position input select switch shall control which inputs (System-1 or System-2) are being used. Each switch position shall be connected to both SYS-1 and SYS-2. The OI display shall indicate the active system.

3.6.9.3 Mode Select Switch

The 4-position switch selects what mode of fueling is active: Automatic, flush, Tightness Test or off. Each switch position shall be connected to both SYS-1 and SYS-2. The screen number 2 status shall indicate the active mode.

3.6.9.4 Lead Pump Selector Switch

The 3-position switch selects which pump shall be the lead pump. The switch position shall fix the starting sequence for all pumps. The sequences shall be 1-2-3, 2-3-1, and 3-1-2. The off sequence shall be the reverse of the start sequence, therefore, first on will be last off. A maximum of two pumps will be allowed to run at one time. If a pump fails to start or fails during operation, that pump will be disabled and the next pump in the sequence started. The screen number 2 status display shall indicate the lead pump.

3.6.9.5 PCP Temperature Alarm

The alarm thermostat when activated shall activate the alarm annunciator's non-critical alarm sequence.

3.7 OPERATING PROGRAM REQUIREMENTS

The control system's logic program shall be stored on a EEPROM chip. Default values of operator adjustable parameters shall be permanently stored on the chip with the capability of resetting the values in RAM to the values with in the range specified below. The default values can be changed through the use of the personal computer (after the correct password has been entered). After loss of power and battery failure the adjustable settings shall revert back to the default values located on the chip. The default values shown here shall be reset to the values determined during the system start up and test.

<table>
<thead>
<tr>
<th>Set Point Description</th>
<th>Set Point Range</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead pump starting pressure</td>
<td>30 to 150 psi</td>
<td>60 psi</td>
</tr>
<tr>
<td>Issue flow to start second pump in sequence</td>
<td>750 to 950 gpm</td>
<td>840 gpm</td>
</tr>
<tr>
<td>Return flow to enable next pump in sequence to start</td>
<td>10 to 100 gpm</td>
<td>60 gpm</td>
</tr>
<tr>
<td>Return flow to stop second pump in sequence (lag pump)</td>
<td>850 to 1100 gpm</td>
<td>1000 gpm</td>
</tr>
<tr>
<td>Return flow to initiate lead pump shutdown sequence</td>
<td>750 to 950 gpm</td>
<td>840 gpm</td>
</tr>
</tbody>
</table>
### 3.8 AUTOMATIC MODE - IDLE CONDITION

The fueling system is intended to remain continuously pressurized while in the idle condition. This allows the system to respond immediately to aircraft refueling and defueling requirements. Periodically, in the idle condition, the system will lose minimal pressure. When this occurs, the control system will automatically repressurize in the following sequence:

a. The lead pump will start when the system pressure is less than [60] psig continuously for [0] seconds. If the pressure then rises above [60] psig before the timer expires, the timer shall reset.

b. After the timer expires:

   (1) The BPCV solenoid 'A' shall be energized to enable the valve to modulate the system pressure at it's set point.

   (2) The PCV solenoid 'A' shall be energized to close the valve.

   (3) The D/FV solenoid 'A' shall be de-energized so the valve is closed and solenoid 'B' shall be de-energized.

c. With the lead pump running, 900 gpm will flow through the issue venturi. The system pressure upstream of the BPCV will increase to the BPCV set point of 110 psig. At this pressure the BPCV will start to open and the valve will modulate as required to pass sufficient flow through the return venturi to maintain pressure upstream of the valve.

d. With the lead pump running and no fueling demand the return venturi flow rate will equal the issue venturi flow rate. When the return
venturi flow rate is greater than [840] gpm a [300] second timer shall start. If the flow rate drops below [840] gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.

e. After the timer expires:

(1) The BPCV solenoid 'A' shall be de-energized to close the valve.

(2) The PCV solenoid 'A' shall be de-energized to bleed system pressure to 75 psig.

(3) When system pressure rises to 140 psig a [2] second timer shall start. After the timer has expired, the lead pump shall be stopped.

(4) The Defuel/Flush valve solenoid "A" shall be energized 30 seconds after lead pump shut down to allow it to open at 80 psig for defuel operations.

f. The system has now returned to a pressurized and idle condition.

g. When a fueling pump is called to start, a 15 second timer shall start. If the timer expires before the flow switch closes the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

h. If a fueling pumps flow switch opens after the pump has successfully started the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

3.9 AUTOMATIC MODE - REFUELING CONDITION

To start an aircraft fueling operation, an operator connects fueling equipment such as a hydrant hose truck to an aircraft and to a hydrant control valve. When the operator opens the hydrant control valve by use of an hydraulic operated "Deadman", the following sequence occurs:

a. The lead pump will start when the PIT senses a pressure less than [60] psig continuously for [0] seconds. If the pressure then rises above [60] psig before the timer expires, the timer shall reset.

b. After the timer expires:

(1) The BPCV solenoid 'A' shall be energized to enable the valve to modulate the system pressure at it's set point.

(2) The PCV solenoid 'A' shall be energized to close the valve.

(3) The D/FV solenoid 'A' shall be de-energized so the valve is closed and solenoid 'B' shall be de-energized.

c. With the lead pump running, +900 gpm will flow through the issue venturi. The system pressure upstream of the BPCV will increase to the BPCV set point of 110 psig. At this pressure the BPCV will start to open and the valve will modulate as required to pass sufficient flow through the return venturi to maintain pressure upstream of the valve.
d. With lead pump running and a issue venturi flow rate greater than [840] gpm and a return venturi flow rate greater than [60] gpm and less than [840] gpm the lead pump will continue to run and the BPCV will modulate to pass flow as necessary to maintain upstream system pressure.

e. With the lead pump running and a issue venturi flow rate greater than [840] gpm and a return venturi flow rate greater than [840] gpm a [300] second timer shall start. If issue venturi flow rate falls below [840] gpm or the return venturi flow rate falls below [840] gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.

f. After the timer expires:

(1) The BPCV solenoid 'A' shall be de-energized to close the valve.

(2) The PCV solenoid 'A' shall be de-energized to bleed system pressure to 75 psig.

(3) When system pressure rises to 140 psig a [2] second timer shall start. After the timer has expired, the lead pump shall be stopped.

(4) The Defuel/Flush valve solenoid "A" shall be energized 30 seconds after lead pump shut-down to allow it to open at 80 psig for defuel operations.

g. With the lead pump running and a issue venturi flow rate greater than [840] gpm and a return venturi flow rate less than [60] gpm a [10] second timer shall start. If the issue venturi flow rate falls below [840] gpm or the return venturi flow rate rises above [60] gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.

h. After the timer expires: The second pump shall start.

i. With the lead and second pumps running and a issue venturi flow rate greater than [1740] gpm and a return venturi flow rate of greater than [60] gpm and less than [1000] gpm the lead and second pumps shall continue to run and the BPCV shall modulate as necessary to maintain system pressure.

j. With the lead and second pumps running and a issue venturi flow rate greater than [1740] gpm and a return venturi flow rate greater than [1000] gpm a [15] second timer shall start. If issue venturi flow rate falls below [1740] gpm or the return venturi flow rate falls below [1000] gpm before the timer expires, the timer shall reset and no changes shall be made to the pump and valve status.

k. After the timer expires: The second pump shall be stopped.

l. With the lead and second pump running and a issue venturi flow rate greater than [1160] gpm and a return venturi flow rate less than [40] gpm a [10] second timer shall start. If the issue venturi flow rate falls below [1160] gpm or the return venturi flow rate rises above [40] gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
m. When a fueling pump is called to start, a 15 second timer shall start. If the timer expires before the flow switch closes the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

n. If a fueling pumps flow switch opens after the pump successfully started the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

3.10 AUTOMATIC MODE – DEFUELING CONDITION

To start an aircraft defuel operation, an operator connects a hydrant hose truck to an aircraft and a fuel sense line and an air sense line to the hydrant control valve. The hydrant hose truck has an on-board defuel pump capable of delivering 300 gpm at 165 psig. When the operator starts the defuel operation one of the following occurs:

a. If the fueling pumps are running (D/FV closed) the fuel being removed from the aircraft will either go to the other aircraft(s) connected to the system or be returned to the pumphouse where the BPCV will modulate to control system pressure and the fuel will be returned to the operating tanks. The return venturi flow rate will control the number of pumps that are on as discussed in Paragraph "Automatic Mode - Fueling Condition".

b. If the fueling pumps are off (D/FV enabled) the fuel being removed from the aircraft will be returned to the pumphouse and both the D/FV and the PCV will modulate to return the fuel to the operating tanks.

3.11 FLUSH MODE

This mode shall be used when the system need to be flushed of water or sediment. The operators shall first place the manual valve in the desired position to select the appropriate flow path. Placing the selector switch in "flush" the following shall occur:

a. The BPCV solenoid 'A' shall be de-energized to force it closed.

b. The D/FV solenoid 'A' shall be de-energized to allow the valve to open and the D/FV solenoid 'B' shall be energized to force it open.

c. Start the fueling pump(s) manually using the Hand-Off-Auto or Hand-Auto switch to obtain the desired flow rate. The automatic pump starts shall be disabled in this mode.

d. The PCV solenoid 'A' shall be energized when pump(s) are on and de-energized when the pumps are off.

e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.

f. If a fueling pumps flow switch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence shall activate.
3.12 TIGHTNESS TEST MODE

This mode shall be used in conjunction with the Tightness Monitoring Panel provided by Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT to perform tightness tests. Placing the selector switch to "TIGHTNESS TEST" the PCP will send a signal to the Tightness Monitoring Panel telling it that it is ready to perform the tests. At this time it will also operate three MOV valves, closing I16 and I17 and opening I20. The PCP will then receive signals from the Tightness Monitoring Panel to prepare for High Pressure Test, run High Pressure Test, Prepare for Low Pressure Test, run Low Pressure Test, prepare for 2nd High Pressure Test, run 2nd High Pressure Test, and when the test is over. The following PCP actions will occur after the corresponding signal:

Prepare for High Pressure Test:

a. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B" shall be energized to enable the valve at the 160 psi value.

b. The D/FV solenoid "A" shall be de-energized and the D/FV solenoid "B" shall be de-energized to force it closed.

c. Automatically start the lead fueling pump to obtain pressure.

d. The PCV solenoid "A" shall be Energized and PCV solenoid "B" shall be de-energized to close the valve.

e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.

f. If a fueling pumps flow switch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence shall activate.

g. MOV I21 will be opened.

h. The pump will continue to run until such time as the run High Pressure test signal is received. Note: The Tightness Monitoring Panel is monitoring the Loop pressure and when it is satisfied that it is high enough it will instruct the PCP to Run the High Pressure test.

Run High Pressure Test:

a. MOV I21 will be closed.

b. Fueling pump will be shut off.

c. The BPCV solenoid "A" shall be d-energized and the BPCV solenoid "B" shall be de-energized to close valve.

d. The PCV solenoid "A" will be de-energized and the PCV solenoid "B" will be de-energized to enable the valve at the 75 psi value. Note: The Tightness Monitoring Panel will wait for a ten minute settling time to pass, then it will monitor the loop pressure for two minutes. Upon finishing this test it will instruct the PCP to Prepare for the Low Pressure Test.

Prepare for Low Pressure Test:
a. MOV I21 will be opened.

b. The PCV solenoid "A" will be energized and the PCV solenoid "B" will be energized to enable the valve at the 50 psi value.

c. The system will remain in this status until such time as the PCP receives a Run Low Pressure test signal from the Tightness Monitoring Panel. Note: The Tightness Monitoring Panel will monitor the loop pressure until it reaches the 50 psi value. It will then instruct the PCP to run the Low pressure test.

**Run Low Pressure Test:**

a. MOV I21 will be closed.

b. The system will remain in this status until such time as the PCP receives a Prepare for 2nd High Pressure test signal from the Tightness Monitoring Panel. Note: The Tightness Monitoring Panel will wait for a ten minute settling period to expire, then it will monitor the loop pressure for two minutes. Upon finishing this test it will instruct the PCP to prepare for 2nd High Pressure Test.

**Prepare for 2nd High Pressure Test:**

a. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B" shall be energized to enable the valve at the 160 psi value.

b. The D/FV solenoid "A" shall be de-energized and the D/FV solenoid "B" shall be de-energized to force it closed.

c. Automatically start the lead fueling pump to obtain pressure.

d. The PCV solenoid "A" shall be de-energized and PCV solenoid "B" shall be de-energized to close the valve.

e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.

f. If a fueling pumps flow switch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence shall activate.

g. MOV I21 will be opened.

h. The pump will continue to run until such time as the run 2nd High Pressure test signal is received. Note: The Tightness Monitoring Panel is monitoring the Loop pressure and when it is satisfied that it is high enough it will instruct the PCP to Run the 2nd High Pressure test.

**Run 2nd High Pressure Test:**

a. MOV I21 will be closed.

b. Fueling pump will be shut off.

c. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B"
shall be de-energized to close valve.

d. The PCV solenoid "A" will be de-energized and the PCV solenoid "B" will be de-energized to enable the valve at the 75 psi value. Note: The Tightness Monitoring Panel will wait for a ten minute settling time to pass, then it will monitor the loop pressure for two minutes. Upon finishing this test it will instruct the PCP that testing is finished.

e. The PCP will leave the system as is until such time as the PCP selector switch is placed into a different mode.

3.13 OFF MODE

a. Automatic starting of fueling pumps shall be disabled. All other functions (GDP, alarm annunciator, personal computer, control valve solenoids, etc.) shall be active to allow manual control of the fueling pumps using the Hand-Off-Auto or Hand-Auto switch.

b. When the first pump has been started:
   (1) The BPCV solenoid "A" shall be energized to enable the valve to modulate the system pressure at it's set point.
   (2) The PCV solenoid "A" shall be energized to close the valve.
   (3) The D/FV solenoid 'A' shall be de-energized so the valve is closed and solenoid 'B' shall be de-energized.

c. The second pump may be started or stopped manually as needed by the operator.

d. After the last pump has been stopped:
   (1) The BPCV solenoid "A" shall be de-energized.
   (2) The PCV solenoid "A" shall be de-energized.
   (3) The D/FV solenoid 'A' shall be energized and D/FV solenoid 'B' shall be de-energized.

3.14 MANUAL OPERATION OF FUELING PUMPS

a. If the PLC system is still active see Paragraph "OFF MODE".

b. If the PLC system has no power or both CPUs have faulted (CPU lights on PCP off) the pumping system will be in a completely manual mode. The safety circuit will need power so that the ESO solenoids on the non-surge check valves will be open and fuel can flow. The solenoids on the other solenoid controlled valves will be de-energized so the valves will have to be manually opened or enabled for the system to run. Other valves may need to be opened or closed manually by the operators for the system to work properly.

3.15 6-VALVE MANIFOLD SUPERVISION

a. Prior to initiating fueling operations in the automatic or in the test mode, the 6-valve manifold valves and the two tank outlet valves be in the proper positions for successful fueling operations. The PLC shall monitor valve positions of the 6-valve manifold (sensed by position
3.16 TRUCK LOADING AND UNLOADING PUMPS (EXISTING SYSTEM)

Truck loading and unloading occurs at islands located on the western portion of the Site. The two existing operating tanks issue and receive fuel via existing truck loading and unloading pumps. The loading and unloading pumps will be connected in a similar manner to the third operating tank (new tank) as part of this Project.

Controls for the existing system are configured such that a high level condition for an operating tank receiving fuel will cease the truck unloading process by shutting down the pumps. The loading pumps are not connected to operating tank level controls and will not stop issuing upon low level in either operating tank.

The following truck loading and unloading controls modifications shall be made:

a. Existing Scully Level Alarm Panel and associated controls at the Level and Alarm Control Panel and Level and Alarm Panel shall be demolished. Refer to electrical drawing EI505 for additional information.

b. The PLC system shall be connected to the existing loading and unloading motor starters such that control of the pumps is made possible when motor starters are in Auto mode. PLC control shall be as follows:

(1) Truck Loading - Truck loading pumps may not be operated, except in hand mode, while all outlet close limit switches are closed (not in issue mode). If one or multiple tanks are in issue mode and each tank reaches low-low level, then truck loading pumps may not be operated.

(2) Truck Unloading - Truck unloading pumps may not be operated, except in hand mode, while all inlet close limit switches are closed (not in receive mode). If one or multiple tanks are in receive mode and each tank reaches high-high level, then truck unloading pumps may not be operated.

-- End of Section --
PART 1   GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300  (2010; Addenda 2011) Hypochlorites
AWWA B301  (2010) Liquid Chlorine
AWWA C104  (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C500  (2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C502  (2014) Dry-Barrel Fire Hydrants
AWWA C515  (2015) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C600  (2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C605  (2013) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
AWWA C651  (2014) Standard for Disinfecting Water Mains
AWWA C800  (2014) Underground Service Line Valves and Fittings
AWWA M11  

AWWA M23  

AWWA M9  
(2008; Errata 2013) Manual: Concrete Pressure Pipe

ASME INTERNATIONAL (ASME)

ASME B16.15  
(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250

ASME B16.18  
(2012) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.22  
(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26  
(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASTM INTERNATIONAL (ASTM)

ASTM A126  

ASTM A48  

ASTM B32  

ASTM B42  

ASTM B61  

ASTM B62  
(2015) Standard Specification for Composition Bronze or Ounce Metal Castings

ASTM B88  

ASTM C94  
(2016a) Standard Specification for Ready-Mixed Concrete

ASTM D1785  
(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D2241  


ASTM D2774 (2012) Underground Installation of Thermoplastic Pressure Piping


ASTM F2164 (2013) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

ASTM F402 (2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings


FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List (continuously updated) List of Approved Backflow Prevention Assemblies

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80 (2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Pipe, Fittings, Joints and Couplings; G
Valves; G
Hydrants; G
Pipe Anchorage; G
Tapping Sleeves; G
Corporation Stops; G

SD-06 Test Reports

Bacteriological Samples; G

SD-07 Certificates
Pipe, Fittings, Joints and Couplings

Shop-Applied Lining and Coating

Lining

Lining for Fittings

Valves

Hydrants

Disinfection Procedures

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with NSF/ANSI 61 and NSF 372 for materials for potable water piping, components and specialties for domestic water; comply with lead content requirements for "lead-free" plumbing as defined by the U.S. Safe Drinking Water Act effective January 2014.

Comply with NSF/ANSI 14 for plastic potable water piping and components. Provide plastic pipe and fittings, bearing the seal of the National Sanitation Foundation (NSF) for potable water service from the same manufacturer.

Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

1.3.2 Backflow Preventers

1.3.2.1 Backflow Preventers Certificate

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

1.3.2.1.1 Backflow Tester Certificate

Prior to testing, submit to the Contracting Officer certification issued by the State or local regulatory agency attesting that the backflow tester has successfully completed a certification course sponsored by the regulatory agency. Tester must not be affiliated with any company participating in any other phase of this Contract.

1.3.2.1.2 Backflow Prevention Training Certificate

Submit a certificate recognized by the State or local authority that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.
1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling and in accordance with manufacturer's instructions. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, hydrants, and other accessories free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, valves, hydrants, and other accessories in accordance with manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace material found to be defective before or after laying with sound material without additional expense to the Government. Store rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.

Handle PVC, fittings, and accessories in accordance with AWWA C605.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Water Distribution Mains

Provide water distribution mains indicated as 4 through 12 inch lines of PVC pipe. Provide water main accessories and valves as specified and where indicated.

2.1.2 Water Service Lines

Provide water service lines indicated as less than 4-inch diameter pipe sizes from water distribution main to building service at the points indicated. Provide water service lines of copper pipe, copper tubing, or PVC pipe. Provide water service line appurtenances as specified and where indicated.

2.2 PIPE, FITTINGS, JOINTS AND COUPLINGS

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on joints. Include information concerning gaskets with submittal for joints and couplings.
2.2.2.1 Plastic Piping

2.2.1.1 PVC Piping

a. Plain end or gasket bell end, with a minimum Pressure Class 165 (DR25), AWWA C900 with ductile iron outside diameter (DIOD).

2.2.1.1 Fittings for PVC Pipe

Gray iron or ductile iron fittings, AWWA C110 or AWWA C153, with cement-mortar lining for fittings, AWWA C104, standard thickness. Fittings with push-on joint ends are to conform to the same requirements as fittings with mechanical-joint ends, except that bell design is to be factory modified for push-on joint compatible for use with PVC plastic pipe specified in this paragraph. Provide cement-mortar lined iron fittings and specials in accordance with AWWA C104. Fittings and specials of the same material as the pipe with elastomeric gaskets, in conformance with AWWA C605 and AWWA C900.

2.2.1.2 Joints and Jointing Material

Provide push-on joints ASTM D3139 between pipes, pipes and metal fittings, valves, and other accessories or compression-type joints/mechanical joints, ASTM D3139 and AWWA C111. Provide each joint connection with an elastomeric gasket compatible for the bell or coupling with which it is to be used. Gaskets for push-on joints for pipe, ASTM F477. Gaskets for push-on joints and compression-type joints/mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, AWWA C111, respectively, for push-on joints and mechanical joints. Utilize mechanically coupled joints using a sleeve-type mechanical coupling, as specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS, as an optional jointing method in lieu of push-on joints on plain-end PVC plastic pipe, subject to the limitations specified for mechanically coupled joints using a sleeve-type mechanical coupling and to the use of internal stiffeners as specified for compression-type joints in ASTM D3139.

2.2.1.2 PVC Piping for Service Lines

2.2.1.2.1 Pipe and Fittings

ASTM D1785, Schedule 40; or ASTM D2241, with SDR as necessary to provide 150 psi minimum pressure rating. Fittings, ASTM D2466 or ASTM D2467. Provide pipe and fittings of the same PVC plastic material and of the following pipe/fitting combinations, as marked on the pipe and fitting, respectively: PVC 2120/PVC II; PVC 2116/PVC II.

2.2.1.2.1.1 Joints and Jointing Materials

Provide screw or elastomeric-gasket joints. Test pipe couplings, when used as required by ASTM D2464.

2.2.2 Copper Pipe and Tubing

2.2.2.1 Copper Pipe and Associated Fittings

Pipe, ASTM B42, regular, threaded ends. Provide lead-free brass or bronze fittings, ASME B16.15, 125 pound.
2.2.2.2 Copper Tubing and Associated Fittings

Tubing, ASTM B88, Type K. Fittings for solder-type joint, ASME B16.18 or ASME B16.22; fittings for compression-type joint, ASME B16.26, flared tube type.

2.2.3 Pipe Anchorage

Provide pipe anchorage designed for a minimum working pressure of 350 psi and in accordance with AWWA C605. Provide concrete thrust blocks (reaction backing) and/or restrained joints.

2.3 VALVES

2.3.1 Gate Valves 3 Inch Size and Larger on Buried Piping

AWWA C500, AWWA C509, AWWA C515, or UL 262. Unless otherwise specified, valves matching requirements of: (1) AWWA C500: Nonrising stem type with double-disc gates and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe, (2) AWWA C509 or AWWA C515: Nonrising stem type with mechanical-joint ends or resilient-seated gate valves 3 to 12 inches in size, and (3) UL 262: Inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 175 psi, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined. Match materials for UL 262 valves to the reference standards specified in AWWA C500. Valves open by counterclockwise rotation of the valve stem. Stuffing boxes have O-ring stem seals. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Use valves with special ends for connection to sleeve-type mechanical coupling in lieu of mechanical-joint ends and push-on joint ends. Provide valve ends and gaskets for connection to sleeve-type mechanical couplings that conform to the requirements specified respectively for the joint or coupling. Provide valves from one manufacturer.

Valves on service lines have ends compatible with joining to the pipe used; push-on joint ends or mechanical-joint ends for joining to PVC plastic water main pipe; gaskets and pipe ends, AWWA C111.

2.3.2 Water Service Valves

2.3.2.1 Gate Valves Smaller than 3 Inch in Size on Buried Piping

Gate valves smaller than 3 inch size on Buried Piping MSS SP-80, Class 150, solid wedge, nonrising stem, with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.3.3 Indicator Posts

Provide upright gate valve with indicator post in accordance with UL 789 and NFPA 24, where indicated. Construct indicator post body of cast iron, ductile iron or a combination of both, bronze operating nut, cast iron locking wrench meeting the requirements of ASTM A126 Class B, with open and shut target window.

2.3.4 Valve Boxes

Provide a valve box for each gate valve on buried piping. Construct adjustable valve boxes manufactured from cast iron of a size compatible for
the valve on which it is used. Provide cast iron valve boxes with a minimum cover and wall thickness of 3/16 inch and conforming to ASTM A48, Class 35B. Coat the cast-iron box with a heavy coat of bituminous paint. Provide a round head. Cast the word "WATER" on the lid. The least diameter of the shaft of the box is 5-1/4 inches.

2.3.5 Valve Pits

Construct the valve pits at locations indicated or as required above and in accordance with the details shown.

2.4 FIRE HYDRANTS AND HOSE HOUSES

2.4.1 Fire Hydrants

Provide hydrants where indicated. Paint hydrants with at least one coat of primer and two coats of enamel paint. Paint barrel and bonnet colors in accordance with UFC 3-600-01. Stencil hydrant number and main size on the hydrant barrel using black stencil paint.

2.4.1.1 Dry-Barrel Type Fire Hydrants

Provide Dry-barrel type hydrants, AWWA C502 or UL 246, "Base Valve" design, with 6 inch inlet, 5-1/4 inch valve opening, one 4-1/2 inch pumper connection, and two 2-1/2 inch hose connections. Provide mechanical-joint or push-on joint end inlet, except where flanged end is indicated; with end matching requirements as specified for the joint as specified in AWWA C502 or UL 246 for size and shape of operating nut, cap nuts, and threads on hose and pumper connections. Provide hydrants with fragible sections as mentioned in AWWA C502. Design the hydrant with special couplings joining upper and lower sections of hydrant barrel and upper and lower sections of hydrant stem that break from a force imposed by a moving vehicle. Hydrant is to be fully operational under normal conditions.

2.5 ACCESSORIES

2.5.1 Tapping Sleeves

Provide cast gray, ductile, malleable iron or stainless steel, split-sleeve type tapping sleeves of the sizes indicated for connection to existing main with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Utilize similar metals for bolts, nuts, and washers to minimize the possibility of galvanic corrosion. Provide dielectric gaskets where dissimilar metals adjoin. Construction is to be compatible with a maximum working pressure of 150 psi. Provide bolts with square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, utilize an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 50 foot-pound.

2.5.2 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.
2.5.3 Water Service Line Appurtenances

2.5.3.1 Corporation Stops

Ground key type; lead-free bronze, ASTM B61 or ASTM B62; compatible with the working pressure of the system and solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.

2.6 DISINFECTION

Chlorinating materials are to conform to: Chlorine, Liquid: AWWA B301; Hypochlorite, Calcium and Sodium: AWWA B300.

PART 3 EXECUTION

3.1 PRECAUTIONS

3.1.1 Connections to Existing System

Perform all connections to the existing water system in the presence of the Contracting Officer.

3.1.2 Operation of Existing Valves

Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the Contracting Officer.

3.2 INSTALLATION OF PIPELINES

3.2.1 General Requirements for Installation of Pipelines

Submit manufacturer's instructions for pipeline installations. These manufacturer's instructions apply to all pipeline installation except as noted herein.

3.2.1.1 Location of Water Lines

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated.

Where the location of the water line is not clearly defined by dimensions on the drawings, do not lay water line closer horizontally than 10 feet from any sewer line.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility. Do not install copper tubing in the same trench with ferrous piping materials. Where nonferrous metallic pipe, e.g., copper tubing, cross any ferrous piping, provide a minimum vertical separation of 12 inches between pipes.

Where water piping is required to be installed within 3 feet of existing structures, sleeve the water pipe. Provide ductile-iron or Schedule 40 steel sleeves. Fill annular space between pipe and sleeves with mastic. Install the water pipe and sleeve ensuring that there will be no damage to the structures and no settlement or movement of foundations or footings.
3.2.1.1.1 Water Piping Installation Parallel With Sewer Piping

3.2.1.1.1.1 Normal Conditions

Lay water piping at least 10 feet horizontally from a sewer or sewer manhole whenever possible. Measure the distance edge-to-edge. Provide at least 18 inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping. The sewer piping is to be constructed of AWWA-compliant water pipe and pressure tested in place without leakage prior to backfilling where this vertical separation can not be obtained. Shop drawings for the waste water disposal method are required. Test the sewer manhole in place to ensure watertight construction.

3.2.1.1.2 Installation of Water Piping Crossing Sewer Piping

a. Normal Conditions: Provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.

b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA-compliant ductile iron water piping, pressure tested in place without leakage prior to backfilling. Protect water piping passing under sewer piping by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on and breaking of the water piping; and that the length, minimum 20 feet, of the water piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the sewer piping.

3.2.1.1.3 Sewer Piping or Sewer Manholes

No water piping is to pass through or come in contact with any part of a sewer manhole.

3.2.1.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2.1.3 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work.
into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 3 feet depth of cover over top of pipe.

3.2.1.4 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.2.1.5 Connections to Existing Water Lines

Make connections to existing water lines after coordination with the facility and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated, except as otherwise specified, tap concrete pipe in accordance with AWWA M9 for tapping concrete pressure pipe.

3.2.1.6 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.7 Flanged Pipe

Only install flanged pipe aboveground or with the flanges in valve pits.

3.2.2 Special Requirements for Installation of Water Lines

3.2.2.1 Installation of PVC Water Main Pipe

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS FOR INSTALLATION OF PIPELINES; with the requirements of AWWA C605 for laying of pipe, joining PVC pipe to fittings and accessories, and setting of hydrants, valves, and fittings; and with the recommendations for pipe joint assembly and appurtenance installation in AWWA M23, Chapter 7, "Installation."

a. Jointing: Make push-on joints with the elastomeric gaskets specified for this type joint, using either elastomeric-gasket bell-end pipe or elastomeric-gasket couplings. For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel; for push-on joint connections to metal fittings, valves, and other accessories, cut spigot end of pipe off square and re-bevel pipe end to a bevel approximately the same as that on ductile-iron pipe used for the same type of joint. Use a lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of AWWA C605 for laying the pipe and the recommendations in AWWA M23, Chapter 7, "Installation," for pipe joint assembly. Assemble push-on joints for connection to fittings, valves, and other accessories in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories and with the requirements of AWWA C600 for joint assembly. Make compression-type joints/mechanical joints with
the gaskets, glands, bolts, nuts, and internal stiffeners previously specified for this type joint; assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories, with the requirements of AWWA C600 for joint assembly, and with the recommendations of Appendix A to AWWA C111. Cut off spigot end of pipe for compression-type joint/mechanical-joint connections and do not re-bevel. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer using internal stiffeners as previously specified for compression-type joints.

b. Offset: Maximum offset in alignment between adjacent pipe joints as recommended by the manufacturer and not to exceed 5 degrees.

c. Fittings: Install in accordance with AWWA C605.

3.2.2.2 Installation of Metallic Piping for Service Lines

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS FOR INSTALLATION OF PIPELINES and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

3.2.2.2.1 Jointing

3.2.2.2.1.1 Screwed Joints

Make screwed joints up tight with a stiff mixture of graphite and oil, inert filler and oil, or graphite compound; apply to male threads only. Threads are to be full cut; do not leave more than three threads on the pipe exposed after assembling the joint.

3.2.2.2.1.2 Joints for Copper Tubing

Cut copper tubing with square ends; remove fins and burrs. Replace dented, gouged, or otherwise damaged tubing with undamaged tubing. Make solder joints using ASTM B32, 95-5 tin-antimony or Grade Sn96 solder. Solder and flux are not to contain more than 0.2 percent lead. Before making joint, clean ends of tubing and inside of fitting or coupling with wire brush or abrasive. Apply a rosin flux to the tubing end and on recess inside of fitting or coupling. Insert tubing end into fitting or coupling for the full depth of the recess and solder. For compression joints on flared tubing, insert tubing through the coupling nut and flare tubing.

3.2.2.2.1.3 Flanged Joints

Make flanged joints up tight, avoid undue strain on flanges, valves, fittings, and accessories.

3.2.2.3 Installation of Plastic Piping

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS FOR INSTALLATION OF PIPELINES and with the applicable requirements of ASTM D2774 and ASTM D2855, unless otherwise specified. Handle solvent cements used to join plastic piping in accordance with ASTM F402.

3.2.2.3.1 Jointing

Make plastic pipe joints to other pipe materials in accordance with the
recommendations of the plastic pipe manufacturer.

3.2.2.3.2 Plastic Pipe Connections to Appurtenances

Connect plastic pipe service lines to corporation stops and gate valves in accordance with the recommendations of the plastic pipe manufacturer.

3.2.2.4 Pipe Anchorage Installation

a. Provide thrust blocks where indicated. Use concrete, ASTM C94, having a minimum compressive strength of 2,500 psi at 28 days; or use concrete of a mix not leaner than one part cement, two and one half parts sand, and five parts gravel, having the same minimum compressive strength.

b. Provide restrained joints in accordance with NFPA 24, Chapter 10 and in accordance with ASTM F1674.

c. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.3 Installation of Valves

3.2.3.1 Installation of Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Install gate valves on PVC water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation." Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.4 Installation of Fire Hydrants

Install hydrants in accordance with AWWA C600 for hydrant installation and as indicated. Make and assemble joints as specified for making and assembling the same type joints between pipe and fittings. Provide metal harness as specified under pipe anchorage requirements for the respective pipeline material to which hydrant is attached. Install hydrants with the 4-1/2 inch connections facing the adjacent paved surface. If there are two paved adjacent surfaces, install hydrants with the 4-1/2 inch connection facing the paved surface where the connecting main is located.

3.2.5 Installation of Water Service Piping

3.2.5.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately 5 feet from the building line at the points indicated; close such water service lines with plugs or caps.

3.2.5.2 Service Line Connections to Water Mains

Connect service lines to the main with a rigid connection and install a
gate valve on service line below the frostline. Connect service lines to PVC plastic water mains in accordance with UBPPA UNI-PUB-08 and the recommendations of AWWA M23, Chapter 9, "Service Connections." Connect service lines to steel water mains in accordance with the recommendations of the steel water main pipe manufacturer and with the recommendations for special and valve connections and other appurtenances in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

3.2.6 Disinfection

Disinfection of systems supplying nonpotable water is not required.

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection procedures as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Fill piping systems with solution containing minimum of 50 parts per million of available chlorine and allow solution to stand for minimum of 24 hours. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 and 0.5 parts per million, or the residual chlorine content of domestic water supply. Obtain at least two consecutive bacteriological samples from new water piping. Analyze samples by a certified laboratory, and submit the results of the bacteriological samples. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Tests and Inspections

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing, except that water needed for field tests will be furnished as set forth in "AVAILABILITY AND USE OF UTILITY SERVICES" in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide documentation that all items of work have been constructed in accordance with the Contract documents. Do not begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least five days after placing of the concrete.

3.3.2 Testing Procedure

3.3.2.1 Hydrostatic Testing

Test the water system in accordance with the applicable specified standard. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Test PVC plastic water systems made with PVC pipe in accordance with the requirements of AWWA C605 for pressure and leakage tests. The amount of leakage on pipelines made of PVC plastic water main pipe is not to exceed the amounts given in AWWA C605, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Repair of welded joints to stop leakage is to be done by welding only. Test water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), plastic pipe joints, flanged joints, and screwed joints.
3.3.2.2 Leakage Testing

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

For PE perform leak testing in accordance with ASTM F2164.

3.3.3 Special Testing Requirements for Fire Service

Test water mains and water service lines providing fire service or water and fire service in accordance with NFPA 24. The additional water added to the system must not exceed the limits given in NFPA 24.

3.3.4 Tracer Wire Continuity

Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration. Verify that tracer wire is locatable with electronic utility locating equipment. Repair breaks or separations and re-test for continuity.

3.4 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

-- End of Section --
PART 1 GENERAL

1.1 SUMMARY

1.1.1 Sanitary Sewer Gravity Pipeline

Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.

1.1.2 Containment Drain Gravity Pipeline

Provide containment drain pipeline of ductile iron.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104 (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water


AWWA C600 (2010) Installation of Ductile-Iron Water Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)


Gray Iron Castings


ASTM C478  (2015a) Standard Specification for Precast Reinforced Concrete Manhole Sections


ASTM C924  (2002; R 2009) Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method


ASTM C969  (2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

ASTM C972  (2000; R 2011) Compression-Recovery of Tape Sealant


Using Flexible Elastomeric Seals


ASTM D624 (2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers


U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27 Fixed Ladders

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6 (1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
   Existing Conditions

SD-02 Shop Drawings
   Drawings
   Precast Concrete Manhole
   Metal Items
   Frames, Covers, and Gratings
   Plug Valve
   Plug Valve Operators
1.4 QUALITY ASSURANCE

1.4.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Installing Contractor's License shall be current and be state certified or state registered.

1.4.2 Drawings

a. Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

b. Submit As-Built Drawings for the complete sanitary sewer system and containment drain system showing complete detail with all dimensions, both above and below grade, including invert elevation.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

1.5.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.1.2 Metal Items

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.5.1.3 Cement, Aggregate, and Reinforcement

As specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.
2.2.1 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry, do not drag, pipe to trench.

1.6 PROJECT/SITE CONDITIONS

Submit drawings of existing conditions, after a thorough inspection of the area in the presence of the Contracting Officer. Details shall include the environmental conditions of the site and adjacent areas. Submit copies of the records for verification before starting work.

PART 2 PRODUCTS

2.1 PIPELINE MATERIALS

Pipe shall conform to the respective specifications and other requirements specified below. Submit manufacturer's standard drawings or catalog cuts.

2.1.1 Ductile Iron Gravity Sewer Pipe and Associated Fittings

2.1.1.1 Ductile Iron Gravity Pipe and Fittings

Ductile iron pipe shall conform to ASTM A746, Thickness Class 51. Fittings shall conform to AWWA C110 or AWWA C153. Fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that the bell design shall be modified, as approved by the Contracting Officer, for push-on joint. Fittings shall have strength at least equivalent to that of the pipe. Ends of pipe and fittings shall be suitable for the joints specified hereinafter. Pipe and fittings shall have cement-mortar lining conforming to AWWA C104, standard thickness.

2.1.1.2 Ductile Iron Gravity Joints and Jointing Materials

Pipe and fittings shall have push-on joints or mechanical joints, except as otherwise specified in this paragraph. Push-on joint pipe ends and fitting ends, gaskets, and lubricant for joint assembly shall conform to AWWA C111. Mechanical joint requirements for pipe ends, glands, bolts and nuts, and gaskets shall conform to AWWA C111. Gaskets for containment drain pipelines shall be fuel/oil resistant.

2.1.2 PVC Plastic Gravity Sewer Piping

2.1.2.1 PVC Plastic Gravity Pipe and Fittings

ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.

2.1.2.2 PVC Plastic Gravity Joints and Jointing Material

Joints shall conform to ASTM D3212. Gaskets shall conform to ASTM F477.

2.2 CONCRETE MATERIALS

2.2.1 Cement Mortar

Cement mortar shall conform to ASTM C270, Type M with Type II cement.
2.2.2 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of precast manholes. Portland cement shall conform to ASTM C150, Type II for concrete used in manholes and type optional with the Contractor for cement used in concrete cradle, concrete encasement, and thrust blocking. Where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33, a cement containing less than 0.60 percent alkalies shall be used.

2.2.3 Portland Cement Concrete

Portland cement concrete shall conform to ASTM C94, compressive strength of 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement shall have a compressive strength of 2500 psi minimum at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Precast Concrete Manholes

Precast concrete manhole risers, base sections, and tops shall conform to ASTM C478; base and first riser shall be monolithic.

2.3.2 Gaskets and Connectors

Gaskets for joints between manhole sections shall conform to ASTM C443. Resilient connectors for making joints between manhole and pipes entering manhole shall conform to ASTM C923 or ASTM C990. Gaskets and connectors for containment drain system shall be fuel/oil resistant.

2.3.3 External Preformed Rubber Joint Seals

An external preformed rubber joint seal shall be an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" shall be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal shall be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 60 mils. Each unit shall consist of a top and bottom section and shall have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic shall be a non-hardening butyl rubber sealant and shall seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections shall cover up to two more adjusting rings. Properties and values are listed in the following table:

| Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals |
|-----------------------------------------------|----------------|----------------|----------------|----------------|
| Physical Properties | Test Methods | EPDM | Neoprene | Butyl Mastic |
| Tensile, psi | ASTM D412 | 1840 | 2195 | -- |
### Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Test Methods</th>
<th>EPDM</th>
<th>Neoprene</th>
<th>Butyl Mastic</th>
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<tr>
<td>Tear Resistance, ppi</td>
<td>ASTM D624 (Die B)</td>
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<td>Rebound, percent, 2 hours</td>
<td>ASTM C972</td>
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<td>12</td>
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</tbody>
</table>

### 2.3.4 Metal Items

#### 2.3.4.1 Frames, Covers, and Gratings for Manholes

Frame and cover must be cast gray iron, ASTM A48, Class 35B, cast ductile iron, ASTM A536, Grade 65-45-12, or reinforced concrete, ASTM C478. Frames and covers must be circular without vent holes. Size must be for 24 inch opening. The words "Sanitary Sewer" shall be cast into sanitary sewer covers so that it is plainly visible. Containment drain manholes shall be stamped "Containment Drain".

#### 2.3.4.2 Manhole Steps

Zinc-coated steel conforming to 29 CFR 1910.27. As an option, plastic or rubber coating pressure-molded to the steel may be used. Plastic coating shall conform to ASTM D4101, copolymer polypropylene. Rubber shall conform to ASTM C443, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 4 feet deep.

#### 2.3.4.3 Manhole Ladders

A steel ladder shall be provided where the depth of a manhole exceeds 12 feet. The ladder shall not be less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers shall be a minimum 3/8 inch thick and 2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123.

### 2.3.5 Eccentric Plug Valves for Containment Drains

Provide a full port eccentric plug valve for containment drains at the locations shown on the drawings. Plug valves shall conform to AWWA C517 and be fuel resistant. Plug valve operators shall be floor stand assemblies with horizontal handwheel operators (lockable and with an indicator).

### 2.4 REPORTS

Compaction and density test shall be in accordance with Section 31 00 00 EARTHWORK. Submit Test Reports. Submit Inspection Reports for daily activities during the installation of the sanitary system. Information in
the report shall be detailed enough to describe location of work and amount of pipe laid in place, measured in linear feet.

PART 3 EXECUTION

3.1 INSTALLATION OF SANITARY SEWER AND CONTAINMENT DRAIN PIPELINES AND APPURTENANT CONSTRUCTION

3.1.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

Submit request for field support from the Installation's Utilities Field Support two weeks prior to making connection. Submit request for pre-connection inspection to be conducted after trenching and layout is completed, but before the proposed service has been connected.

3.1.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.1.2.1 Location

The work covered by this Section shall terminate at a point approximately 5 feet from the building, unless otherwise indicated. Where the location of the sewer is not clearly defined by dimensions on the drawings, do not lay sewer line closer horizontally than 10 feet to a water main or service line.

Where sanitary sewer lines pass above water lines, encase sewer in concrete for a distance of 10 feet on each side of the crossing, or substitute rubber-gasketed pressure pipe for the pipe being used for the same distance. Where sanitary sewer lines pass below water lines, lay pipe so that no joint in the sewer line will be closer than 3 feet, horizontal distance, to the water line.

3.1.2.1.1 Piping Installation Parallel with Water Line

3.1.2.1.1 Normal Conditions

Piping or manholes shall be laid at least 10 feet horizontally from a water line whenever possible. The distance shall be measured edge-to-edge.

3.1.2.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 10 feet, the piping or manhole may be laid closer to a water line provided that:

a. The top (crown) of the sanitary or containment drain piping shall be at least 18 inches below the bottom (invert) of the water main.

b. Where this vertical separation cannot be obtained, the piping shall be constructed of AWWA-approved ductile iron water pipe pressure tested in place without leakage prior to backfilling.

c. The manhole shall be of watertight construction and tested in place.
3.1.2.1.2 Installation of Piping Crossing a Water Line

3.1.2.1.2.1 Normal Conditions

Lay piping by crossing under water lines to provide a separation of at least 18 inches between the top of the piping and the bottom of the water line whenever possible.

3.1.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

a. Piping passing over or under water lines shall be constructed of AWWA-approved ductile iron water pipe, pressure tested in place without leakage prior to backfilling.

b. Piping passing over water lines shall, in addition, be protected by providing:

   (1) A vertical separation of at least 18 inches between the bottom of the piping and the top of the water line.

   (2) Adequate structural support for the piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.

   (3) That the length, minimum 20 feet, of the piping be centered at the point of the crossing so that joints shall be equidistant and as far as possible from the water line.

3.1.2.1.3 Manholes

No water piping shall pass through or come in contact with any part of a sanitary sewer or containment drain manhole.

3.1.2.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.1.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell ends in the upgrade direction. Adjust spigots in bells to give a uniform space all around. Blocking or wedging between bells and spigots will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Branch connections shall be made by use of regular fittings or solvent cemented saddles as approved. Saddles for PVC pipe shall conform to Table 4 of ASTM D3034.
3.1.3 Special Requirements

3.1.3.1 Installation of Ductile Iron Gravity Sewer Pipe

Unless otherwise specified, install pipe and associated fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this Section and with the requirements of AWWA C600 for pipe installation and joint assembly.

a. Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111.

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105, using Class A polyethylene film.

3.1.3.2 Installation of PVC Plastic Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this Section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.1.4 Concrete Work

Cast-in-place concrete is included in Section 03 30 00 CAST-IN-PLACE CONCRETE. The pipe shall be supported on a concrete cradle, or encased in concrete where indicated or directed.

3.1.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Cast-in-place concrete work shall be in accordance with the requirements specified under paragraph entitled "Concrete Work" of this Section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously
3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

The Contracting Officer will conduct field inspections and witness field tests specified in this Section. Perform field tests and provide labor, equipment, and incidentals required for testing. Be able to produce evidence, when required, that each item of work has been constructed in
accordance with the drawings and specifications.

3.2.2 Tests for Nonpressure Lines

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line. When pressure piping is used in a nonpressure line for nonpressure use, test this piping as specified for nonpressure pipe.

3.2.2.1 Leakage Tests

Test lines for leakage by either infiltration tests or exfiltration tests, or by low-pressure air tests. Prior to testing for leakage, backfill trench up to at least lower half of pipe. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.2.2.1.1 Infiltration Tests and Exfiltration Tests

Perform these tests for sewer lines made of the specified materials, not only concrete, in accordance with ASTM C969. Make calculations in accordance with the Appendix to ASTM C969.

3.2.2.1.2 Low-Pressure Air Tests

Perform tests as follows:

3.2.2.1.2.1 Ductile-Iron Pipelines

Test in accordance with the applicable requirements of ASTM C924. Allowable pressure drop shall be as given in ASTM C924. Make calculations in accordance with the Appendix to ASTM C924.

3.2.2.1.2.2 PVC Plastic Pipelines

Test in accordance with UBPPA UNI-B-6. Allowable pressure drop shall be as given in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.2.3 Field Tests for Concrete

Field testing requirements are covered in Section 03 30 00 CAST-IN-PLACE CONCRETE.

-- End of Section --
SECTION 33 40 00

STORM DRAINAGE UTILITIES

02/10

PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM C1433 (2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers

ASTM C231 (2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method


ASTM C478 (2015a) Standard Specification for Precast Reinforced Concrete Manhole Sections

and Sewer Pipe

ASTM C828 (2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines

ASTM C877 (2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections


ASTM C969 (2002; R 2009) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines


ASTM D2167 (2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method


1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:
SD-03 Product Data

Placing Pipe

Submit printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

SD-04 Samples

Pipe for Culverts and Storm Drains

SD-07 Certificates

Resin Certification
Pipeline Testing
Hydrostatic Test on Watertight Joints
Determination of Density
Frame and Cover for Gratings

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76, Class III.
2.2 DRAINAGE STRUCTURES

2.2.1 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements under Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C231. The concrete covering over steel reinforcing shall not be less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751 or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.3.3 Precast Reinforced Concrete Manholes

Conform to ASTM C478. Joints between precast concrete risers and tops shall be made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.3.4 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26, Alloy 356.0T6. Weight, shape, size, and waterway openings for graters and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.5 Joints

2.3.5.1 Flexible Watertight Joints

a. Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the...
physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

b. Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.3.5.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877.

2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 12 feet. These ladders shall be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers shall be a minimum 3/8 inch thick and 2-1/2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123.

2.5 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.

2.6 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.6.1 Concrete Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced concrete pipe shall conform to ASTM C990 or ASTM C443.

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 24 inches to permit
satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 00 00 EARTHWORK.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as
Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this Specification for all pipe products including deflection testing requirements for flexible pipe.

3.3.1 Concrete Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.4 JOINTING

3.4.1 Concrete Pipe

3.4.1.1 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete or precast reinforced concrete; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically, and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted.
with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of RCP. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical tampers or tampers in layers not exceeding 12 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 12 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials
and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density

Testing is the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

3.8.1 Leakage Tests

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for concrete pipes shall conform to ASTM C969. Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C969, after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 0.2 gallons per inch in diameter per 100 feet of pipeline per hour. When
leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.

3.8.2 Post-Installation Inspection

Check each reinforced concrete pipe installation for joint separations, soil migration through the joint, cracks greater than 0.01 inches, settlement and alignment.

a. Replace pipes having cracks greater than 0.1 inches in width or deflection greater than 5 percent deflection. An engineer shall evaluate all pipes with cracks greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required. RCP with crack width less than 0.10 inches and located in a non-corrosive environment (pH 5.5) are generally acceptable. Repair or replace any pipe with crack exhibiting displacement across the crack, exhibiting bulges, creases, tears, spalls, or delamination.

b. Reports: The deflection results and final post installation inspection report shall include: A copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe systems, inspector notes, condition of joints, condition of pipe wall (e.g., distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.9 FIELD PAINTING

After installation, clean cast-iron frames, covers, gratings, and steps not buried in masonry or concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Painting shall conform to Section 09 90 00 PAINTS AND COATINGS. Do not paint surfaces subject to abrasion.

-- End of Section --
PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASME INTERNATIONAL (ASME)


ASME B40.100     (2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM C827        (2010) Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1        (2016) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)


NFPA 70          (2017) National Electrical Code

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

AFLP-3747        (2013; Rev 9) Guide Specifications (Minimum Quality Standards) for Aviation Turbine Fuels (F-24, F-27, F-34, F-35, F-37, F-40 And F-44)

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS3275      (2009; Rev C) Sheet, Acrylonitrile Butadiene (NBR) Rubber and Non-Asbestos Fiber Fuel and Oil Resistant

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-130      (2007; Rev N; Change 1 2012)
1.2 ADMINISTRATIVE REQUIREMENTS

Submit detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operation of the equipment and systems. Provide the drawings as one package with the design analysis. Shop fabrication drawings shall include type of material, configuration, thickness, and necessary details of construction of the steel tank and vault. Shop drawings shall also show the steel grating and supports. Submit Manufacturer's Catalog Data and Certificates of Compliance. Operation and maintenance information shall be submitted for the equipment items or systems listed in PART 2. Automatic pump controls shall include step-by-step procedures required for system startup, operation, and shutdown. Refer to Section 01 78 23.33 OPERATION AND MAINTENANCE MANUALS FOR AVIATION FUEL SYSTEMS for the information to be submitted for various types of equipment and systems.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
   Venturi Tubes; G
   Water Draw-Off System; G
   Hydrant Outlet Pits and Isolation Valve Pits; G
   High Point Vent and Low Point Drain Pits; G
   Day Tank; G
   Tightness Monitoring System; G

SD-03 Product Data
   Pressure Gages; G
   Automatic Pump Controls; G
   Day Tank; G
Pressure Indicating Transmitters; G
Flow Switches; G
Pressure Transmitter; G
Differential Pressure Transmitter; G
Hydrant Outlet Pits and Isolation Valve Pits; G
High Point Vent and Low Point Drain Pits; G
Operating Tank Level Indicator; G
Operating Tank Level Switches; G
Water Draw-Off System; G
Venturi Tubes; G
Tightness Monitoring System; G

SD-06 Test Reports
Tightness Monitoring System; G
Coating Testing; G

SD-07 Certificates
System Supplier; G
Tightness Monitoring System; G

SD-10 Operation and Maintenance Data
Automatic Pump Controls; G
Day Tank; G
Operating Tank Level Indicator; G
Water Draw-off System; G
Tightness Monitoring System; G

1.4 QUALITY ASSURANCE

Submit the following data for approval:

a. Certification stating that the system supplier has provided and installed at least five PLC-based pump control systems in the last five years, for automatic cycling of pumps based upon varying dispensing demands, utilizing multiple pumps. These systems shall be for dispensing jet fuel.

b. Certification that six systems have been successfully operated over the last three years and are currently in service.
c. Project names, locations, system description, and items provided at these installations. Include user point-of-contact and current telephone numbers.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 MATERIALS

Materials of construction shall be stainless steel, aluminum, or nonferrous material except meter case may be steel with electrolyses nickel plated internals coated to 3 mil thickness. No ferrous or zinc-coated material bronze, brass, or other copper bearing alloys shall be used in contact with the fuel.

2.2.1 Composition of Materials

Materials in contact with the fuel shall be noncorrosive. No zinc-coated metals, brass, bronze, iron, lead or lead alloys, copper or copper alloys, or other light metal alloys containing more than 4 percent copper shall be used in contact with the fuel.

2.2.2 Gaskets

Gaskets shall be in accordance with Section 33 52 43.13 AVIATION FUELING PIPING.

2.2.3 Bolts and Nuts

Bolts and nuts shall be in accordance with Section 33 52 43.13 AVIATION FUELING PIPING.

2.3 EQUIPMENT AND MATERIAL

2.3.1 General

All items of equipment and material shall be new and of the best quality used for the purpose in commercial practice and shall be products of reputable manufacturers. Each major component of equipment shall have the manufacturer's name, address and catalog number on a plate securely affixed in a conspicuous place. The nameplate of a distributing agent only will not be acceptable. The gears, couplings, projecting set screws, keys and other rotating parts located so that any person may come in close proximity thereto shall be fully enclosed or properly guarded. Equipment, assemblies and parts shall be marked for identification in accordance with MIL-STD-130 and MIL-STD-161. Pump and filter vessel numbers shall be as indicated on the drawings. In addition, filter vessels shall include element numbers and the date of the next element change. Identification tags made of brass, stainless steel, or engraved anodized aluminum, indicating valve number and normally open (NO) or normally closed (NC) shall be installed on valves. Tags shall be 1-3/8 inch minimum diameter, and marking shall be
stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No 12 AWG, copper wire, stainless or aluminum hanging wires, or chrome-plated beaded chain designed for that purpose.

2.3.2 Supplier

Since the pump control system, including but not limited to pump control panel, venturi tubes, transmitters, flow switches, fueling system pumps, all field instrumentation, tightness monitoring system, and control valves with all hardware and software, is an integrated system it shall be furnished by a single systems supplier regularly engaged in the supplying of this equipment. System Supplier shall be a company whose regular, normal, and primary business is representing manufacturers in the distribution and start-up of aviation fueling facilities, and have no affiliation with the Contractor other than as a seller to the Contractor. Supplier shall provide all equipment and appurtenances regardless of manufacture, be a factory authorized certified representative, and be responsible to the Contractor for satisfactory operation of the entire system, and shall oversee the installation of the equipment. Substitutions of functions specified will not be acceptable. The Contractor and the System Supplier shall be present at the system commissioning, and shall coordinate and schedule the work during construction, testing, calibration, and acceptance of the system. The System Supplier shall be responsible to the Contractor for scheduling all Contractor, Sub-contractor, and manufacturer's service personnel during system start-up and final commissioning.

2.4 ELECTRICAL EQUIPMENT

Motors, manual or automatic motor control equipment except where installed in motor control centers, and protective or signal devices required for the operation specified shall be provided under this Section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Any wiring required for the operation specified herein, but not shown on the electrical plans, shall be provided under this Section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.5 PRESSURE GAGES

Pressure gages shall conform to ASME B40.100 with metal cases and 4-inch diameter white dials. Gages shall be bottom connected, without back flanges. A pulsation dampener, adjustable to the degree of dampening required, shall be provided for each gage. Range of gages shall be as indicated. A ball valve shall be provided for each pressure gage. Gages shall have all parts immersed in silicone oil. Gages shall be labeled with the calibration date.

2.6 AUTOMATIC PUMP CONTROLS

The pressure and flow transmitters specified in this Paragraph shall be obtained from a single supplier of such products. The same supplier shall also furnish the associated venturi tubes and GPM meter. The supplier shall be responsible for furnishing components that are compatible and that operate as a system to perform the required pump control functions. Control tubing between controls/instruments and fuel lines shall be installed to eliminate air entrapment. Control tubing shall be as specified in Section 33 52 43.13 AVIATION FUELING PIPING. Each item of equipment specified hereafter shall have manufacturer's authorized service
2.6.1 Pressure Indicating Transmitters

Pressure indicating transmitters shall consist of a capacitance sensor operating on a differential in pressure of fuel (one side being open to atmospheric pressure). The output shall be a 4 - 20 mA dc, linear signal between 0 - 100 percent of the input. It simultaneously will produce a digital HART (Highway Addressable Remote Transducer) output signal. Loop power shall be provided from remote power supply located in the pump control panel (PCP).

a. Transmitter body shall be stainless steel with stainless steel diaphragm capsule process connecting to a 1/2 inch NPT. Drain and vent valves to be stainless steel. Accuracy shall be ± 0.20 percent of calibrated span including combined effects of linearity, hysteresis and repeatability.

b. One pressure indicating dial shall be supplied with each pair of transmitters. Pressure indicating dials shall consist of a bellows type pressure sensing element operating on a differential in pressure of fuel (one side being open to atmospheric pressure) and a mechanical indicator (driven by the bellows unit). The bellows shall be dual opposed, liquid filled, rupture-proof type with bellows movement converted to rotation and transmitted by a torque tube. Bellows housing shall be stainless steel and shall have a rated working pressure of not less than 500 psi with a minimum differential pressure range of 0 to 250 psi. Liquid used to fill the bellows shall be suitable for the expected minimum ambient temperature. The indicating dial shall be at least 6 inches in diameter with a weatherproof glass cover. The case shall be finished with a weather resistant epoxy resin enamel. The indicating pointer shall traverse a 270 degrees arc. The scales shall be graduated over the selected pressure ranges so that the pressure can be read in psig. Indicator accuracy shall be 0.75 percent of full scale. Pressure indicating dial shall be provided with suitable over-range protection.

c. Display at the pressure transmitter shall be LCD, one per each transmitter. The digital scale shall be a 4 digit LCD capable of being read in low light/no light conditions. Indicator scale shall be in psig.

d. Pressure transmitters shall be UL, FM, or CSA listed for Class I, Division 1, Group D hazardous environment as defined by NFPA 70, with maximum temperature rating T3 (392 degrees F). Each transmitter and dial shall be supplied with a factory assembled two valve stainless steel manifold. Vent valves shall be furnished on upper ports of each transmitter and dial. Pressure transmitters and the indicating dial shall be suitable for mounting on a 2-inch pipe stand. Complete installation shall be in accordance with manufacturer’s recommendations.

e. Provide a HART (Highway Addressable Remote Transducer) protocol interface handheld calibration device. Communicator to be intrinsically safe and have Class 1, Div 1, Group C and D approval. Device to include NIST traceable modules, one 0-500 psig range, one 0-2000 wc, and also one protection module for open sensor bay. Unit
shall be furnished in hard carrying case and to include 250 ohm shunt for HART communicator, A900 HART test lead kit, 145 psig pressure pump with variator, low pressure fittings and tubing kit. Hand-held pump capable of producing a minimum of 300 psig pressure.

2.6.2 Flow Switches

Switches shall be actuating vane type flow switch with single adjustable set-point. Switches shall mount on ASME B16.5 Class 150 raised face flange. Flange material shall match the piping material at their connection to the system. Provide snap action switch mechanism U.L. listed for Class I, Division 1, Group D hazardous locations. Switches to be double pole double throw (DPDT). Switch power shall be 120 volts, single phase, 60 hertz, 10 amps minimum.

2.6.3 Venturi Tubes

a. The venturi tubes shall be provided in conjunction with Section 33 09 53 AVIATION FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM.

b. Start-up, adjustments and calibration, and instruction of personnel in the operation and maintenance of the venturi tubes shall be considered as a required portion of the controls package.

c. The venturi tubes shall be low loss differential pressure producers consisting of a short housing piece and a fully machined, contoured throat section providing a restriction at the center, with both inlet approach and exit having geometrically symmetrical curves. They shall be velocity head, impact, differential producing devices designed to measure differential pressure of F-24 fuel. They shall be constructed of 304L stainless steel with ANSI Class 150 flanges on each end and be suitable for operation of 275 psig at 100 degrees F. They shall be of sufficient thickness to withstand the same stresses as the upstream and downstream piping. Each venturi tube shall have a minimum of four 1/2-inch connections. An individual head-capacity curve shall be furnished for each venturi tube.

d. Operating conditions for the venturi tubes shall be as follows:

(1) Issue Venturi Tube. Minimum inlet-to-throat differential pressure at 1,800 gpm: 200 in H2O.

(2) Return Venturi Tube. Minimum inlet-to-throat differential pressure at 900 gpm: 200 in H2O.

(3) Venturi tubes discharge coefficient "C" to be greater than or equal to 0.97 over pipe Reynolds number range between 200,000 and 1,000,000 and shall be independent of Beta over a Beta range of 0.4 to 0.75. Pressure loss shall be less than 24 percent of differential pressure generated by the venturi tube. Repeatability of the discharge coefficient "C" shall be 2 percent for Reynolds number range of 10,000 to 1,000,000.

(4) Provide two portable GPM Meters, one for each size of venturi. The meters shall be complete with valves, hoses and connecting disconnects, and carrying case. The meters shall have stainless steel bellows, mounting bracket, 500 psi swp, 6-inch dial with 270 degrees arc. Dial shall read GPM Jet Fuel. Range of scale shall match the flow transmitter for issue and return. The venturi
2.6.4 Differential Pressure Transmitter

Differential pressure transmitter shall consist of a capacitance sensor operating on a differential in pressure of fuel. The output shall be a 4 – 20mA dc, square root signal between a minimum of 4 – 100 percent of the input. It may be linear between 0 – 4 percent. It simultaneously will produce a digital HART (Highway Addressable Remote Transducer) output signal. Loop power shall be provided from remote power supply located in the pump control panel (PCP).

a. Transmitter body shall be stainless steel with stainless steel diaphragm capsule process connecting to a 1/2 inch NPT. Drain and vent valves to be stainless steel. Accuracy shall be plus or minus 0.20 percent of calibrated span including combined effects of linearity, hysteresis and repeatability.

b. One differential pressure dial shall be supplied with each pair of transmitters. Differential pressure dial shall consist of a bellows type pressure sensing element, operating on a differential in pressure of fuel, and a mechanical indicator, driven by the bellows unit. The bellows shall be dual opposed, liquid filled, rupture-proof type with bellows movement converted to rotation and transmitted by a torque tube. Displacement of bellows shall be 1.5 cubic inches for full scale travel. Bellows housing shall be stainless steel and shall have a rated working pressure of not less than 500 psi. Liquid used to fill the bellows shall be suitable for the expected minimum ambient temperature. The indicating dial shall be at least 6 inches in diameter with a weatherproof glass cover. The case shall be finished with a weather resistant epoxy resin enamel. The indicating pointer shall traverse a 270 degree arc. The scales shall be graduated over the selected pressure ranges so that the flow rate can be accurately read in gallons per minute. Indicator accuracy shall be 0.5 percent of full scale. Differential pressure indicating dial shall be provided with built-in pulsation damper and suitable over-range protection.

c. Display at the transmitter shall be LCD, one per each differential pressure transmitter. The digital scale shall be a 4 digit LCD, capable of being read in low light/no light conditions. Indicator scale shall be in gallons per minute.

d. Each venturi tube shall have two transmitters and one indicating dial per function and shall be installed as indicated on the drawings. Differential pressure ranges shall be selected as necessary to operate in conjunction with associated venturi tube:

(1) Issue Venturi Tube – 0 to 1,800 GPM (full range).

(2) Return Venturi Tube – 0 to 1,100 GPM (full range).

e. Differential pressure transmitters shall be UL, FM, or CSA listed for Class I, Division 1, Group D hazardous environment as defined by NFPA 70, with maximum temperature rating T3 (392 degrees F). Each transmitter and indicating dial shall be supplied with a factory assembled five valve stainless steel manifold. Vent valves shall be furnished on
upper ports of each transmitter and indicating dial. Differential pressure transmitters and the indicating dial shall be suitable for mounting on a 2-inch pipe stand. Complete installation shall be in accordance with manufacturer's recommendations.

2.6.5 Pressure Transmitter

Transmitter shall be UL, FM, or CSA listed for Class 1, Division 1, Group D hazardous environment as defined by NFPA 70, with maximum temperature rating T3 (392 degrees F). Excitation voltage shall be 12-28 VDC. Output signal shall be 4-20 mA. Unit shall have 0.25 percent accuracy and have built-in high pressure snubbers, minimum pressure range shall be 0-300 PSI. Wetted material shall be stainless steel.

2.7 PRODUCT RECOVERY TANK AND ACCESSORIES

See Specification Section 33 56 10 FACTORY FABRICATED FUEL STORAGE TANK for product recovery tank and accessories.

2.8 HYDRANT OUTLET PITS AND ISOLATION VALVE PITS

Hydrant hose truck hydrant outlet pits and isolation valve pits shall be prefabricated units that are the standard products of a firm regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least (3) years prior to bid opening. The basic pit shall consist of a 0.50 inch thick fiberglass walls and floor with main body dimensions as shown on the drawings. The pit shall contain twelve (minimum) integral concrete anchors or two integral anchors that run continuous on three sides of pit. The integral fiberglass top flange shall require no exposed corrosive material, weldments, or strongbacks within the pit to support the aluminum cover assembly. The manufacturer shall have had a minimum of three years successful experience in the production and usage of their fiberglass service pits and shall supply proof of experience at time of submittals. Pits shall be provided with a 2 inch pump-out line terminating with a male cam type bronze connector with female dustcap. Pits shall be provided with removable aluminum grating platform suitable for loading of 400 pounds per square foot. The grating shall cover the entire opening when the lid is in the open position. The grating platform shall have outside edges and cut-outs framed. The inside of the lid shall have a 14 by 10 inch permanently attached sign which says "DANGER CONFINED SPACE ENTER BY PERMIT ONLY". The sign shall be white with black letters, made of PVC, completely and permanently encapsulated 50 mil plastic.

2.8.1 Pit Cover

The pit cover assembly shall consist of a completely removable one-piece aluminum lid attached to a rigid frame which is an integral part of the fiberglass pit. The lid shall be attached to the frame with hinges which do not carry wheel loads applied to the top surface of the lid in its closed position. The lid shall be equipped with a device to hold the lid in its fully-opened position. This lid-staying device shall automatically engage when the lid is opened to its fully-opened position. The device shall also be provided with a quick-release mechanism designed to be operated with one hand. The lid shall be considered fully-open when it is rotated approximately 90 degrees from its closed position. Each cover lid shall move smoothly through its entire range of motion and shall be counterbalanced sufficiently to require an externally-applied opening force of 35 pounds (maximum) to be applied to the center of the long side of the
cover (opposite the hinge side). Similarly, the maximum closing force required to be applied at the same point shall be approximately 50 pounds. In addition, the cover shall be counterbalanced in such a fashion that the cover will not close under its own weight if released when open to any angle greater than 70 degrees (from its closed position). Operation of the lid will not have spring assist. Lifting handles (two minimum) shall be provided for each lid. Each handle shall provide comfortable, secure grip for and average adult male's full (gloved) hand. All covers shall be provided with a latch, operable from the exterior of the vault, to securely hold the lid to the frame in the closed position. The latch will be capable of being released from either lifting handle. Tools shall not be required to engage (or disengage) the latch or the lid lifting handles. Latch and handle designs shall be weather-resistant with features to prelude freeze-up and the collection of dirt and precipitation. Projections of the lid's hinges, lifting handles, or latches above the plane of the lid, whether temporary or permanent, shall not be allowed. The weight bearing flange surfaces of both the fiberglass pit liner and the aluminum cover lid shall be machined flat to assure uniform weight distribution. The word FUEL shall be integrally cast in raised letters on the top surface of each lid. The lettering shall be a minimum of 1 inch high and 0.0625 inch deep. Pit lid shall be designed for resisting debris and water accumulation at seals, load bearing surfaces, hinges, and handle pockets. Seal shall be an elastomeric perimeter seal, easy to replace, secured to lid by dovetail grooves, no adhesive. Push buttons are not allowed.

2.8.2 Pit Cover Materials, Design, and Testing

All cover lids and frames shall be designed using an appropriate cast aluminum alloy or rolled aluminum plate to support an aircraft wheel load simulated by a roving 200,000 pound test-load applied perpendicular to a 200 square inch contact area( 10 by 20 inches) of the cover's top surface. The aluminum alloy material selected for design shall be ductile, corrosion-resistant, impact-resistant, and suitable for the intended use. All covers shall be non-skid surface construction and free of injurious defects. Welding for the purpose of structural repair of casting defects shall not be allowed. Minor cosmetic welding is acceptable. The cover shall be capable of supporting the test-load without failure regardless of the location or orientation of the load. Localized yielding or cracking or excessive deformations shall be considered as failure. Actual load-tests shall be performed on a minimum of 10 percent of all the covers supplied. Load-tested units shall be randomly selected. Load-test conditions shall model field-installed conditions as nearly as practicable. The 200 Kip test-load shall be applied to the cover for a minimum duration of 5 minutes. Absolute maximum deflection of the cover lid under the test-load shall not exceed 1/180th of the minimum interior opening dimension of the fiberglass pit body. Maximum deflection of the cover lids, remaining after removal of the test load, shall be + 0.010 inches to assure that no permanent set has taken place. Upon removal of the test-load, the cover lid and frame shall be carefully examined for cracks or localized areas of permanent deformation. All results shall be submitted for review and approval. A single failure to meet any of the stated criteria shall be considered sufficient grounds for the testing of 50 percent of the units.

2.8.3 Pipe Seal

The pipe penetrations through the pit floor or wall shall be sealed by means of a Buna-N boot. The boot shall be secured to the pipe and to a steel sleeve bonded to the pit wall at the pit penetration by stainless
2.8.4 Hydrant Outlet Pit Equipment

At the Contractor's option, hydrant pits may be furnished complete with hydrant control valves and shutoff valves assembled in a pipe riser. All valves and piping furnished by the pit manufacturer shall comply with the requirements specified herein. All control valves shall be of the same manufacturer.

2.9 HIGH POINT VENT AND LOW POINT DRAIN PITS

Use for On-Shoulder and On-Apron installations.

2.9.1 Pit Assembly

Each pit shall incorporate the following items built into a self-contained assembly.

2.9.2 Pit

The basic pit shall consist of 0.25 inch wall fiberglass liner with a main body approximately 23 inches in diameter and a minimum of 37 inches deep. The pit shall contain two integral concrete anchors. The fiberglass top flange shall require no exposed corrosive material, weldments, or strongbacks within the pit to support the cast aluminum ring and cover assembly. The pits shall be the standard products of a firm regularly engaged in the manufacture of such product and shall essentially duplicate items that have been in satisfactory use for at least three (3) years prior to bid opening. Proof of experience will be submitted.

2.9.3 Pit Cover, General Requirements

The pit cover shall include a removable outer ring frame and an interior 18-inch diameter (clear opening) hinged lid that opens 160 degrees. The pit shall have a tamperproof cover. The removable outer ring shall have anchors to provide for means to secure the manhole and its moveable cover and lid to the "concrete" fiberglass containment. The inner hinged lid shall have a means of being locked. Each cover lid shall move smoothly through its entire range of motion and shall require a maximum opening force of 35 pound-force to be applied at a single lifting handle. Each handle shall provide a comfortable, secure grip for an average adult male's full gloved hand. Tools shall not be required to engage the lifting handle. Projections of the lid's hinges or handles above the plane of the lid, whether temporary or permanent, shall not be allowed. The pit service shall be integrally cast in raised letters on the top surface of each lid. The lettering shall be a minimum of 1 inch high and 0.0625 inch deep. The weight bearing flanges of the fiberglass pit liner and the aluminum cover frame (and lid) shall be machined to assure uniform weight distribution.

2.9.4 Pit Cover Materials, Design, and Testing

The cover frames and lids shall be designed and manufactured by a qualified company having a minimum of five years successful experience in the production of similar airport apron slab fixtures. All cover lids and frames shall be designed using an appropriate cast aluminum alloy or rolled aluminum plate to support an aircraft wheel load simulated by a roving
200,000 pound test-load applied perpendicular to a 200 square inch contact area (10 by 20 inches) of the cover's top surface. The aluminum alloy material selected for design shall be ductile, corrosion-resistant, impact-resistant, and suitable for the intended use. All covers shall be non-skid surface construction and free of injurious defects. Welding for the purpose of structural repair of casting defects shall not be allowed. Minor cosmetic welding is acceptable. The cover shall be capable of supporting the test-load without failure regardless of the location or orientation of the load. Localized yielding or cracking or excessive deformations shall be considered as failure. Actual load-tests shall be performed on a minimum of 10 percent of all the covers supplied. Load-tested units shall be randomly selected. Load-test conditions shall model field-installed conditions as nearly as practicable. The 200 Kip test-load shall be applied to the cover for a minimum duration of 5 minutes. Absolute maximum deflection of the cover lid under the test-load shall not exceed 1/180th of the interior diameter of the fiberglass pit body. Maximum deflection of the cover lids, remaining after removal of the test load shall be plus 0.010 inches to assure that no permanent set has taken place. Upon removal of the test-load, the cover lid and frame shall be carefully examined for cracks or localized areas of permanent deformation. All results shall be submitted for review and approval. A single failure to meet any of the stated criteria shall be considered sufficient grounds for the testing of 50 percent of the units.

2.9.5 Pipe Riser Seal

The riser pipe penetration through the pit floor shall be sealed by means of a Buna-N boot. The boot shall be secured to a metal collar welded to the pipe riser and to a flange at the floor opening by stainless steel clamps. Collar shall be fabricated from the same material as the pipe. Segmented elastomeric seals shall be used to seal between the steel sleeve and carrier pipe.

2.10 OPERATING TANK LEVEL INDICATOR

The level indicating system must perform tank gauging and have local tank readout. The level indicating system must use a servo to measure all the various locations required for the primary measurement. The level indicating system must be able to measure and compute fuel level, fuel density, fuel actual volume, fuel and water corrected volume, and fuel ambient temperature. The reference point for all level measurements must be from the tank's datum plate. The servo system must attach to the tank's 10 inch riser/8 inch stilling well to minimize the effects of turbulence on the measurements and still allow the government access to take quality control samples. The level indicating system must be able to measure in underground, aboveground and cut and cover tanks with all floor and roof types. The level indicating system must be able to measure multiple tanks with a single field interface unit. The level indicating system must be able to determine whether the tank is issuing or receiving fuel while in the transfer mode and also with the same unit be able to perform leak detection. The level indicating system must require no periodic calibration after installation is complete. The level indicating system must be approved for installation in a hazardous area and certified intrinsically safe by an approved agency and provide lightning protection. The level indicating system must be able to interface with government owned information systems. The level indicating system must provide five sets of alarm outputs; high, intermediate high, low, intermediate low, and static tank movement alarm.
a. Level accuracy plus or minus 0.05 inches.

b. Corrected volume accuracy plus or minus 0.1 percent.

c. Density accuracy plus or minus 1 percent.

d. Temperature accuracy plus or minus 1 degrees F.

e. Detect water in the tank sump to a level equal to or slightly above the water draw-off pipe.

It will be an ENRAF Servo Gauge Model 854 Automatic Tank Gauging System or approved equal. Equality being determined by compatibility with the Base FAS System. The system shall include a relocated RTU 8130 and a new local display similar or equal to a Varec OIT 8650. The Varec OIT 8650 shall be programmed to display inventory data, including all parameters identified above, of each operating tank and product recovery tank. The RTU shall transmit data to the Base FAS System located in the Operations Building 39 via fiber communications as shown on the drawings. Base personnel shall coordinate reprogramming of the FAS System to accept this new data.

2.11 OPERATING TANK LEVEL SWITCHES

The switches shall be an external mount liquid level switch with a stainless steel float chamber and stainless steel, type 304 or 316, float and trim. Switch contacts shall be two single pole double throw switches factory mutual approved or U.L. listed for use in Class I, Division 1, Group D hazardous location with a maximum temperature rating of T3 (392 degrees F). Units shall have provisions to check level switch operations without increasing the fuel level in the tanks as shown on the Contract Drawings.

2.12 WATER DRAW-OFF SYSTEM

Provide a water draw-off system complete with all equipment and controls and connected to the ASTs as indicated. System shall remove fuel from its associated storage tank, separate the fuel and water by gravity, return the fuel back to the storage tank, and discharge the water. The system and its components shall meet the requirements of the Specification herein. The system shall include, but is not limited to, the following piping, fittings, valves, equipment, and controls.

2.12.1 Tank

Product Saver Tank: Provide a product saver tank with the tank, piping and fittings packaged and fabricated as a single system. Fabricate tank and support legs from Type 304 stainless steel with tank volume of 55 gallons. Provide tank with removable top, 1 inch inlet line, 1 inch drain line, and other lines as indicated, all with full port ball valves and cam-type connections. Provide tank with concrete mounting pad and anchor tank to it.

2.12.2 Product Saver Pump

Pump shall be a close coupled centrifugal having a capacity of 10 gpm at not less than 60 feet of head and with a Net Positive Suction Head of more than 3 feet. Pump motor shall be in accordance with NEMA MG 1. All pump components in contact with fuel shall be stainless steel. The unit shall be UL listed and labeled for use in Class I, Division 1, Group D hazardous environments as defined by NFPA 70, with a maximum temperature rating of T3
(392 degrees F). The motor shall be non-overloading at every point on the pump curve. Contractor has the option of selecting either centrifugal or positive displacement type pump with the restriction of the positive displacement type pump shall include an internal and external pressure relief valve between the discharge and suction piping to protect the pump from overloading. Internal relief valve shall be set at 45 psi and external relief valve shall be as specified in under "Safety Relief Valves" in specification section 33 52 43.13 AVIATION FUEL PIPING.

2.12.3 Piping, Valves, Fittings, and Instruments

Pipe, pipe fittings, flanges, manual valves, gaskets, and bolting shall be in accordance with Section 33 52 43.13 AVIATION FUEL PIPING. Materials of construction shall be as described in this Specification Section in "Materials for Equipment, Pipe, and Fittings," except as modified herein.

2.12.4 Controls

Provide a pump start/stop pushbutton station with red (run) and green (stop) lights. All lights shall be push to test type. All equipment shall be rated for Class I, Division 1, Group D service.

2.12.5 Electrical

Provide completely pre wired with single point of service connection at horsepower rated disconnect switch. Provide combination motor/starter with HOA switch for pump motor. Provide suitable for Class I, Division 1, Group D service.

2.12.6 Basis of Design of Water Draw-Off System

The system shall be arranged in the same general configuration as indicated. However, these are not fabrication drawings and are for basis of design only. The Contractor shall be responsible for providing a complete and usable system.

2.12.6.1 Detail Drawing

Submit detailed drawings showing the Water Draw-Off System, including types, sizes, location, and installation details for:

a. Pipe hangers and supports.
b. Grounding.
c. Tank.
d. Pump.
e. Controls.
f. Valves.
g. Piping.

2.13 TIGHTNESS MONITORING SYSTEM

The system shall be a permanent, fully automated, pressure step (no volume measurement) leak detection system, and will be used for tightness testing.
2.14 DAY TANK

A day tank shall be provided in the pumphouse.

2.14.1 Tank

The day tank shall be a 50-gal fabricated stainless steel tank with supporting legs. Tank and support legs shall be fabricated from Type 304 stainless steel.

2.14.2 Sight Glass

Sight glasses for tank shall be standard tubular gages with density ball and shut-off valves on each end. Wetted parts other than sight glass shall be stainless steel. If glass breakage should occur, a stainless steel ball in the valve shall close preventing product loss. Glass shall be protected by minimum of four guard rods.

2.14.3 Level Sensors

The level sensors shall be ultrasonic tip sensitive level control switches, NEMA 7/9, weatherproof, explosion proof for Class I, Div I, Group D, temperature T3 (392 degrees F), 120-volt input power, single pole, single throw (SPST) relay output, 1-inch flanged mounting.

2.14.4 Anchoring

The tank shall be installed plumb and level and secured in place by anchor bolts.
2.14.5 Pressure/Vacuum Conservation Vent

Size and construct vent pipe in accordance with NFPA 30, NFPA 30A, and UL 142. Provide a Pressure/Vacuum Conservation Vent at the termination point of each vent pipe. Vent to be sized to maintain a maximum of 1/2-ounce per square inch pressure or vacuum. Vent body shall be constructed of 316 Stainless Steel. Seats to be replaceable and comprised of Teflon. Provide a minimum 40-mesh stainless-steel insect screen. The vent hood shall prevent rain, snow, or ice from entering the vent piping. Vent opening shall be a minimum of 12 ft above grade.

PART 3 EXECUTION

3.1 GENERAL

3.1.1 Installation

Install equipment and components in position, true to line, level and plumb, and measured from established benchmarks or reference points. Follow manufacturer's recommended practices for equipment installation. Provide required clearances between equipment components. Equipment, apparatus, and accessories requiring normal servicing or maintenance to be accessible.

3.1.2 Anchoring

Anchor equipment in place. Check alignment of anchor bolts before installing equipment and clean-out associated sleeves. Do not cut bolts because of misalignment. Notify Contracting Officer of errors and obtain the Contracting Officer's acceptance before proceeding with corrections. Cut anchor bolts of excess length to the appropriate length without damage to threads. Where anchor bolts or like devices have not been installed, provide appropriate self-drilling type anchors for construction condition.

3.1.3 Grouting

Equipment which is anchored to a pad is to be grouted in place. Before setting equipment in place and before placing grout, clean surfaces to be in contact with grout, including fasteners and sleeves. Remove standing water, debris, oil, rust, and coatings which impair bond. Clean contaminated concrete by grinding. Clean metal surfaces of mill scale and rust by hand or power tool methods. Provide necessary formwork for placing and retaining grout. Grout to be non-metallic, non-shrink, fluid precision grout of a hydraulic cementitious system with graded and processed silica aggregate, Portland cement, shrinkage compensating agents, plasticizing and water reducing agents; free of aluminum powder agents, oxidizing agents and inorganic accelerators, including chlorides; proportioned, pre-mixed and packaged at factory with only the addition of water required at the project site. Grouting shall be in accordance with ASTM C827. Perform all grouting in accordance with equipment manufacturer's and grout manufacturer's published specifications and recommendations.

3.1.4 Leveling and Aligning

Level and align equipment in accordance with respective manufacturer's published data. Do not use anchor bolt, jack-nuts or wedges to support, level or align equipment. Install only flat shims for leveling equipment. Place shims to fully support equipment. Wedging is not permitted. Shims
to be fabricated flat carbon steel units of surface configuration and area not less than equipment bearing surface. Shims to provide for full equipment support. Shim to have smooth surfaces and edges, free from burrs and slivers. Flame or electrode cut edges not acceptable.

3.1.5 Direct Drives

Alignment procedure follows:

3.1.5.1 Rotation Direction and Speed

Check and correct drive shaft rotation direction and speed.

3.1.5.2 End Play

Run drive shafts at operational speed. Determine whether axial end play exists. Run drive shaft at operational speed and mark drive shaft axial position when end play exists. Block drive shaft in operating position when aligning drive shaft with driven shaft.

3.1.5.3 Shaft Leveling and Radial Alignment

Pump alignment shall be accomplished by the factory technician or a millwright trained in pump alignment, and with the use of dial gauges or laser alignment equipment.

3.1.5.4 Angular Alignment and End Clearance

Check angular alignment and end clearance by inserting a feeler gage at 4 points, 90 degrees apart around outer edges of coupling halves.

3.1.5.5 Final Recheck

Check adjustments with dial indicator after completing recheck. Align shafts within 0.001 inch tolerance, except as other-wise required by more stringent requirements of equipment manufacturer.

3.1.6 Precautions

Special care shall be taken to ensure that equipment and materials are stored properly to prevent damage and maintain cleanliness, and that the completed system is free of rocks, sand, dirt, and foreign objects. Take the following steps to insure these conditions.

a. Equipment brought to the site and not stored inside, shall be stored on blocks or horses at least 18 inches above ground.

b. Visual inspection shall be made of each piece of equipment to ensure that it is clean prior to installation.

c. The open ends of equipment shall be closed when work with that piece of equipment is not in progress.

3.2 INSTALLATION OF FIBERGLASS PITS

Submit recommended installation procedures and setting tolerances from the pit manufacturer/supplier for the fiberglass pit and the aluminum cover. These procedures shall indicate recommended methods of supporting the pit in its proper position in the open excavation prior to and during concrete
placement operations. Also, required installation tolerances, especially for flatness/levelness of the fiberglass pit lip, shall be provided. Follow these recommendations and apply other procedures as required to ensure the integrity of the pit liner and cover assemblies in their installed positions. All penetrations through the fiberglass pit liner shall be tightly sealed by suitable means to preclude water infiltration, with consideration for potential relative movements between the penetrating objects and the pit liner. Reference the Contract Drawings for additional installation requirements.

3.3 POSTED OPERATING INSTRUCTIONS

For each designated system or equipment item, provide instructions for guidance of operating and maintenance personnel. Following approval of content, prepare these instructions in a form and scale that will be readily legible when displayed in appropriate locations, to be designated by the Contracting Officer and meet the following requirements:

3.3.1 Each System

For each system, include diagrams of equipment, piping, wiring and control. Define control sequences.

3.3.2 Each Tank

For each tank provide a P.E. stamped certified tank calibration chart in 1/16 inch increments reading in gallons.

3.3.3 Each Item

For each equipment item, include starting, adjustment, operation, lubrication, safety precautions and shut-down procedures. Identify procedures to be performed in event of equipment failure. Provide other instructions recommended by the manufacturer.

3.3.4 Diagrams

Provide a professionally prepared isometric piping diagram of the fueling system apparatus. Diagram shall be 36 by 54 inches and shall be color coded to match PCP color diagrams. Diagram shall show the entire facility and shall include all equipment and the operational sequences of all equipment with equipment numbers displayed. Diagram shall show all valves along with the valve numbers shown on the drawings and listed as normally open/closed. It shall be wall mounted under glass.

3.3.5 Volume of Fuel

Provide a certified system inventory of fuel in the pipe, tank, pumphouse, etc. The piping will show length of pipe, size of pipe, gal/foot, and total gal. Verify during initial fill.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

**AMERICAN PETROLEUM INSTITUTE (API)**

**API RP 1110**  (2013) Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide

**API RP 582**  (2016) Welding Guidelines for the Chemical, Oil, and Gas Industries

**API STD 600**  (2015) Steel Gate Valves-Flanged and Butt-welding Ends, Bolted Bonnets

**API STD 608**  (2012) Metal Ball Valves - Flanged, Threaded, And Welding End


**API Spec 6D**  (2014; Errata 1-2 2014; Errata 3-5 2015; ADD 1 2015) Specification for Pipeline Valves


**AMERICAN WELDING SOCIETY (AWS)**

**AWS A5.1**  (2012) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

**AWS A5.5**  (2014) Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding

**AWS A5.9**  (2012) Specification for Bare Stainless Steel Welding Electrodes and Rods

**ASME INTERNATIONAL (ASME)**

**ASME B1.1**  (2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
<table>
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<tr>
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<th>Description</th>
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<tr>
<td>ASME B16.11</td>
<td>2011</td>
<td>Forged Fittings, Socket-Welding and Threaded</td>
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<tr>
<td>ASME B16.21</td>
<td>2011</td>
<td>Nonmetallic Flat Gaskets for Pipe Flanges</td>
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<td>ASME B16.34</td>
<td>2013</td>
<td>Valves – Flanged, Threaded and Welding End</td>
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<td>ASME B16.5</td>
<td>2013</td>
<td>Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard</td>
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<td>ASME B16.9</td>
<td>2012</td>
<td>Standard for Factory-Made Wrought Steel Buttwelding Fittings</td>
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<tr>
<td>ASME B18.2.1</td>
<td>2012</td>
<td>Square and Hex Bolts and Screws (Inch Series)</td>
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<td>2015</td>
<td>Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)</td>
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<td>2016</td>
<td>Power Piping</td>
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<td>ASME B31.3</td>
<td>2014</td>
<td>Process Piping</td>
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<td>2010</td>
<td>BPVC Section IX-Welding and Brazing Qualifications</td>
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<tr>
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<td>2015</td>
<td>BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1</td>
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**ASTM INTERNATIONAL (ASTM)**

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<tr>
<td>ASTM A105</td>
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<td>Standard Specification for Carbon Steel Forgings for Piping Applications</td>
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<tr>
<td>ASTM A182</td>
<td>2016</td>
<td>Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service</td>
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<tr>
<td>ASTM A193</td>
<td>2016</td>
<td>Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications</td>
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<tr>
<td>ASTM A194</td>
<td>2016</td>
<td>Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both</td>
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<tr>
<td>ASTM A217</td>
<td>2014</td>
<td>Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service</td>
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<tr>
<td>ASTM A234</td>
<td>2013</td>
<td>Standard Specification for</td>
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Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service


ASTM D229  (2013) Rigid Sheet and Plate Materials Used for Electrical Insulation

ASTM E94  (2004; R 2010) Radiographic Examination

ASTM F436  (2011) Hardened Steel Washers

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)


1.2 ADMINISTRATIVE REQUIREMENTS

Design conditions shall be as specified in Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT. Submit a copy of welding qualified procedures, where the procedures will be used, and a list of names and identification symbols of qualified welders and welding operators. Submit Operation and Maintenance Manuals for the equipment items or systems listed under SD-10 Operation and Maintenance Data. Refer to Section 01 78 23.33 OPERATION AND MAINTENANCE MANUALS FOR AVIATION FUEL SYSTEMS for the information to be submitted for various type of equipment and systems.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data
Carbon Steel Pipe; G
Interior Epoxy Coating for Carbon Steel Piping; G
Stainless Steel Pipe; G
Carbon Steel Fittings; G
Stainless Steel Fittings; G
Stainless Steel Control Tubing; G
Isolating Gasket Kits; G
Lightning Surge Arrester; G
Bolts and Nuts; G
Gaskets; G
Ball Valves; G
Plug (Double Block and Bleed) Valves; G
Electric Valve Actuator; G
Swing Check Valves; G
Silent Check Valves; G
Thermal Relief Valves; G
Sight Flow Indicators; G
Flexible Ball Joints; G
Pipe Sleeves; G
Strainers; G
Pipe Hangers and Supports; G
Fuel Sample Connection; G
Flanged Swivel Joints; G
Quick Disconnect Adapters; G
Quick Disconnect Couplers; G
Flexible Connectors; G
Surge Suppressor Tank and Valve; G

SD-05 Design Data
Welding Procedure Specification (WPS); G

SD-06 Test Reports
Procedure Qualifications Records (PQR); G
Welder and Welding Operator Qualification Record (WQR); G
Factory Testing and Inspection Records; G
Pneumatic Test
Hydrostatic Test
Geometry Tool Reports; G

SD-07 Certificates
Welder and Welding Operator Certifications; G
Qualified Commercial or Testing Laboratory
Quality Assurance Plan
Fittings
Surge Suppressor Tank and Valve
Isolating Flange Gasket Kits
Survey Final Elevations
Pipeline Pigging Verification; G

SD-10 Operation and Maintenance Data
Isolating Gasket Kits
Ball Valves
Plug (Double Block and Bleed) Valves
Electric Valve Actuators
Swing Check Valves
Silent Check Valves
Thermal Relief Valves
Sight Flow Indicators
Fuel Sample Connection
Flexible Ball Joints
Flexible Connectors
Strainers
Surge Suppressor Tank and Valve
Isolating Flange Gasket Kits
1.4 QUALITY ASSURANCE

1.4.1 Welding Qualifications

Welding of fuel pipe joints shall comply with Section 33 52 90.00 20 WELDING FOR POL SERVICE PIPING. Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record.

1.4.2 Qualifications of Welders

Welders and welding procedures shall be qualified in accordance with requirements of ASME B31.3. Submit for each pipe material and process a Welding Procedure Specification (WPS), its corresponding Procedure Qualifications Records (PQR), and the welder Performance Qualification (WPQ) for each welder and each specification. Submit on the forms contained within Appendix A of ASME BPVC SEC IX. All welding is to be performed in accordance with applicable requirements of API RP 582 and AWS WHB-2.9, Chapter 5 as it applies to stainless steel piping.

1.4.2.1 Weld Identification

Each qualified welder shall be assigned an identification symbol. All welds shall be permanently marked with the symbol of the individual who made the weld.

1.4.2.2 Defective Work

Welders found making defective welds shall be removed from the work or shall be required to be requalified in accordance with ASME B31.3.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 MATERIALS AND EQUIPMENT

Pipe and fittings in contact with fuel shall be stainless steel, interior epoxy coated carbon steel, or carbon steel as indicated on the drawings. No zinc coated metals, brass, bronze or other copper bearing alloys shall be used in contact with the fuel. All carbon steel and stainless steel underground piping shall have an exterior protective coating and shall be cathodically protected in accordance with Section 26 42 19.00 20 CATHODIC
PROTECTION BY IMPRESSED CURRENT. Identification of piping shall be in accordance with MIL-STD-161G unless specified otherwise. Material for manual valves shall be as specified hereinafter.

2.2.1 Carbon Steel Piping

Subject each length of pipe to factory hydrostatic testing and ultrasonic testing in accordance with their respective pipe specification.

a. Piping 12-Inches and Larger: Seamless, ASTM A53 Grade B having a wall thickness of 0.375-inch.

b. Piping 2 1/2 through 10-Inches: Seamless, Schedule 40 API Spec 5L Grade B or ASTM A53 Grade B.

c. Piping 2-Inches and Smaller: Seamless, Schedule 80 API Spec 5L Grade B or ASTM A53 Grade B.

d. Welding Electrodes (Factory Fabrication): E70XX low hydrogen electrodes conforming to AWS A5.1 or AWS A5.5. Provide pipe with coating system Section 33 52 80 LIQUID FUELS PIPELINE COATING SYSTEM. Interior epoxy coating system shall be factory applied and in accordance with MIL-PRF-4556, 6 to 8 mils dry film thickness. Documentation of conditions during application shall be submitted to the Contracting Officer.

2.2.1.1 Interior Epoxy Coated Carbon Steel Piping

Before applying the epoxy coating, the inside of the pipe shall be sandblasted to "white" metal conforming with SSPC SP 5. If the pipe is not internally epoxy lined immediately after cleaning, a rust preventative coating shall be applied. The rust preventative shall be approved by the epoxy manufacturer. The ends of the pipe shall be masked or wiped back a minimum of one inch but not more than 1-1/2 inches.

2.2.1.2 Coat Testing

After the top coat has cured, the internal epoxy lining shall be tested electrically using an approved holiday detector and shall be free of holidays. The ends of the pipe shall then be capped. The shop doing the application shall have a minimum of five years of experience at applying internal epoxy coating. The application and holiday testing at the shop shall be available for inspection at any time by the Contracting Officer. The shop shall notify the Contracting Officer at least one week before the pipe and fittings will be cleaned and epoxy coated. Provide a certified technical representative of the epoxy manufacturer to make at least three separate inspection trips with at least one day in the shop per trip. Each trip report shall be submitted to the Contracting Officer. Pipe 2-1/2-inches and smaller shall not be interior coated.

2.2.2 Stainless Steel Piping

a. Piping 2-1/2 Inches and Larger:

(1) ASTM A358, Grade 304L, Class 1 or Class 3 with supplementary requirements of S1, S2 and S3, or ASTM A312 Type 304L, seamless (only). Any agreements between the purchaser and the manufacturer or supplier as referenced in the applicable ASTM shall include the Contracting Officer as a party to the agreement. All piping welds
will receive 100 percent radiographic inspection, 100 percent liquid penetrant inspection, 100 percent visual inspection and all tests as required by the applicable ASTM Standard. Piping shall be provided with a nominal wall thickness as shown in Table A for ASTM A358 with the deviation from the nominal wall thickness less than 0.01-inch. ASTM A312 seamless piping shall be provided with a minimum schedule 10S wall thickness.

(2) Pipe Ends: All Piping shall be provided with beveled ends per Chapter V, ASME B31.3, and shall be shipped with the ends capped.

(3) Seam and End Welds: All sections of the piping provided shall be accepted on the project site if the seam welds meet the requirements of the paragraph K341 of ASME B31.3 and Appendix 4 of ASME BPVC SEC VIII D1. One hundred spots may be reinspected at the project site prior to installation and backfilling at the request of the Contracting Officer. End welds shall be properly aligned prior to welding per Chapter V of the ASME B31.3; welds found to be defective shall be repaired at no additional cost to the government. Observation by the Contracting Officer of the manufacturing and field procedures shall be allowed under this contract.

(4) Welders Qualifications: Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Welding procedures qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.

(5) Factory Testing and Inspection Records: Per Table K341.3.2 of Chapter IX of ASME B31.3, visual, radiographic and liquid penetrant tests shall be performed for each section of piping provided as all sections are subjected to cyclic conditions. All testing and inspections records shall be submitted to the Contracting Officer and shall indicate the pipe mark and installed location of each piping section on the project site. Observation by the Contracting Officer of the manufacturers and the field testing and inspection procedures shall be allowed under this contract. Pipe certification along with pipe markings shall be submitted before the pipe arrives on the job site.

(6) Qualifications of Welding Inspectors for Stainless Steel Piping: Submit the qualifications of all the testing personnel that will perform all field tests as requested by the Contracting Officer. The qualifications of all personnel on the job site that will perform welding inspection shall be submitted for approval. These inspectors shall meet the qualifications as defined in Chapter VI of the ASME B31.3, and use the methods as defined in Table K341.3.2 of the ASME B31.3.

(7) Provide a qualified inspector in accordance with Chapter VI of ASME B31.3 to act as the owner's inspector (for the Government) at the pipe manufacturer's facility in addition to the manufacturer's inspector.

(8) Submit Quality Assurance Plan for the welding, inspecting and
testing of the welded seam pipe.

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<tr>
<td>14 inches</td>
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<td>12 inches</td>
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</tr>
<tr>
<td>4 inches</td>
<td>4.500 inches</td>
<td>0.219 inch</td>
</tr>
<tr>
<td>2.5 inches</td>
<td>2.875 inches</td>
<td>0.156 inch</td>
</tr>
</tbody>
</table>

b. Piping 2-inches and Smaller: Schedule 80 ASTM A312 seamless Type 304L for threaded piping and schedule 40 (unless otherwise indicated) ASTM A312 seamless Type 304L for welded piping.

c. Stainless Steel Control Tubing: Seamless, fully annealed tubing conforming to ASTM A269, Grade TP316, Rockwell hardness B80 or less. Wall thickness for 1/2-inch tubing to be 0.049 inch.

d. Welding Electrodes (Factory Fabrication): E308L conforming to AWS A5.9.

2.2.3 Protective Coatings for Aboveground Piping

Provide coating of aboveground piping, piping in pits, pipe supports, filter separators, and miscellaneous metal and equipment in accordance with Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES. Color of finish coat shall be white. Do not paint stainless steel or aluminum surfaces.

2.2.4 Protective Coatings for Buried Steel Piping

Provide pipe with coating system Section 33 52 80 LIQUID FUELS PIPELINE COATING SYSTEM.

2.2.5 Fittings

2.2.5.1 General

Welding ells, caps, tees, reducers, etc., shall be of materials compatible for welding to the pipe line in which they are installed, and wall thickness, pressure and temperature ratings of the fittings shall be not less than the adjoining pipe line. Unless otherwise required by the conditions of installation, all elbows shall be the long radius type. Miter joints are not acceptable. Make odd angle offsets with pipe bends or elbows cut to the proper angle. Butt weld fittings shall be factory-made wrought fittings manufactured by forging or shaping. Fabricated fittings will not be permitted. Welding branch fittings shall be insert type
suitable for radiographic inspections specified herein.

2.2.5.2 Carbon Steel Fittings

a. Fittings 2.5 Inches and Larger: Butt weld, conforming to ASTM A234, grade WPB and ASME B16.9 of the same wall thickness as the adjoining pipe. All welds shall be radiographically examined throughout the entire length of each weld. Each fitting shall be subjected to the Supplementary Requirements S3 and S4, Liquid Penetration examination and Magnetic-Particle Examination. Detectable flaws will not be accepted in the supplementary examinations. Fittings shall be identified to relate them to their respective radiograph. Elbows located between the pig launcher and the receiver, shall have a radius three times the pipe diameter. Tees with branches 6 inches and larger, located between the pig launcher and pig receiver, shall have guide bars as detailed on the drawings.

b. Fittings 2 Inches and Smaller. Forged (socket welded or if indicated on drawings, threaded), 3,000-pound W.O.G., conforming to ASTM A105, Grade 2 and ASME B16.11. Threaded fittings shall only be used for above grade applications. Underground and in pits low point drain pipe and high point vent pipe shall be butt welded.

c. Flanges: 150 pound weld neck, forged flanges conforming to ASTM A105, and ASME B16.5. Flanges to be 1/16-inch raised face with phonographic finish, except where required otherwise to match equipment furnished. Match flange face to valves or equipment furnished. Flange face shall be machined to match valves or equipment furnished. Use of spacing rings or gaskets discs are not allowed. Flanges shall be subjected to the Supplementary Requirements S56, Liquid Penetrant Examination as outlined in ASTM A961. Detectable flaws will not be accepted.

d. Interior Epoxy Coating System shall be applied to the fittings as specified in paragraph "Carbon Steel Piping."

2.2.5.3 Stainless-Steel Fittings

a. Fittings 2.5 Inches and Larger: Butt weld stainless steel conforming to ASTM A403, Class WP, Type 304L, seamless, and ASME B16.9 of the same minimum wall thickness as the adjoining pipe. Welded fittings shall be tested and inspected the same as the welded seam pipe and meet the same requirements as for the pipe. Elbows located between the pig launcher and the receiver, shall have a radius three times the pipe diameter. Tees with branches 6 inches and larger, located between the pig launcher and pig receiver, shall have guide bars as detailed on the drawings.

b. Fittings 2 Inches and Smaller: Forged Type 304 or 304L (socket welded or if indicated on drawings, threaded), 3,000-pound W.O.G. conforming to ASTM A182 and ASME B16.11. Threaded fittings shall only be used for above grade applications. Underground and in pits low point drain pipe and high point vent pipe shall be butt welded.

c. Unions. Conforming to ASTM A312, Grade 304 or 316.

d. Flanges. 150 pound weld neck, forged Type 304 stainless-steel flanges conforming to ASTM A182 and ASME B16.5, except flanges that are to be connected to the fueling pumps shall be 300 pound. Flanges to be 1/16-inch raised-face with phonographic finish, except where required
otherwise to match equipment furnished. Match flange face to valves or equipment furnished. Flanges shall be subjected to the Supplementary Requirements S56, Liquid Penetrant Examination as outlined in ASTM A961.

e. Stainless-Steel Tube Fittings. Flareless, 316 stainless-steel fittings conforming to SAE J514.

2.2.5.4 Isolating Gasket Kits (Insulating) for Flanges

Provide ASTM D229 electrical insulating material of 1,000 ohms minimum resistance; material shall be resistant to the effects of aviation hydrocarbon fuels. Provide full face insulating gaskets between flanges. Provide full surface 0.03 inch thick wall thickness, spiral-wound mylar insulating sleeves between the bolts and the holes in flanges; bolts may have reduced shanks of a diameter not less than the diameter at the root of threads. Provide 0.125-inch thick high-strength phenolic insulating washers next to flanges and provide flat circular stainless steel washers over insulating washers and under bolt heads and nuts. Provide bolts 0.5 inch longer than standard length to compensate for the thicker insulating gaskets and the washers under bolt heads and nuts. Exterior above grade flanges separated by electrically isolating gasket kits shall be provided with weatherproof lightning surge arrester devices. The surge arrester shall bolt across flanges separated by insulating gasket kits per detail on contract drawings. The arrester shall have the following features:

a. Weatherproof NEMA 4 enclosure.

b. Bidirectional and bipolar protection.

c. Constructed of solid state components, no lights, fuses or relays and used without required maintenance or replacement.

d. Withstand unlimited number of surges at 50,000 Amperes.

e. Maximum clamping voltage of 700 Volts based on a IEEE C62.41 8x20 microsecond wave form at 50,000 Amperes peak measured at the device terminals (zero lead length).

f. A UL listed arrester for installation in Class 1, Division 2, Group D, hazardous areas.

Install the mounting bracket and leads on the flange side of the bolt insulating sleeve and washer, and size in accordance with this schedule:

<table>
<thead>
<tr>
<th>Line Size</th>
<th>Bolt Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>2.5 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>3 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>4 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>6 inch</td>
<td>3/4 inch</td>
</tr>
</tbody>
</table>
2.2.6 Bolts and Nuts

Bolts and nuts for pipe flanges, flanged fittings, valves and accessories shall conform to ASME B18.2.1 and ASME B18.2.2, except as otherwise specified. Bolts shall be of sufficient length to obtain full bearing on the nuts and shall project no more than three full threads beyond the nuts with the bolts tightened to the required torque. Bolts shall be regular hexagonal bolts conforming to ASME B18.2.1 with material conforming to ASTM A193, Class 2, Grade B8, stainless steel, when connections are made where a stainless steel flange is involved, and Grade B7 when only carbon steel flanges are involved. Bolts shall be threaded in accordance with ASME B1.1, Class 2A fit, Coarse Thread Series, for sizes one inch and smaller and Eight-Pitch Thread Series for sizes larger than one inch. Nuts shall conform to ASME B18.2.2, hexagonal, heavy series with material conforming to ASTM A194, Grade 8, stainless steel for stainless steel bolts, and Grade 7 for carbon steel bolts. Nuts shall be threaded in accordance with ASME B1.1, Class 2B fit, Coarse Thread Series for sizes one inch and smaller and Eight-Pitch Thread Series for sizes larger than one inch. Provide washers under bolt heads and nuts. Use carbon steel washers conforming to ASTM F436 Type 1 (carbon steel), flat circular for carbon steel bolts. Stainless steel washer dimensioned in accordance with ASTM A436 flat circular, use material the same as the bolt. Use torque wrenches to tighten all flange bolts to the torque recommended by the gasket manufacturer. Tight in the pattern recommended by the gasket manufacturer. Use anti-seize compound on stainless steel bolts.

2.2.7 Gaskets

ASME B16.21, composition ring, using a Buna-N, polytetrafluoroethylene (PTFE), or a protein and glycerin binder, 0.1250 inch thick. Gaskets shall be resistant to the effects of aviation hydrocarbon fuels and manufactured of fire-resistant materials. Full-face gaskets shall be used for flat-face flanged joints. Ring gaskets shall be used for raised-face flanged joints. Gaskets shall be of one piece factory cut.

2.2.8 Relief and Drain System Piping

Pressure relief valve discharge lines and drain lines to the product recovery tank shall be as indicated.
2.2.9 Field Applied Protective Coatings

The field joints and fittings of all underground piping shall be coated as specified in Section 33 52 80 LIQUID FUELS PIPELINE COATING SYSTEM.

2.2.10 Threaded Joints

Threaded joints, if indicated on the drawings, shall be made tight with manufacturer recommended PTFE tape or a mixture of graphite and oil, inert filler and oil, or with a graphite compound, applied with a brush to the male threads. Not more than three threads shall show on made up joints. Threaded joints, mechanical couplings and flanges will not be permitted in buried piping. Threaded joints shall not get welded.

2.2.11 Welded Joints

Welded joints in steel pipe shall be as specified in Part 3.

2.3 MANUAL VALVES

All portions of a valve coming in contact with fuel in stainless-steel pipe lines or epoxy lined carbon steel pipe lines shall be of noncorrosive material. Valves in stainless steel pipe lines or epoxy lined carbon steel pipe lines shall be Type 304 or Type 316 stainless steel or carbon steel internally plated with chromium or nickel or internally electroless nickel plated. Valves in unlined carbon steel pipelines shall have carbon steel body. Stem and trim shall be stainless steel for all valves. Manually operated valves 6 inches and larger shall be worm-gear operated and valves smaller than 6 inches shall be lever operated or handwheel operated. Valves smaller than 2 inches shall have lever-type handles. Valves installed more than 8 feet above finished floor shall have chain operators and a position indicators visible from ground level. Sprocket wheel for chain operator shall be aluminum. Valves in the isolation pits in fuel piping between the pig launchers and the pig receivers shall be full bore, piggable, double block and bleed type.

2.3.1 Ball Valves

Ball valves shall be fire tested and qualified in accordance with the requirements of API Std 607 and API STD 608. Ball valves shall be nonlubricated valves that operate from fully open to fully closed with 90 degree rotation of the ball. Valves 2 inches and larger shall conform to applicable construction and dimension requirements of API Spec 6D, ANSI Class 150 and shall have flanged ends. Valves smaller than 2 inches shall be ANSI class 150 valves with one piece bodies with flanged ends, unless noted otherwise. The balls in valves 10 inches full port and 12 inch regular port and larger shall have trunnion type support bearings. Except as otherwise specified, reduced port or full port valves may be provided at the Contractor's option. Balls shall be solid, not hollow cavity.

2.3.1.1 Materials

Ball shall be stainless steel. Ball valves shall have tetrafluoroethylene (TFE) or fluoroelastomer (FKM), commonly referred to as Viton seats, body seals and stem seals. Valves 4 inches and smaller shall have a locking mechanism.
2.3.2 Plug (Double Block and Bleed) Valves

API Spec 6D, Type III, ANSI Class 150, non-lubricated, resilient, double seated, trunnion mounted, tapered lift plug capable of two-way shutoff. Valve shall have tapered plug of steel or ductile iron with chrome or nickel plating and plug supported on upper and lower trunnions. Sealing slips shall be steel or ductile iron, with Viton seals which are held in place by dovetail connections. Valve design shall permit sealing slips to be replaced from the bottom with the valve mounted in the piping. Valves shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valves shall have weatherproof operators with mechanical position indicators. Indicator shaft shall be stainless steel. Minimum bore size shall be not less than 65 percent of the internal cross sectional area of a pipe of the same nominal diameter unless bore height of plug equals the nominal pipe diameter and manufacturer can show equal or better flow characteristics of the reduced bore size design. Valves indicated as Full Bore (FB) shall be piggable. Full port plug valves in distribution piping shall be provided with a 1-inch flanged body drain.

2.3.2.1 General

Valves in the operating tank suction and fill lines and the valves at the six valve manifold in the pump shelter in the tank fill lines shall be provided with a factory-installed limit switch that is actuated by the valve closure, as indicated. Each switch shall have one double pole double throw contacts or four single pole, double throw contracts, two for open, two for closed, and shall be watertight and U.L. listed for Class I, Division 1, Group D hazardous areas.

2.3.2.2 Valve Operation

Rotation of the handwheel toward open shall lift the plug without wiping the seals and retract the sealing slips so that during rotation of the plug clearance is maintained between the sealing slips and the valve body. Rotation of the handwheel toward closed shall lower the plug after the sealing slips are aligned with the valve body and force the sealing slips against the valve body for positive closure. When valve is closed, the slips shall form a secondary fire-safe metal-to-metal seat on both sides of the resilient seal. Plug valves located in Isolation Valve Pits or vaults shall be provided with handwheel extensions.

2.3.2.3 Relief Valves

ANSI Class 150. Provide plug valves with automatic thermal relief valves to relieve the pressure build up in the internal body cavity when the plug valve is closed. Relief valves shall open at 25 psi differential pressure and shall discharge to the throat of, and to the upstream side, of the plug valve.

2.3.2.4 Bleed Valves

ANSI Class 150, stainless steel body valve. Provide manually operated bleed valves that can be opened to verify that the plug valves are not leaking when in the closed position.

2.3.3 ELECTRIC VALVE ACTUATORS

The actuator, controls and accessories shall be the responsibility of the valve-actuator supplier for sizing, assembly, certification, field-testing.
and any adjustments necessary to operate the valve as specified. The electric valve actuator shall include as an integral unit the electric motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, drive bushing or stem nut, declutch lever, wiring terminals for power, remote control indication connections and handwheel. The electrically actuated plug valve or ball valve shall be set to open and close completely in 30 to 60 seconds against a differential pressure of 275 PSIG. The actuator settings of torque and limit contacts shall be adjustable. The valve actuator shall be suitable for mounting in a vertical or horizontal position and be rated for 30 starts per hour. The valve actuator shall be capable of functioning in an ambient environment temperature ranging from -32 to 158 degrees F. Provide where indicated on the drawings.

a. The electrical enclosure shall be specifically approved by UL or Factory Mutual for installation in Class I, Division 1, Group D locations.

b. The electric motor shall be specifically designed for valve actuator service and shall be totally enclosed, non-ventilated construction. The motor shall be capable of complete operation at plus or minus 10 percent of specified voltage. Motor insulation shall be a minimum NEMA Class F. The motor shall be a removable subassembly to allow for motor or gear ratio changes as dictated by system operational requirements. The motor shall be equipped with an embedded thermostat to protect against motor overload and also be equipped with space heaters. It shall de-energize when encountering a jammed valve.

c. The reversing starter, control transformer and local controls shall be integral with the valve actuator and suitably housed to prevent breathing or condensation buildup. The electromechanical starter shall be suitable for 30 starts per hour. The windings shall have short circuit and overload protection. A transformer, if needed, shall be provided to supply all internal circuits with 24 VDC or 110 VAC may be used for remote controls.

d. The actuator gearing shall be totally enclosed in an oil-filled or grease-filled gearcase. Standard gear oil or grease shall be used to lubricate the gearcase.

e. The actuator shall integrally contain local controls for Open, Close and Stop and a local/remote three position selector switch: Local Control Only, Off, and Remote Control plus Local Stop Only. A metallic handwheel shall be provided for emergency operation. The handwheel drive must be mechanically independent of the motor drive. The remote control capability shall be to open and close. Rim pull to operate valve manually shall not exceed 80 pounds.

f. Position limit switches shall be functional regardless of main power failure or manual operation. Four contacts shall be provided with each selectable as normally open or normally closed. The contacts shall be rated at 5A, 120 VAC, 30 VDC.

g. Each valve actuator shall be connected to a PLC supplied by "others".

h. The actuator shall have a local display of position even when power has been lost.

i. The actuator shall be supplied with a start-up kit comprising
installation instruction, electrical wiring diagram and spare cover screws and seals.

j. The actuator must be performance tested and a test certificate shall be supplied at no extra charge. The test should simulate a typical valve load with current, voltage, and speed measured.

2.3.4 Swing Check Valves

Swing check valves shall conform to applicable requirements of API Spec 6D, regular type, ANSI Class 150 with flanged end connections. Check valves shall conform to API STD 600 and be swing type with material as previously indicated herein. Discs and seating rings shall be replaceable without removing the valve from the line. The disc shall be guided and controlled to contact the entire seating surface.

2.3.5 Silent Check Valves

Spring assisted, wafer/lug pattern, butterfly check with FKM or PTFE seating ring, designed to prevent flow reversal slamming of valve, dual plate, and shall conform to ASME B16.34, API Std 594, except face to face dimensions may deviate from standard. Valves shall be suitable for installation in any orientation. Valve body and trim material shall be as previously indicated herein.

2.4 THERMAL RELIEF VALVES

Relief valves shall be the fully enclosed, spring loaded, angle pattern, single port, hydraulically operated type with plain caps, and shall be labeled in accordance with ASME BPVC SEC VIII D1. Valve stems shall be fully guided between the closed and fully opened positions. The valves shall be factory-set to open as indicated on the drawings. Operating pressure shall be adjustable by means of an enclosed adjusting screw. The valves shall have a minimum capacity of 20 GPM at 10 percent overpressure. Valves shall have a replaceable seat. Relief valves that do not relieve to a zone of atmospheric pressure or tank must be a balanced type relief or regulator valve.

2.4.1 Valve Materials

Valves shall have carbon steel bodies and bonnets with stainless steel springs and trim. Valves shall be Class 150 flanged end connections.

2.4.2 Sight Flow Indicators

Sight flow indicators shall be ASME Class 150 and shall have flanged end connections. Sight flow indicators shall consist of a housing containing a rotating propeller that is visible through a glass observation port. The housing shall be stainless steel when installed in stainless steel lines and carbon steel when installed in carbon steel lines. The glass in the indicator shall also meet the Class 150 rating.

2.4.3 Safety Relief Valve

ASME BPVC SEC VIII D1 - (2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
2.4.4 SAFETY RELIEF VALVES

Safety relief valves shall be fully enclosed, spring loaded, angle pattern, single port, hydraulically operated type with plan caps. Valves shall meet the requirements of ASME BPVC SEC VIII D1 and API Std 526. Valve stems shall be fully guided between the closed and fully opened positions. Valve seats shall provide a double seal with a metal-to-metal seat in addition to an o-ring soft seat. End connections shall be ASME B16.5, 150 lb class raised face flanges.

2.4.4.1 Materials of Construction

Valve bodies and bonnets shall be ASTM A217, Grade WCC carbon steel unless otherwise noted. Trim and internals shall be 316 stainless steel. O-ring soft seat shall be Viton SRV-8 valve body and bonnet shall be 316 stainless steel.

2.4.4.2 Specific Requirements

Valve manufacturer shall verify sizing of the valve provided in accordance with API Std 520 and the design conditions. Sizing shall include 10 percent overpressure at the given relief flow. Initial sizes and design conditions are given in the following table.

<table>
<thead>
<tr>
<th>Valve Number</th>
<th>Set Pressure (PSI)</th>
<th>Relief Flow (GPM)</th>
<th>Inlet/Outlet Size (Nominal)</th>
<th>API Orifice Size</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRV-1</td>
<td>35</td>
<td>10</td>
<td>1&quot; by 2&quot;</td>
<td>D</td>
<td>PRP-1 (Tank 1)</td>
</tr>
<tr>
<td>SRV-2</td>
<td>35</td>
<td>10</td>
<td>1&quot; by 2&quot;</td>
<td>D</td>
<td>PRP-2 (Tank 2)</td>
</tr>
<tr>
<td>SRV-3</td>
<td>35</td>
<td>10</td>
<td>1&quot; by 2&quot;</td>
<td>D</td>
<td>PRP-3 (Tank 3)</td>
</tr>
<tr>
<td>SRV-4</td>
<td>30</td>
<td>10</td>
<td>1&quot; by 2&quot;</td>
<td>D</td>
<td>WDP-1 (PRT)</td>
</tr>
</tbody>
</table>

Note 1: SRV-1 through SRV-3 are only required if positive displacement pumps are selected for the product saver tank return.

2.5 PIPING ACCESSORIES

2.5.1 Flexible Ball Joints

Flexible ball joints shall be carbon steel with electroless nickel-plating to a minimum of 3 mils thickness, capable of 360-degree rotation plus 15-degree angular flex movement, ASME B16.5, Class 150 flanged end connections. Provide pressure molded composition gaskets designed for continuous operation temperature of 275 degrees F. Joints shall be designed for minimum working pressure of ANSI Class 150. Injectable packing will not be allowed.

2.5.2 Pipe Sleeves

Pipe sleeves shall be installed where indicated and at all points where the piping passes through concrete construction. Such sleeves shall be of sufficient inside diameter to provide a minimum clear distance between the pipe and the sleeve of 1/2 inch. Sleeves through concrete pits or slabs shall be standard weight carbon steel pipe with a protective coating. Each sleeve shall extend through the respective pit wall or slab and shall be
provided with a Buna-N casing seal. Sleeves where piping passes under roads or piping indicated to be double walled shall be standard weight carbon steel pipe with a protective coating as previously specified. Alignment of the sleeve and piping shall be such that the pipe is accurately centered within the sleeve by a nonconductive centering element. The sleeve shall be securely anchored to prevent dislocation. Closure of space between the pipe and the pipe sleeve shall be by means of a mechanically adjustable segmented elastomeric seal. The seal shall be installed so as to be flush.

2.5.3 Strainers

2.5.3.1 Basket Type

Strainer shall be in compliance with MIL-PRF-13789, except as specified otherwise. Strainer end connections shall be designed in accordance with ASME B16.5, Class 150. Strainer body material shall be the same as the material specified for manual valves. Strainers shall have removable baskets of 60 mesh wire screen with larger wire mesh reinforcement; wire shall be stainless steel, Type 316. Pressure drop for clean strainer shall not exceed 3 psig at maximum design flow rate. The ratio of net effective strainer area to the area of the connecting pipe shall be not less than three to one. Each strainer shall be provided with a suitable drain at the bottom, equipped with a ball valve. The strainer shall be equipped with a direct-reading, piston type differential pressure gauge that measures the differential pressure across the basket. The gauge shall consist of a spring-supported, corrosion resistant piston moving inside a glass cylinder, with high pressure applied on top of the piston and low pressure applied below it. Under a differential pressure of 30 PSI, leakage past the piston shall not exceed 120 drops per minute. The cylinder shall have stainless steel and flanges with FKM O-ring seals. The high pressure inlet of the gauge shall have a 10-micron pleated paper filter and the low pressure connection shall have a fine mesh stainless steel strainer. The gauge shall have an operating pressure of 300 PSI. Differential pressure range of the gauge through approximately 3 inches of piston movement shall be 0-30 PSI with an accuracy of ± 0.5 PSI, calibrated linearly with one PSI scale graduations. High and low pressure connections shall be 1/4 inch NPT female with a stainless-steel bar stock valve at each connection. Construction of the gauge shall be such that a 3-valve manifold is not necessary. If only one bar stock valve is closed, the gauge shall not be damaged by up to 300 PSI differential pressure in either direction. A pressure gauge shall be attached to the differential pressure gauge to indicate the high pressure and have a range of 300 psi.

2.5.3.2 Cone Type (Temporary)

Strainer shall be stainless steel type 304 or 316, 100 mesh screen with the ratio of net open area of strainer to the area of the connecting pipe shall be not less than three to one at the pump suction, and 5/32-inch perforations and suitable for bi-directional flow at the inlet to the hydrant pit control valves.

2.5.4 Pipe Hangers and Supports

2.5.4.1 General

Pipe hangers and supports shall conform to MSS SP-58. Supports shall be provided at the indicated locations. Support channels for drain lines shall be epoxy coated on all surfaces or hot-dip galvanized after the
channels are cut to length. Coated supports shall be coated with fusion bonded epoxy resin applied by the fluidized bed method. Thickness of the coating shall be not less than 10 mils. Surface preparation and coating application shall be in accordance with the epoxy manufacturer's instructions. The coating shall be pinhole free when tested with a low voltage holiday detector set at no more than 100 times the mil thickness of the coating. All pinholes shall be marked, repaired and retested to ensure a pinhole free film. The coating material shall be a 100 percent solids, thermosetting, fusion-bonded, dry powder epoxy resin. The manufacturer shall certify that the material is suitable for fluidized bed application and that it is approved by the Environmental Protection Agency. A PTFE pad shall be installed between the pipe and the u-bolt.

2.5.4.2 Adjustable Pipe Supports

Adjustable pipe supports shall consist of a cast iron saddle and a threaded nipple connected to a carbon steel pipe by means of a special reducer conforming to MSS SP-69. The supports shall be provided with PTFE insulation strips.

2.5.4.3 Low Friction Supports

Low friction supports shall be self-lubricating antifriction element composed of reinforced PTFE. Units shall be factory designed and manufactured.

2.5.4.4 Concrete and Grout

Concrete and grout for anchors and supports shall comply with SECTION 03 30 00 CAST-IN-PLACE CONCRETE.

2.5.5 Sample Connections

a. Sample connections shall be factory assembled units specifically designed for obtaining representative samples from fuel pipelines. Each connection shall include a 1/4-inch sampling probe where the probe faces upstream, ball valve and 1/4-inch quick disconnect coupling with dust plug, all assembled into a unit that is suitable for installation in a pipe nipple. The sampling probe shall extend not less than one inch into the fuel pipe. All materials in the sample connections shall be stainless steel or aluminum.

b. Furnish two sampling hose assemblies to the Contracting Officer at the project site. Each assembly shall consist of a 6-foot length of 1/4-inch clear plastic tubing with internal bonding/grounding wire. One end of the tubing will contain a male connector that actuates flow when inserted into the quick disconnect coupler. Each end of the bonding/grounding wire shall be equipped with clips for attaching to the pipe and metal sample container.

2.5.6 Flanged Swivel Joints

Flanged swivel joints shall be stainless steel, single plane, capable of rotating 360 degrees. Welded swivel joints and welding of swivel joints to the pipe and/or elbow is not permitted. Swivel joints shall be of the non-lubricated, maintenance free type with nonlubricated bearings and no lubricating fitting. Swivel joint shall be flanged at the end connecting to the piping system and threaded (female NPT) at the end connecting to the fuel hose. No leakage shall be permitted under positive or negative
pressure conditions. No leakage shall be permitted under high or low temperature conditions. Welding of swivel joint to six-bolt flange connector is permitted. The swivel joints shall be warranted for three years against leakage. There must be electrical continuity from one flange to the other without the use of ground straps. The electrical continuity from one flange to another (without the use of ground straps) shall be less than 1000 ohms. Each swivel joint shall have at least two ball bearings and one roller bearing and two seals.

2.5.7 Monitoring Points

At the following locations, provide half-inch pipe, flanged ball valve, and blind flange for future test equipment connections:

a. On the filter separator discharge header in the pumphouse.

b. At the Hydrant Hose Truck Checkout, inlet to Hydrant Valve.

c. At the inlet to the Back Pressure Control Valve in the Pumphouse.

d. At both sides of the isolation valve in all the isolation valve pits.

2.5.8 Quick Disconnect Adapters

Provide a male cam-and-groove style adapter of stainless steel. Process connection shall be flanged or threaded. Provide with a dust cap and Buna-N seal.

2.5.9 Quick Disconnect Couplers

Provide a female cam-and-groove style coupler of stainless steel. Process connection shall be flanged or threaded. Provide with a dust plug and Buna-N seal.

2.5.10 Nozzle Adapter (SPR)

Adapter shall be a nominal 2-1/2 inches with self-closing valve in accordance with MIL-A-25896. Adapter shall have a 4-inch flange mounting and vacuum tight, locking dust cap using the SPR lugs.

2.6 FLEXIBLE CONNECTORS

Flexible hoses for fueling pumps shall have ANSI Class 300 flanges to mate to the pump and Class 150 to connect to the system flanges of stainless steel construction conforming to ASME B16.5. Flexible hoses shall be of stainless steel flexible metal hose consisting of an inner corrugated stainless steel tube with stainless steel braid cover. All components to be suitable for not less than 275 psig. Length and application of flexible hoses shall be per manufacturer's written recommendations.

2.7 AUTOMATIC AIR VENT

Unit shall have one-inch connections and automatically vent air under pressure, and prevent a vacuum when pressure drops below a positive pressure. As fuel fills the vent, a float shall rise and form a drip-tight closure. The unit pressure rating shall be a minimum of 275 psi. The float shall be stainless steel. Body and cover be carbon steel or ductile iron and be internally epoxy coated.
2.8 SURGE SUPPRESSOR TANK AND VALVE

The unit shall be fabricated from carbon steel, internally coated pressure vessel with a rubber bladder or a stainless steel diaphragm separating the fuel from the gas charge. The epoxy coating shall be in accordance with MIL-PRF-4556. The rubber bladder shall be molded synthetic nitrile rubber (Buna-N). The unit shall be constructed and labeled in accordance with ASME BPVC SEC VIII D1. The housing shall be designed for a working pressure of 275 PSIG. The gas precharge shall be dry nitrogen and shall have a pressure gauge, gas valve, and an adapter for field charging. Bladder precharge pressure shall be 80 PSIG. The connection to the piping system shall be Class 150 ANSI flange, size as indicated on the drawings. The connection shall have a check valve to provide unrestricted flow into the vessel and restricted flow from the vessel. The flange shall have a 1/2-inch NPT connection with a valve and adapter to relieve fluid pressure during gas recharging and to drain the vessel during removal. A charging assembly shall be provided. The surge control supplier shall furnish a service person trained to provide installation check-out assistance and to supervise operation and testing necessary to place the surge control system into service and to provide training on charging, recharging, and checking the surge suppressor.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 CLEANING OF PIPING

Keep the interior and ends of all new piping, affected by construction operations, thoroughly cleaned of foreign matter and water before and after being installed. Piping systems shall be kept clean during installation by means of plugs or other approved methods. When work is not in progress, open ends of piping and fittings shall be closed so that no water or other foreign substance will enter the pipes or fittings. Piping shall be inspected before placing into position. The interior of each length of pipe shall be cleaned after welding insuring that the interior of the piping is free of foreign matter when it is connected into the system.

3.3 TRENCHING AND BACKFILLING

Trenching and backfilling shall conform to Section 31 00 00 EARTHWORK, and the following bedding and backfill requirements. The pipe shall be laid in a bed of sand 6 inches deep, compacted in accordance with Section 31 00 00 EARTHWORK, paragraph "Backfilling and Compaction". Sand shall meet the requirements of Section 31 00 00 EARTHWORK, paragraph "Select Granular Material". The full length of each section of pipe without any protective covering shall be excavated to permit installation of the protective covering. Pipe that has the grade or joint disturbed after laying, shall be taken up and relaid. Pipe shall not be laid in water or when the trench or weather conditions are unsuitable for such work. After testing and application of protective covering to joints, sand backfill shall be placed and compacted around the pipe or protective coating to a depth of 1 foot above top of pipe. The remainder of the backfill shall be the same as for other types of pipe.
3.4 PIPING LAYOUT REQUIREMENTS

3.4.1 Pipe Fabrication

Fabricate piping to measurements established on the project site and position into place without springing or forcing. Make provisions for absorbing expansion and contraction without undue stress in any part of the system.

3.4.2 Interferences and Measurements

Provide offsets, fittings, and accessories required to eliminate interferences and to match actual equipment connection locations and arrangements. Verify measurements before commencing work. Submit discrepancies for clarification before proceeding with the installations to the Contracting Officer.

3.4.3 Space and Access

Keep piping, control tubing, which is not detailed close to structures and columns so as to take up a minimum amount of space. Ensure that access is provided for maintenance of equipment, valves and gauges.

3.4.4 Location

Do not place unions in locations that will be inaccessible after the completion of the work. Place unions on each side of equipment.

3.4.5 Piping and Equipment

Provide anchors where required to absorb or transmit thrust or eliminate vibration or pulsation. Provide hangers and supports near each change of direction. Select support components which do not restrict the movement of the pipe due to thermal expansion. Space hangers uniformly and arrange symmetrically.

3.4.6 Structural Support

Provide supplementary or intermediate steel or other structural members as required for transmission of loads to members forming part of the supporting structure.

3.4.7 Grade

Where profiles of piping lines are shown on the drawings, grade the line uniformly between changes in slope or direction. Maintain gradient to within ± 1/4 inch over the entire length of pipe. When backfilling has been completed to the top of the pipe, the pipe shall be surveyed at each joint, and logged by station number. Submit to the Contracting Officer for approval the survey final elevations before backfilling can continue.

3.4.8 Size Changes

Make changes in pipe size with reducing fittings. Do not use bushings. In lieu of welding reducing outlet tees for piping 2 inches and larger, welding branches suitable for 100 percent radiographic inspection may be used. Do not use weldolets unless specifically called out (labeled) on the drawings.
3.4.9 Direction Changes

Make changes in direction of pipes with long radius fittings. Provide special fittings when required. Do not make miter welds. Make odd-angle offsets with pipe bends or elbows cut to the proper angle.

3.5 WELDING

3.5.1 General

All joints, unless indicated otherwise, in carbon steel and stainless steel piping systems shall be welded. Welding of fuel pipe joints shall comply with Section 33 52 90.00 20 WELDING FOR POL SERVICE PIPING.

3.5.2 Tests

a. All steel pipe welds, except factory seam welds, including high point vent pipe and low point drain pipe, shall be site examined by radiographic methods to determine conformance to the paragraph "Standards of Acceptance". Socket welds and branch connections which cannot be radiographed shall be examined per ASME B31.3, paragraph 341.4.3. All of the socket welds shall be examined, except the socket welds on the non-pressurized drain lines in the pump shelter to the product recovery tank in which a minimum of 10 percent shall be examined, and 10 percent of the socket welded pipe on the tanks, and to the conformance of the paragraph "Standards of Acceptance".

b. The services of a qualified commercial or testing laboratory approved by the Contracting Officer shall be employed for testing of piping welds. The weld inspector shall have a minimum of two years experience in inspection of stainless steel piping and two years in commercial or military aircraft hydrant fueling systems, petroleum refineries, power generating plants, or chemical process plants. Costs of testing, including retesting or repaired welds, shall be borne by the Contractor.

c. Procedures for radiographic inspection shall be in accordance with NAVSEA T9074-AS-GIB-010/271 or ASTM E94. Weld ripples or surface irregularities that might mask or be confused with the radiographic image of any objectionable defect shall be removed by grinding or other suitable mechanical means. The weld surface shall be merged smoothly with the base metal surface.

3.5.3 Standards of Acceptance

Interpretation of test results and limitations on imperfections in welds shall comply with the requirements for 100 percent Radiography for the circumferential butt welds, and visual examination for the welds that cannot be radiographed, per ASME B31.3, Chapter IX, Table K341.3.2.

3.5.4 Corrections and Repairs

Defects shall be repaired in accordance with approved procedures. Defects discovered between passes shall be repaired before additional weld material is deposited. Whenever a defect is removed and repair by welding is not required, the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is thought to have been removed, and prior to rewelding, the area shall be examined by suitable methods to insure that the defect has been eliminated. After repairs have been made, the repaired area shall be
reinspected and shall meet the standards of acceptance for the original weld. Any indication of a defect shall be regarded as a defect unless reevaluation by nondestructive methods and/or by surface conditioning shows that no defect is present.

3.5.4.1 Defect Removal

Defective or unsound weld joints shall be corrected by removing and replacing the entire weld joint, or for the following defects corrections shall be made as follows:

a. Excessive Convexity and Overlap: Reduce by removal of excess metal.

b. Excessive Concavity of Weld, Undersized Welds, Undercutting: Clean and deposit additional weld metal.

c. Excessive Weld Porosity, Inclusions, Lack of Fusion, Incomplete Penetration: Remove defective portions and reweld.

d. Crack in Weld or Base Metal: Remove crack throughout its length, including sound weld metal for a distance of twice the thickness of the base metal or 2 inches, whichever is less, beyond each end of the crack, followed by the required rewelding. Complete removal shall be confirmed by magnetic particle inspection for carbon steel or liquid penetrant inspection for stainless steel. Inspection procedures shall comply with the requirements of ASME B31.3.

e. Poor Fit-Up: Cut apart improperly fitted parts, and reweld.

3.5.4.2 Methods of Defect Removal

The removal of weld metal or portions of the base metal shall be done preferably by chipping, grinding, sawing, machining, or other mechanical means. Defects also may be removed by thermal cutting techniques. If thermal cutting techniques are used, the cut surfaces shall be cleaned and smoothed by mechanical means. In addition, at least 1/8-inch of metal shall be removed by mechanical means from the cut surfaces of stainless steel.

3.5.4.3 Rewelding

Repair welds shall be made using an electrode or filler wire preferably smaller than that used in making the original weld. Rewelding shall be done using qualified welding procedures. The surface shall be cleaned before rewelding. Repair welds shall meet the requirements of this specification.

3.5.4.4 Peening or Caulking

The use of force (peening) or foreign materials to mask, fill in, seal, or disguise any welding defects shall not be permitted.

3.6 INSTALLATION

3.6.1 Precautions

Take special care to ensure that the protective coating on buried pipe is not damaged during installation and that the completed system is free of rocks, sand, dirt, water, weld slag, and foreign objects including
construction debris. Take the following steps to ensure these conditions.

a. Coated pipe shall be handled only with canvas or nylon slings or padded clamps. Any coating damaged by improper handling or storage shall be repaired as specified.

b. Pipe brought to the site shall be stored on blocks or horses at least 18 inches above the ground and adequately supported to prevent sagging. Padded blocks or horses shall be used for coated pipe. The method and height of storing coated pipe shall be in accordance with the coating manufacturer's instructions. Pipe ends shall be protected and capped against weather at all times, except to accommodate immediate installation.

c. Visual inspection shall be made of the inside of each length of pipe to ensure that it is clear and clean prior to installation.

d. The open ends of the pipe system shall be closed at the end of each day's work or when work is not in progress by use of expansion plugs and shall not be opened until the work is resumed.

e. A swab, with a leather or canvas belt disc to fit the inside diameter of pipe, shall be pulled through each length of pipe after welding in place.

f. Obstruction remaining in the pipe after completion of the system shall be removed at the expense of the Contractor.

g. Plasma cutters and torches are not to be used to make penetrations in the pipe or to cut pipe.

h. After installation and backfill of the hydrant loop is complete and before fuel is put in the pipe, the pipe will be cleaned using foam swabs and poly coated wire brush pigs and compressed dry gas, residual humidity of not over 20 percent. Ten flights of a combination of swab and brush pigs shall be run. During this, low point drains and high point vents shall be blown clean.

3.6.2 Protective Coatings

3.6.2.1 Application of Tape Wrapping

Surfaces to receive tape shall be clean, dry, grease-free and dust-free. Extruded polyethylene coating and adhesive undercoat surfaces to be tape wrapped shall be primed with a compatible primer prior to application of the tape. The primer shall be as recommended by the tape manufacturer and approved by the extruded polyethylene coating manufacturer. Weld beads shall be wire brushed. Burrs and weld spatter shall be removed. Weld beads shall be covered with one wrap of tape prior to spiral wrapping. Fittings shall be wrapped spirally beginning with one complete wrap three inches back from each edge of the extruded polyethylene coating. For pipe less than four-inch size, one layer half-lapped shall be used. For pipe 4-inch size and larger, two layers half-lapped shall be used, with the second layer wrapped opposite hand to the first. On irregular surfaces one layer shall be applied half-lapped and stretched to conform to the surface, followed by a second layer half-lapped and applied with the tension as it comes off the roll.
3.6.2.2 Inspection and Testing

The condition of factory field coated and wrapped piping shall be the responsibility of the Contractor and all damage to the protective covering during transit and handling shall be repaired at no additional cost to the Government. All field coating and wrapping shall be subject to approval by the Contracting Officer. The entire pipe shall be inspected as specified in sub-paragraph "Testing of Protective Coatings" under paragraph "Protective Coatings for Buried Steel Piping." The inspection for holidays shall be performed just prior to lowering the pipe into the ditch and every precaution shall be taken during lowering and backfilling to prevent damage to the protective covering.

3.6.2.3 Damage Repair

Damaged areas of extruded polyethylene coating shall be repaired by tape wrapping as specified in the preceding paragraph for fittings. Residual material from the extruded polyethylene coating shall be pressed into the break or shall be trimmed off; all areas to be taped shall be primed, and the tape shall be applied half-lapped.

3.7 INTERIOR EPOXY COATING

When internally epoxy lined pipe is cut, the lining shall be ground back from the end a minimum of one inch but not more than 1-1/2 inches.

3.8 INSTALLATION OF UNDERGROUND PIPE

Underground fuel pipelines shall be pitched as shown on the drawings. Where not indicated they shall be pitched a minimum of 2 inches per 100 feet. Branch lines to the hydrant pits shall slope up to the pit. 2-inch pipe size valved drain connections shall be provided at all low points and 1-1/2-inch pipe size valved outlet vent connections shall be provided at all high points. Vent and drain lines shall terminate in male cam-type locking end connectors with matching female dust covers and installed in pits. The pipe shall have cover as shown on the drawings. Drain lines shall be installed at the slopes indicated.

3.8.1 Pipe Assembly

Pipe shall be strung parallel and adjacent to or above a trench. The pipe shall be supported on padded skids during welding and inspection of joints. Protective coating shall be inspected and repaired prior to lowering the pipe into the trench. The pipe shall be lowered using only canvas or nylon slings. The sling shall be dug from underneath the pipe after placements and shall not be pulled from underneath the pipe while in contact with it. Care shall be taken to prevent damage to the pipe, welded joints or coating and any such damage shall be repaired as directed by the Contracting Officer. Pressure testing of the pipe shall be done after it has been placed in final position in the trench.

3.8.2 Warning Tapes in Earth Trenches

For the purpose of early warning and identification of buried pipes outside of building walls during future trenching or other excavation, continuous identification tapes shall be provided in the trench. Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured for the purpose of early warning and identification of utilities buried below the tape. Tape shall be at least
3 inches in width. Color of tape shall be as standard with the manufacturer with respect to the type of utility buried below the tape. Tape shall have lettering at least 1 inch high with warning and identification imprinted in bold black letters continuously over the entire tape length with not less than the following identification on the tape: BURIED JET FUEL PIPING BELOW. Tape shall be installed in accordance with the printed recommendations of the tape manufacturer, as modified herein. Tapes shall be buried at a depth of 6 inches from the top of the subgrade or 12 inches below the top surface of earth. Provide permanent color and printing, unaffected by moisture or soil.

3.8.3 Clearances

Install pipe to be clear of contact with other pipes, pipe sleeves, casings, reinforcing steel, conduits, cables, or other metallic structures. Where pipes cross other pipes or structures with a separation of less than 6 inches, install an insulating separator. Protect the pipe from contact with a 12-inch square by 1-inch thick bituminous-impregnated canefiber board.

3.8.4 Protective Coating

When the protective coating on pipe is damaged, the Contracting Officer shall be notified and shall inspect the pipe before the coating is patched. If the damage to the pipe is deeper than 0.050 inch, the damage shall be repaired by welding in accordance with paragraph "WELDING". If the pipe is dented, out of round or damaged to the point that welding will not make it good as new, the length of pipe shall be rejected.

3.9 TESTING

Piping shall be tested by pneumatic and hydrostatic pressure. Testing shall comply with applicable requirements of ASME B31.3, NFPA 30, and the requirements specified herein. Hydrostatic testing shall be performed using fuel as the liquid. Water shall not be introduced into the system for testing. Pressure and hydrostatic testing shall be performed only after welding inspection has been completed.

3.9.1 Pneumatic Test

Piping to be installed underground shall not receive field applied protective covering at the joints or be covered by backfill until the piping has passed the pneumatic test described herein. To facilitate the tests, isolate various sections of the piping system and test each one separately. Where such sections terminate at flanged valve points, the line shall be closed by means of blind flanges in lieu of relying on the valve. Furnish tapped flanges that can be attached to the end of the section of line being tested, and that will permit a direct connection between the piping and the air compressor and/or pressurizing pump. No taps in the permanent line will be permitted. Furnish all necessary equipment for testing; all gauges shall be subject to testing and approval of the Contracting Officer. The air used for pneumatic testing shall have a residual humidity of not over 20 percent. Provide dehumidifying equipment on the suction or discharge side of the air compressor used to provide air for testing. Pressurizing pump shall not exceed 10 cfm.

3.9.1.1 Pneumatic Test Procedure

Special safety measures, including the wearing of face mask, shall be taken
during testing under pressure. Only authorized personnel shall be permitted in the area during testing. The pneumatic test pressure shall be applied in increments. A preliminary 25 psig test shall be applied. Examine joints with soap solution. Leaks revealed by this test shall be repaired. The full test pressure shall then be applied. Unless otherwise directed by the Contracting Officer, all piping shall be tested at a pressure of 50 psig for not less than 2 hours, during which time there shall be no drop in pressure, only pressure rises with temperature. The pressure source shall be disconnected during the final test period. Any leaks revealed by the test shall be repaired and the test repeated.

3.9.1.2 Hydrostatic Test

Upon completion of pneumatic testing and after backfilling, hydrostatically test each piping system with fuel at 355 psig in accordance with ASME B31.3 and API RP 1110, with no leakage or reduction in gauge pressure for four hours. Furnish electricity, instruments, connecting devices, and personnel for test. Fuel shall be furnished by the Government. Defects in work shall be corrected at the Contractor's expense, and the test repeated until the work is proven to be in compliance with the Contract requirements.

3.9.2 Performance Testing

The completed fuel system shall be cleaned and performance tested as specified in Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START UP. All control valves, both manual and automatic, shall be checked for leaks (any area wetted with fuel) and proper operation and adjusted, repaired or replaced to correct any defects.

3.10 PIPELINE PIGGING VERIFICATION

3.10.1 Geometry Tool Reports

After the system is installed and prior to performance testing, a field/preliminary report shall be issued and a debrief given to Government personnel onsite on the condition of the fuel hydrant loop. This shall be comprised of raw data in the form of a PC download or equivalent which shows a continuous scan of each data unit output. Results of a preliminary interpretation of the data shall be reported. These shall include as a minimum all critical anomalies. A final report shall include a description of the principle of operation, explanation of raw data, presentation of raw data, data to be clearly marked with distance traveled scale with classified anomaly location and all identifiable pipeline features, and all anomalies to be classified with locations in summary tabular form.

3.10.2 Workmanship

Verify pipe bend radii at pipe locations between pig launchers and receivers. If a pipe bend is less than 3D, replace the bend.

3.10.3 Pipeline Internal Inspection Operations

3.10.3.1 General

The following pigs will be propelled through the pipeline with product in order to inspect the pipeline: 5 pound density foam swab, combination poly scraper-magnetic, stainless steel wire brush, aluminum plate gauge, and geometry tool. Tracking devices shall be used on all pigs. At a minimum, the sequence of pig runs shall be as follows: 1) foam swab for proving and
cleaning, 2) wire brush for cleaning, 3) scraper-magnetic for cleaning, 4) aluminum plate gauge for gauging internal anomalies, 5) scraper-magnetic for cleaning, 6) wire brush for cleaning, 7) scraper-magnetic for cleaning, 8) foam swab for cleaning, (Note: the number of pig flights of each type of cleaning pigs shall be determined by the amount and type of debris removed. The conclusion of the cleaning process shall be when debris recovered is only that from the pigs themselves. This determination will be determined by the project's system supplier and the Contracting Officer), 9) geometry tool. The pipe wall shall be continuously monitored on a real-time basis during the geometry pig run. Anomalies such as patches, couplings, or flanges shall also be identified, and the wall thickness given. The geometry pig's technician will determine if additional runs are necessary. A permanent data set of internal inspection survey findings shall be generated.

3.10.3.2 Preparatory Work

The Government will bring to the attention of the Contractor all statutes, rules and regulations relevant to the performance of the work on the site (on Government property) and will also provide the Contractor with a copy of its own site regulations (if any). Provide the pigging vendors with all-available pipeline records and drawings.

3.10.3.3 Pig Load And Launch

The pig shall be loaded into the temporary pig launcher by the Contractor. The method of loading and lodging the front pig cup into the launcher shall not involve the use of uncontrolled mechanical force applied to the rear of the pig. The Contractor shall provide temporary pig launcher and receiver that will be removed upon completion and acceptance of the fueling hydrant system.

3.10.3.4 Pipeline Operation During Pigging

All pig runs shall be made with the line packed with product. The system pumps will be used to propel the pig. The pig traps will be used for pig launch and retrieval.

3.10.3.5 Brush and Gauging Survey

Run a brush pig at least as often as previously indicated. The brush pig shall be designed and provided by the geometry pig vendor. Additional runs may be required based upon the amount of debris found in the pipeline. The onsite geometry pig vendor's personnel shall determine if additional runs are required. Immediately following the brush pig run and immediately prior to the geometry survey, run, as a minimum, a single batching pig fitted with a gauge plate equal to 90 percent of the pipeline normal inside diameter. The plate is to be a segmented aluminum disk of 1/8 inch thickness. The plate gauge pig shall also include a tracker and tracking equipment. Track the pig assembly above ground during the operation.

3.10.3.6 Geometry Survey

After a satisfactory gauging pig run, the pipeline geometric defects shall be determined by a geometry tool. The geometry tool shall provide accuracy geometric anomaly detection, and bend radius measuring capability. The data obtained shall be presented in a PC software format to allow user friendly analysis and presentation. The geometry tool assembly shall be capable of:
C-17 Type III Fuel System & Ramp Expansion
145th Airlift Wing, North Carolina Air National Guard

- Operating in hydrocarbon liquid environment, specifically jet fuel, at a pressure of up to ANSI 300 rating.
- Traversing the pipeline with nominal wall thickness and possible bore restrictions down to 90 percent of nominal pipe inside diameter.
- Traversing the pipeline length at a speed of between 3 and 5 ft/sec when propelled by pumped jet fuel. Pressure differential across pig not to exceed 50 psi.
- Traversing through smooth pipe bends as small as 3D (3 pipe diameters) radius and single miter bends of up to 10 degrees change of direction.
- Include a tracker and tracking equipment. Track the pig assembly above ground during the operation. The battery life of the tracker shall not be less than 72 hours.
- Manual loading into the new horizontal pig trap.

The geometry tool assembly instrumentation performance shall be capable of:

- Battery life to be minimum 18 hours at operating conditions.
- Principle of operation to be electronically stored geometry system.
- Geometry sensing to span full circumference and length of pipe, with associated distance measuring method.
- Geometry system shall be capable of:
  - (1) positive location and identification of each geometric anomaly.
  - (2) positive location and identification of each bend.
  - (3) positive location and identification of distance marker reference points of either magnetic or electronic type placed on or above the pipe.
- Classification of geometric anomalies to be as minimum:
  - (1) discrimination between ovality and intrusion anomalies.
  - (2) mechanical damage such as mill defects, dents, internal gouges, and buckles.
  - (3) pipeline weld defects (such as excess weld penetration).
  - (4) geometric thickness anomalies. As a minimum, these shall be reported in the following categories within the listed accuracy.
    - (a) magnitude of anomaly (+/- 1 inch);
    - (b) span of anomaly (+/- 1 inch);
    - (c) ovality (+/- 0.1 inch);
    - (d) span of ovality (+/- 1 inch);
3.10.3.7 Pipe Wall Thickness Survey

After a satisfactory cleaning, gauging, and geometry pig run, the pipeline wall thicknesses shall be determined using an ultrasonic testing tool. The tool shall provide accuracy measurement of pipe wall thickness (+/- 0.01 inch). The data obtained shall be presented in a PC software format to allow user friendly analysis and presentation.

3.10.3.8 Lost Pig

The Contractor is responsible for a lost pig, finding the pig, retrieval of the pig, and all repairs, radiographs to the pipeline system and the pig.

-- End of Section --
PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASME INTERNATIONAL (ASME)

ASME B16.24 (2011) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500


ASME BPVC SEC VIII D1 (2015) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A194 (2016) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both


ASTM D751 (2006; R 2011) Coated Fabrics
1.2 ADMINISTRATIVE REQUIREMENTS

Design conditions shall be as specified in Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT. Components shall be suitable for ASME Class 150 (275 psig at 100 degrees F).

a. Control valves specified herein shall be of one manufacturer. The valve manufacturer shall also produce the hydraulically-operated pilots. For each type control valve required and specified, submit the following:

(1) Flow diagrams.

(2) Operational description of the control valve and pilot control system.

(3) Complete valve assembly list of materials, along with material Certificates of Conformance, used in the manufacture of the control valves and pilot systems.

(4) Sectional drawings of main valve and control pilot systems.

b. Before shipment, each individual control valve shall be operationally tested and adjusted by manufacturer under actual flow conditions utilizing a hydrocarbon test fluid with a specific gravity comparable to F-24 fuel. Manufacturer shall submit certified records of test data.

c. Operation and maintenance information shall be submitted for each individual type control valve specified herein. Refer to Section 01 78 23.33 OPERATION AND MAINTENANCE MANUALS FOR AVIATION FUEL SYSTEMS for the information to be submitted.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
High Liquid Level Shut-Off Valve (HLCV-1 Thru HLCV-3); G
High Level Float Pilot; G
Non-Surge Flow Control Valve (FCV-1 Thru FCV-4); G
Filter Separator Control Valve (FSCV-1 Thru FSCV-5); G
Water Slug Float Control Pilot; G
Back-Pressure Control Valve (BPCV-1); G
Overfill Prevention Valve (OV-1); G
Pressure Control Valve (PCV-1); G
Hydrant Control Valve (HCV-1 Thru HCV-6); G

SD-03 Product Data
High Liquid Level Shut-Off Valve (HLCV-1 Thru HLCV-3); G
High Level Float Pilot; G
Non-Surge Flow Control Valve (FCV-1 Thru FCV-4); G
Filter Separator Control Valve (FSCV-1 Thru FSCV-5); G
Water Slug Float Control Pilot; G
Back-Pressure Control Valve (BPCV-1); G
Overfill Prevention Valve (OV-1); G
Pressure Control Valve (PCV-1); G
Hydrant Control Valve (HCV-1 Thru HCV-6); G

SD-06 Test Reports
High Liquid Level Shut-Off Valve (HLCV-1 Thru HLCV-3); G
High Level Float Pilot; G
Non-Surge Flow Control Valve (FCV-1 Thru FCV-4); G
Filter Separator Control Valve (FSCV-1 Thru FSCV-5); G
Water Slug Float Control Pilot; G
Back-Pressure Control Valve (BPCV-1); G
Overfill Prevention Valve (OV-1); G
Pressure Control Valve (PCV-1); G
Hydrant Control Valve (HCV-1 Thru HCV-6); G
SD-07 Certificates

Previous Air Force/Military Projects
Qualified Engineers
Field Assistance

SD-10 Operation and Maintenance Data
High Liquid Level Shut-Off Valve (HLCV-1 Thru HLCV-3)
High Level Float Pilot
Non-Surge Flow Control Valve (FCV-1 Thru FCV-4)
Filter Separator Control Valve (FSCV-1 Thru FSCV-5)
Water Slug Float Control Pilot
Back-Pressure Control Valve (BPCV-1)
Overfill Prevention Valve (OV-1)
Pressure Control Valve (PCV-1)
Hydrant Control Valve (HCV-1 Thru HCV-6)

1.4 QUALITY ASSURANCE

1.4.1 Field Assistance

Provide the following:

a. Proof of experience on previous Air Force/Military projects.

b. Number of qualified engineers (factory trained) available to provide startup support.

c. Written assurance as to ability to respond to specified time for field assistance.

1.4.2 Training

The manufacturer shall conduct two eight hour training classes for Liquid Fuels Maintenance Technicians which include valve overhaul procedures, pilot overhaul procedures, valve adjustments, and valve diagnostics. The manufacturer shall provide a 4-inch valve mock-up with various trim components (i.e., rate of flow, solenoid control, and speed control features) to be used during training. Video taping of training shall be allowed or provided at the time of the class, and an attendance roster maintained by the Contractor. The 4-inch valve mock-up shall become the property of the Government and shall be turned over to the Contracting Officer. Submit copies of the Operation and Maintenance Manuals for approval.

1.5 WARRANTY

If a problem attributable to the valve's manufacturer or installation
arises after the initial system start-up has been accomplished, and after system final acceptance date, 48 hours from the time of notification that a problem exists is allowed to solve the problem. The problem shall be solved to the satisfaction of the Contracting Officer, the Base Civil Engineer and/or the Command Fuel Facilities Engineer. If the Contractor cannot effectuate a proper resolution to the problem as outlined above in the 48 hour period, provide a factory trained engineer from the manufacturer of the valve within 48 hours after the expiration of the Contractor's initial 48 hour period to effectuate a resolution of the problem above. All services provided by the valve manufacturer shall be at no cost to the Government. When it has been determined by the Contractor, Contracting Officer, and the valve manufacturer's representative that the valve(s) cannot be repaired in its installed position in the fuel system, it shall be replaced with a new valve and pilot assembly within 48 hours after the initial 96-hour period listed above expires and at no cost to the Government.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 MATERIALS AND EQUIPMENT

The type of materials which come in contact with the fuel, if not specified herein before, shall be noncorrosive.

2.3 CONTROL VALVES

2.3.1 General

Control valves shall be single-seated globe type, diaphragm actuated, hydraulically operated valves. Valves shall consist of 3 major components: The valve body, valve cover, and diaphragm assembly. The diaphragm assembly shall be the only moving part. In the event of diaphragm failure, valve shall fail closed against flow, unless otherwise indicated. The main valve shall be drip-tight when closed. Each valve shall have an external indicator to show the position of the valve disc at all times. Control valves shall be shipped from the factory as a complete assembly with all pilot controls and pilot auxiliary piping properly installed on the main valve. Materials which come in contact with the fuel shall be resistant to the effects of and not harmful to aircraft engine fuel and shall be stainless steel, or electroless nickel plated ductile iron unless noted otherwise. Materials for control valves, and items to be mounted on the valves shall be as follows:

2.3.1.1 Bodies, Bonnets, and Covers

Shall be constructed of one of the following materials:

a. Cast steel conforming to ASTM A216, Grade WCB internally plated with chromium, nickel or internally electroless nickel plated.
b. Cast stainless steel conforming to ASTM A743.

c. Ductile iron conforming to ASTM A536, electroless nickel plated.

d. Bodies shall have flanged inlet and outlet connections. Valve shall have a screwed bottom drain plug.

2.3.1.2 Valve Seats

Valve seats shall be stainless steel in accordance with ASTM A743. It shall be possible to remove the valve seat while the valve is connected in the line. Valve seat and upper stem bearing shall be removable and screwed in the body and/or cover. The lower stem bearing must be concentrically contained in the valve seat and shall be exposed to flow on all sides. The diameter of the valve seat shall be the same size as the inlet and/or outlet flanges of the main valve.

2.3.1.3 Valve Discs

Valve discs shall contain a resilient, fluororubber (FKM), commonly referred to as Viton disc conforming to SAE AMS 3216 having a rectangular cross section, contained on 3.5 sides by a disc retainer and a disc guide, forming a drip tight seal against the seat. The disc shall be usable on either side. The disc guide shall be the contoured type capable of holding disc firmly in place during high differential pressure conditions that may develop across the seating surface. The disc retainer shall be capable of withstanding rapid closing shocks.

2.3.1.4 Diaphragm Assembly

Diaphragm Assembly shall form a sealed chamber in the upper portion of the valve, separating the operating fluid from the line pressure. The diaphragm assembly shall contain a valve stem which is fully guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. Valve body and cover shall be sealed by the diaphragm. Valve stem shall be stainless steel. The bearing material shall be compatible with the fuel specified and shall not contain zinc coated metals, brass, bronze, or other copper bearing alloys. The diaphragm shall be of a nonwicking material or design, with a minimum of 2 layers of nylon fabric bonded with a minimum of 3 layers of synthetic rubber (valves 2-1/2 inches and smaller one layer of nylon fabric). The edge area of the center hole for the valve stem shall be sealed by vulcanization. Materials to be resistant to aromatics of up to 50 percent in accordance with ASTM D2000 (SAE J200). The diaphragm must have a MULLINS-burst rating according to ASTM D751 of a minimum of 600 psi per layer of nylon fabric. All diaphragm sizes must be cycle tested to a minimum of 100,000 cycles, by alternately applying pressure under the diaphragm (main valve pressure) and above the diaphragm (cover chamber pressure). That test shall be certified by the manufacturer. The diaphragm shall not be used as a seating surface. The diaphragm must be fully supported by the body and cover in either the open or closed position.

2.3.1.5 Bolts, Screws and Nuts

a. For Ductile Iron, and Cast Steel Body Valves.

(1) Bolts and Screws, cadmium plated steel in accordance with SAE J429, Grade 5.
(2) Nuts, cadmium plated steel in accordance with ASTM A194, Grade 2 H.


2.3.1.6 Pilot Control System and Auxiliary Piping

Pilot Control System and auxiliary piping shall be stainless steel, seamless, fully annealed tubing conforming to ASTM A269, Grade TP316, Rockwell hardness B80 or less. Wall thickness for 1/2-inch tubing to be 0.049-inch. Threaded connections shall be used in pilot system piping and shall be o-ring type with FKM o-rings. Tubing connections shall not be welded.

2.3.1.7 Pilot Valves

Pilot valves shall have stainless steel bodies conforming to ASTM A743 with stainless steel internal working parts. Disc and diaphragm assemblies shall be as specified herein before. The setting of adjustable type pressure operated pilot valves shall be easily adjusted by means of a single adjusting screw. The adjusting screw shall be protected by a threaded cap drilled to accommodate a lead-seal wire and a lock nut shall be provided on the adjusting screw to lock it in position at the desired setting. The lead seal wire shall be installed after final acceptance of the system. Spare wire seals and the "embossing" tool will be turned over to the Contracting Officer for the LFM shop.

2.3.1.8 Solenoids

Solenoids for operation of pilot valves shall be housed in an explosion-proof case suitable for Class I, Division 1, Group D with maximum temperature rating of T2D (419 degrees F), hazardous locations as defined in NFPA 70. Solenoids shall operate on 120 volts, 60 cycle, single phase, alternating current. A manual type operator or needle valve to bypass the solenoid valve shall be provided for emergency manual operation.

2.3.2 Serviceability of Main Valve Internal Parts

Main valve movable parts including strainers, valve seat, stem bearings, and control system shall be replaceable without removing the main valve from the line. All nonmetallic parts shall be replaceable.

2.3.3 Total Lengths

The total valve length does not include the orifice plate flange (when used). If the control valve being supplied has the orifice plate built into its flange, the spacer provided shall bring the valve face-to-face dimension equal to those listed below plus 0.0875 inch. The lengths of the valves shall be equal for the following materials: Cast stainless steel, cast steel, and ductile iron.

<table>
<thead>
<tr>
<th>SIZE inches</th>
<th>VALVE LENGTH inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2</td>
<td>8.5</td>
</tr>
<tr>
<td>2</td>
<td>9.375</td>
</tr>
</tbody>
</table>

SECTION 33 52 43.14 Page 7
<table>
<thead>
<tr>
<th>SIZE inches</th>
<th>VALVE LENGTH inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>25.4</td>
</tr>
<tr>
<td>10</td>
<td>29.8</td>
</tr>
<tr>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>14</td>
<td>39</td>
</tr>
<tr>
<td>16</td>
<td>41.375</td>
</tr>
</tbody>
</table>

Note: Tolerance shall be +0.03 inch for size 1-1/2 inches through 8 inches and +0.06 inch for size 10 thru 16 inches.

Control valves not meeting these face to face dimensions shall be supplied with spacers suitable for the proper installation of the valve.

2.3.4 Flanges

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>SEALING SURFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Steel, ASME B16.5 Class 150</td>
<td>Raised Face</td>
</tr>
<tr>
<td>Cast Stainless Steel, ASME B16.5, Class 150</td>
<td>Raised Face</td>
</tr>
<tr>
<td>Ductile Iron, ASME B16.24 Class 150</td>
<td>Flat Face</td>
</tr>
</tbody>
</table>

Note: The mating flange shall be made the same as above.

2.3.5 Identification

2.3.5.1 Main Valve Body

The following shall be cast into the main valve body:

a. Pressure Class.

b. Size.

c. Material.

d. Foundry Heat Number and Identification.

e. Manufacturer.

f. Flow Pattern.
2.3.5.2 Main Valve Cover

The following shall be cast into the main valve cover:

a. Size.
b. Material.
c. Foundry Heat Number and Identification.

2.3.5.3 Brass Name Plates

Brass name plates shall be fastened to the valve. Body name plates shall list the following:

a. Size.
b. Model Number.
c. Stock Number.
d. Manufacturer/Supplier.
e. Manufacturer's Inspection Stamp.

2.3.5.4 Inlet Name Plate

Inlet name plate shall list the following:

a. Size.
b. "Inlet" Marking.
c. Assembly Model Number.
d. Part Number.

2.3.5.5 Outlet Name Plate

Outlet name plate shall list the "Outlet" Marking.

2.3.5.6 Pilot Valves

Pilot valves shall be tag identified. The valve shall have the field adjusted start up setting engraved on a plastic tag, white with black lettering.

2.4 INDIVIDUAL CONTROL VALVE OPERATIONAL REQUIREMENTS

Operation, performance, and special features of the individual control valves shall be as specified herein.

2.4.1 High Liquid Level Shut-Off Valve (HLCV-1 Thru HLCV-3)

2.4.1.1 Size

8-inch.
2.4.1.2 Flow

1800 GPM.

2.4.1.3 Operation

High liquid level shut-off valve shall be hydraulically operated and shall be provided with a tank exterior mounted float. Activation point of the float for opening and closing the high liquid level shut-off valve shall be as shown on the drawings. Upon a rise in fluid level to the float activation point, the float control system shall cause the main valve to close tightly. The main valve shall remain closed until a drop in tank fluid level occurs. Upon a drop in fluid level beneath the float activation point, the float control shall cause the main valve to open completely.

2.4.1.4 Check Valve Feature

Valve shall close rapidly when outlet pressure exceeds inlet pressure.

2.4.1.5 High Level Float Pilot

Pilot shall be float actuated with an externally mounted liquid chamber. Float, pilot valve, and trim shall be stainless steel. Housing shall be cast steel. Provide with manual tester to actuate float pilot with tank liquid level below actuation point.

2.4.1.6 Manual Test Feature

Manual testing of high level shut-off valve and exterior mounted float's automatic opening and closing feature shall be possible.

2.4.1.7 Strainer

A 40-mesh stainless steel wire, self-cleaning strainer shall be provided in the pilot valve supply piping.

2.4.1.8 Pressure Sensitive Close Feature

If the upstream pressure rises to 150 psi or above while closing, the valve will stop closing or open slightly until the pressure is less than 150 psi.

2.4.1.9 Back Pressure Control Feature

Back pressure control feature shall modulate to maintain constant inlet pressure. Valve shall be adjusted as necessary to allow for proper operation of the high level control float. Set-point shall be adjustable with a range of 5 to 25 psig. Factory set at 10 psig.

2.4.1.10 Opening and Closing Feature

The valve shall be equipped with an adjustable differential pressure pilot and a quick cover exhaust system to allow the valve to open in 3-4 seconds when pressure is greater than 170 psig.

2.4.1.11 Solenoid Control

The valve shall be provided with solenoid control and shall operate as indicated.
2.4.1.12 Limit Switch

Limit switch shall be provided with valve for remote indication of valve open or closed position. Assembly shall be explosion proof, double pole double throw DPDT, rated for 120 volt, 15 amp service. Valve closed position will become an alarm condition on the pump control panel (PCP).

2.4.2 Non-Surge Check Valve (FCV-1 THRU FCV-4)

2.4.2.1 Size

6-inch; 2-inch for FCV-4.

2.4.2.2 Flow

950 GPM; 50 GPM for FCV-4.

2.4.2.3 Operation

Non-surge check valve shall open slowly. Opening speed shall be adjustable from two (2) to 30 seconds without affecting closing of valve. Factory set for 15 seconds. The nonsurge check valves shall fail closed against reverse flow in check condition.

2.4.2.4 Quick closure

Valve closure to be rapid, closing quickly when outlet pressure exceeds inlet pressure.

2.4.2.5 Flow Control

Valve to limit flow to 950 GPM (FCV-1 thru FCV-3), 50 GPM (FCV-4). Sensing shall be by orifice. Valve to modulate to limit flow without hunting. Rate of flow to be manually adjustable and utilize a downstream orifice plate holder.

2.4.2.6 Strainer

A 40-mesh, stainless-steel wire, self-cleaning strainer shall be provided in the pilot valve supply piping.

2.4.3 Filter Separator Control Valve (FSCV-1 Thru FSCV-5)

2.4.3.1 Size

6-inch.

2.4.3.2 Flow

900 GPM (FSCV-1 Thru FSCV-3); 900 GPM (FSCV-4 and FSCV-5).

2.4.3.3 Operation

Filter Separator Control Valve shall limit flow to 900 GPM (FSCV-4 and FSCV-5); 900 GPM (FSCV-1 Thru FSCV-3). Controlling to be by orifice. Rate of flow to be manually adjustable and utilize a downstream orifice plate holder.
2.4.3.4 Check Valve Feature

Valve shall close rapidly when outlet pressure exceeds inlet pressure.

2.4.3.5 Water Slug Shut-Off

Valve shall close rapidly when water is sensed at filter separator sump high level as indicated by Float Control Valve float position. Manual testing of operation shall be possible.

2.4.3.6 Shut-Off Feature at Maximum Differential Pressure

Valve shall close rapidly when differential control pilot increases to preset point. Resetting of the differential control pilot shall be manually reset after each shutoff.

2.4.3.7 Emergency Shut-off Operation

Open/closed valve, solenoid operated. Closure shall be accomplished within 10 seconds upon power failure or activation of an emergency-stop pushbutton.

2.4.3.8 Solenoid Control

Solenoid control shall be as indicated on the drawings.

2.4.3.9 Filter Separator Float Control Valve and Tester

2.4.3.9.1 Operation

Float shall ride on the fuel-water interface inside filter separator sump. Activation shall initiate water slug shutoff of filter separator valve.

2.4.3.9.2 Float Control Pilot and Tester

The filter separator housing sump shall be fitted with a float control pilot valve assembly made of stainless steel. The pilot valve is connected to the filter separator control valve. An integral float control tester shall provide a means to remove a portion of the float ball ballast allowing the float to rise, verifying operation of the water slug and flow control valve, and the integrity of the float ball.

2.4.4 Back Pressure Control Valve (BPCV-1)

2.4.4.1 Size

6-inch.

2.4.4.2 Flow

0-1800 GPM.

2.4.4.3 Operation

Back pressure control valve shall modulate to maintain constant inlet pressure. Set-point shall be adjustable with a range of 20 to 200 psig. Factory set at 110 psig, and 160 psig.
2.4.4.4 Check Valve Feature

Valve shall close rapidly when outlet pressure exceeds inlet pressure.

2.4.4.5 Solenoid Control

The valve shall be provided with 2 solenoid controls and shall operate as indicated on the drawings.

2.4.4.6 Speed Control

Valve shall close slowly without affecting the opening speed and shall be factory set for 8 seconds. Closing time shall be adjustable with a range of 2 to 30 seconds. Valve opening time shall be 1.0 second maximum.

2.4.4.7 Opening Feature

The valve shall be equipped with cover quick exhaust system to allow the valve to open in 3-4 seconds when pressure is greater than 170 psig.

2.4.5 Pressure Control Valve (PCV-1)

2.4.5.1 Size

2-inch.

2.4.5.2 Flow

50 GPM under normal operating conditions.

2.4.5.3 Operation

Pressure control valve shall modulate to control inlet pressure and shall have adjustable set-point with ranges of 20 to 200 psig. Factory set at 75 psig, and 50 psig.

2.4.5.4 Check Valve Feature

Valve shall close rapidly when outlet pressure exceeds inlet pressure.

2.4.5.5 Solenoid Control

The valve shall be provided with 2 solenoid controls and shall operate as indicated on drawings.

2.4.5.6 Speed Control

Provide separate opening and closing speed controls each adjustable between 1 and 30 seconds. Factory set at 3 seconds for opening speed and 1 second for closing speed.

2.4.6 Defuel/Flush Valve (D/FV-1)

2.4.6.1 Size

8-inch.
2.4.6.2 Flow

300 to 1800 GPM.

2.4.6.3 Operation

Valve shall modulate to control inlet pressure and shall have adjustable set-point with a range of 20 to 200 psig. Factory set at 80 psig.

2.4.6.4 Check Valve Feature

Valve shall close rapidly when outlet pressure exceeds inlet pressure.

2.4.6.5 Solenoid Control

The valve shall be provided with 2 solenoid controls and shall operate as indicated on drawings.

2.4.6.6 Speed Control

Valve shall open slowly without affecting the closing speed and shall be factory set for 3 seconds. Opening time to be adjustable with a range of 2 to 30 seconds.

2.4.7 Hydrant Control Valve (HCV-1 Thru HCV-6)

2.4.7.1 Size

6-inch.

2.4.7.2 Flow

900 GPM.

2.4.7.3 Operation

Hydrant control valve shall modulate, by use of a liquid sensing line from refueeler venturi, and regulate at a maximum pressure at the skin of the aircraft of 45 psig at any flow rate from 50 to 900 GPM. Pressure to be adjustable with a range of 15 to 75 psi. Valve, adapter, and 90-degree hydrant coupler pressure drop shall not exceed 18.5 psi at 900 GPM with the valve fully open.

2.4.7.4 Quick Closure

Valve shall close rapidly when outlet pressure exceeds control set-point. Valve shall limit the surge pressure on the aircraft to a maximum of 120 psig when fueling at 900 GPM with an aircraft tank valve closure of 0.8 second. The valve shall reopen when the outlet pressure drops below the set-point of the pilot if the deadman control lever is still depressed.

2.4.7.5 Deadman Control

Deadman shall be pneumatically connected to the pilot system of main valve. Valve shall open when deadman control lever is pressed and shall close valve when the lever is released to bleed air from the hydrant hose truck. On rupture of the deadman hose between outlet of deadman control and main valve pilot system, there shall be no fuel leakage. Main valve shall close in 5 seconds maximum when deadman is released or when one of
the deadman hose couplers is disconnected.

2.4.7.6  Defuel

Valve shall be capable of reverse flow at the rate of 300 GPM at 165 psig. Valve shall be capable of defueling regardless of nozzle pressure created by the R-12.

2.4.7.7  Speed Control

Valve shall open slowly without affecting the closure rate. Provide adjustable speed control with a range of 2 to 30 seconds.

2.4.7.8  Thermal Relief

Valve to open for pressure equalization and return flow when downstream pressure exceeds upstream pressure.

2.4.7.9  Adapter

Valves shall be provided with type adapter as indicated on drawings. Adapter shall have pressure equalizing feature and have a vacuum tight dust cap.

2.4.7.10  Strainer

A 40-mesh stainless steel wire, self-cleaning strainer shall be provided in the pilot valve supply piping.

2.4.7.11  Minimum Differential Pressure Feature

The valve shall be equipped with a minimum differential pressure pilot to maintain a differential pressure across the valve. Pressure shall be adjustable with a range of 5 psi to 25 psi.

2.4.8  Overfill Valve for Product Recovery Tank (OV-1)

2.4.8.1  Size

2-inch.

2.4.8.2  Capacity

50 GPM.

2.4.8.3  Operation

Hydraulically operated overfill valve shall close automatically upon rising to Product Recovery Tank 80 percent fill level. Valve shall open automatically upon falling below Product Recovery Tank 80 percent fill level.

2.4.8.4  Control Float

Automatic opening and closing of the valve shall be initiated by a control float located within the Product Recovery Tank. Control float shall be provided with a manual tester, mounted external to the tank, for testing of overfill valve operation.
2.4.8.5 Pressure Reservoir

Valve shall be provided with a pressure reservoir to supply required hydraulic pressure for operation. Reservoir pressure to be supplied by Fuel Transfer Pump (FTP-1) using 0.5-inch tubing connected upstream of the pump non-surge check valve. Valve shall close upon loss of reservoir pressure. Reservoir shall be a 1 gal capacity bladder-type tank, carbon steel constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi and precharged with air of 13-15 psig. The tank will be epoxy lined. The tank will be fitted with an air charging valve and pressure gauge.

2.4.8.6 Thermal Relief

Overfill valve shall be provided with a pressure sustaining control valve that shall automatically, upon inlet pressure rising to 200 psig, open allowing thermal relief around overfill valve. Pressure sustaining valve shall automatically close upon inlet pressure dropping below 200 psig.

2.4.8.7 Limit Switch

Limit switch shall be single pole, single throw contract (SPST) and provided with valve for remote indication of valve open or closed position. Valve closed position will become an alarm condition at the pump control panel (PCP).

2.4.8.8 Strainer

Pressure reservoir inlet line shall be provided with a shut-off valve, strainer and check valves.

PART 3 EXECUTION

3.1 VALVE TESTING AND START-UP SUPPORT

Provide the services of a factory trained and certified service engineer authorized/sanctioned/certified by the valve manufacturer to verify that each valve has been properly installed and to verify valves were factory operationally tested, adjusted and set per these specifications. The service engineer shall assist the Contractor in the valve start-up adjustment process and will remain on site until all control valves function as required by the contract documents.

-- End of Section --
1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 7 (1995; Stabilized (S) 2013) Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plan

AMERICAN PETROLEUM INSTITUTE (API)

API STD 682 (2014) Pumps Shaft Sealing Systems For Centrifugal and Rotary Pumps

API Std 610 (2010; Errata 2011) Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries

ASME INTERNATIONAL (ASME)


ASME BPVC SEC VIII D1 (2015) BPVC Section VIII–Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)


1.2 ADMINISTRATIVE REQUIREMENTS

Design conditions shall be as specified in Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT.

a. Tests: Hydrostatic, performance, vibration, and NPSH tests shall be conducted at the factory on each pump in accord with API 610. Test each pump with the actual motor which will drive the pump in the field, unless the water test media will cause overload of the motor. If so, provide vibration test report for motor separately. Vertical turbine pump vibration test must be run with field driver. All tests will be observed by the Contracting Officer or the designated representative. Provide the Contracting Officer 30 days notice prior to performance of factory tests in order to schedule observing such tests. Performance
testing shall not occur prior to acceptance of shop drawing submittal.

b. Test reports shall bear the serial number of both pump and driver. Submit manufacturer's certified reports of hydrostatic, performance, and NPSH tests. Submit manufacturer's certified test curves.

c. Operation and Maintenance Manuals shall be submitted for the pumps and appurtenance specified herein. Refer to Section 01 78 23.33 OPERATION AND MAINTENANCE MANUALS FOR AVIATION FUEL SYSTEMS for the information to be submitted.

d. Motors, manual or automatic motor control equipment, except where installed in motor control centers, and protective or signal devices required for the operation specified herein shall be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Any wiring required for the operation specified herein, but not shown on the electrical plans, shall be provided under this section in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors shall be high efficiency type and in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
  Fueling Pumps (FP-1 thru FP-3); G
  Fuel Transfer Pump (FTP-1); G

SD-03 Product Data
  Fueling Pumps (FP-1 thru FP-3); G
  Fuel Transfer Pump (FTP-1); G

SD-06 Test Reports
  Certified Test Curves

SD-07 Certificates
  Fueling Pumps (FP-1 thru FP-3)
  Fuel Transfer Pump (FTP-1); G

SD-10 Operation and Maintenance Data
  Fueling Pumps (FP-1 thru FP-3)
  Fuel Transfer Pump (FTP-1)
PART 2  PRODUCTS

2.1  DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2  FUELING PUMPS (FP-1 thru FP-3)

2.2.1  Capacity

Capacity shall be 900 gpm against a total head of 483 feet when driven at 3600 rpm. Overall efficiency at design conditions of pump and driver, connected, shall be minimum of 68 percent. Pump head capacity shall be continually rising and shall be free of dips and valleys from design point to shut-off head. Pump shut-off head shall have a 10 to 20 percent head rise to shut off. Pump shall be capable of at least a 10 percent head increase at rated conditions by installing a new impeller. Pumps shall not overheat or be damaged in any way while operating continuously at a minimum flow condition of 450 gpm and continuously at a maximum flow condition of 125 percent required capacity. The unit will also be required to operate API Std 610 at a flow of 12.5 percent required capacity GPM without exceeding the vibration limits given in API Std 610 at that flowrate. These pumps are for parallel operation and shall have equal head at minimum continuous stable flow, plus or minus 2 percent.

2.2.2  General Requirements

a. The pumps shall meet the requirements of API Std 610, latest edition. Whenever the information contained herein conflicts with said standard, the information herein shall govern. The pumps shall run at a nominal 3600 rpm and shall be single stage centrifugals, horizontally mounted, center line-supported, vertical or radial split case, enclosed impeller, with end suction and top vertical discharge. Pumps shall be of the back pull-out design to permit removing case half from rear for access to internal parts without disturbing the suction or discharge piping or the driver. All parts shall be factory inspected so that parts are interchangeable. Pumps and motors shall be furnished as complete units as herein specified. Pump assembly shall be statically and dynamically balanced for all flow rates from minimum flow to 120 percent of design flow.

b. The pump shall require no more than 20-feet of net positive suction head (NPSHR) when it is operated with water at a capacity of 900 gpm at rated head and speed. A hydrocarbon reduction or correction factor shall not be used. Pump suction specific speed shall be less than 12,000.

c. The pump shall be horizontal, single stage, single suction with double volute construction to assure radial balance. It shall be designed to permit removal of the impeller, shaft, bearings and bearing housing as an assembly, without disconnecting the suction or discharge piping.

d. The pump case shall be end suction, centerline discharge type for ease of piping alignment. Flange ratings shall be class 300-pound per
ASME B16.5. The case shall be designed for maximum discharge pressure at pumping temperature but not less than 550 psig, with a minimum corrosion allowance of 1/8-inch. The suction and discharge flanges as well as the cover bolting surfaces shall be backfaced or spot faced for positive bolt seating. The radial case to cover split shall be a metal-to-metal fit with a confined, controlled compression gasket.

e. The pump cover shall contain a stuffing box designed to accept an unbalanced mechanical seal. The stuffing box shall have a minimum of 3-inch studs for seal gland bolting. The gasket fit for seal gland to stuffing box shall be of the controlled compression type with metal-to-metal joint contact.

f. Both case and cover are to be fitted with renewable wear rings.

g. The impeller shall be of the enclosed type, dynamically and hydraulically balanced. It shall be key driven, held in place by a positive lock, threaded against rotation. The running clearance between the impeller and case-cover wear rings shall be no less than 0.018-inches.

h. Mechanical Seal: A single unbalanced mechanical seal per API Std 610 code USTHN, unbalanced single seal with throttle bushing seal gland, a nitrile seal-ring-to-sleeve gasket and carbon against silicon carbide faces, of multiple spring design shall be supplied. The seal gland shall be tapped for three connections and each shall be stamped for identification as follows: Q for quench; F for flush; and D for drain. A non-sparkling throttle bushing pressed into the seal end plate against an outside shoulder shall be provided to minimize leakage on complete seal failure.

i. Bearing Housing: Oil lubricated anti-friction, radial and thrust bearings of standard design shall be supplied. The bearings shall be selected to give a minimum L-10 rating life of 25,000 hours in continuous operation. Bearings shall be retained on the shaft and fitted into housings in accordance with ABMA 7. Locking of the ball thrust bearing to the shaft shall be by series W tank type washer. Minimum spacing between bearing centerlines shall be 6.5 inches.

j. A sight glass for checking oil level with a permanent indication of proper oil level shall be supplied.

k. Bearing housings shall be equipped with labyrinth type end seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used. Deflectors shall be made of non-sparkling material. The deflector design shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

l. Shafts shall be of ample size to transmit the maximum torque required under specified operating conditions, and to withstand continuously all stresses resulting from supported weights, thrusts and starting, including across-the-line motor starting. It shall be key seated to provide positive drive for the coupling, shaft sleeve and impeller. The shaft stiffness factor shall be under 70. The radial bearing centerline to impeller centerline, distance and the pump shaft diameter under the sleeve shall be provided to calculate the factor.

m. A spacer coupling shall be supplied. The spacer length shall permit the removal of the assembled pullout element without disturbing the
2.2.4 Identification Nameplate

A pump identification nameplate of Type 18-8 stainless steel or monel shall be provided and securely attached by stainless steel pins to a conspicuous
place on the pump head. Tagging in letters 1/4 inch high shall bear the
equipment number as shown on the drawings.

2.2.5 Exterior Primer Coat

Exterior surfaces of the baseplate shall be primed by the manufacturer.
Coating shall be applied meeting requirements of SSPC PA 1. Surface
cleaning shall meet requirements of SSPC SP 10. Metal primer shall be zinc
rich paint conforming to specification MIL-DTL-24441, Type 1, Class 3. Dry
film thickness shall be 2 to 4 mils.

2.2.6 Exterior Topcoat

Manufacturer's standard exterior topcoat shall be applied at factory to the
base plate.

2.2.7 Motors

a. Motor shall be furnished by the pump manufacturer and shall be
non-overloading with 10 percent head increase, and suitable for the
environment and operating conditions to which it will be subjected.
Motors for vertical turbine pumps shall be provided with anti-reversing
ratchet. Provide space heaters suitable for operation on 460 or 120
volts as indicated on the drawings within the motor enclosure to
prevent moisture condensation after shut-down. Motor shall be UL
listed for use in Class 1, Division 1, Group D hazardous areas, and
shall have a maximum temperature rating of T2D (419 degrees F) as
defined by NFPA 70. The motor nameplate shall include the temperature
rating of the motor and locked-rotor indicating code letters in
accordance with NFPA 70, Table 430-7(b).

b. Voltage rating shall be 460 volts, 3 phase, 60HZ. Motor nominal speed
shall match pump. Motors shall be capable of delivering rated
horsepower output successfully and continuously under conditions of
voltage variations of 10 percent above or below rated voltage.

c. Pump manufacturer shall assure the specified output and proper
operation of the pump without being overloaded at unity service factor
when operating at any point on the pump performance curve. In addition
to having sufficient horsepower-output rating at rated speed, motor
shall have performance characteristics which will allow, without
injurious overheating of the motor, accelerating the load from
standstill to rated speed under conditions of 10 starts per hour.
Attention is specifically directed to the fact that thermal
characteristics of motors with regard to capability for accelerating
the load may vary greatly from motor manufacturer to motor
manufacturer, notwithstanding that the horsepower rating may be the
same. It is the pump manufacturer's responsibility to provide motors
with adequate thermal starting characteristics as well as adequate
rated-speed operating characteristics. Service factors shall conform
with NEMA standards; however, service factors are only applicable at
rated nameplate voltage and frequency. Since all system voltages are
subject to variation, service factors above unity shall not be applied
in sizing motor.

d. Motor shall be squirrel-cage induction type. Motor shall be NEMA
Design B (normal-torque, low starting current).

e. Motor shall have a service factor of 1.15.
f. Motor insulation shall be non-hydroscopic, NEMA Class H, 82 degrees F for motors over 10 hp and NEMA Class F, 302 degrees F for 10 hp and smaller. Stator windings shall be epoxy impregnated. The impregnations shall be applied by the vacuum and pressure process.

g. Winding temperature rise, (based on a maximum ambient temperature of 4 degrees F at 3,300-feet altitude) shall not exceed 176 degrees F.

h. Bearings shall be ABMA minimum L10 life of 60,000 hours or L50 life of 300,000 hours suitable for the size, type, and application when the pump is operating at the specified flow and head.

i. Motor enclosures shall be totally enclosed, weather sealed, fan cooled, explosion-proof and shall be listed and labeled for Class I, Group D areas. Provide bronze ground bolt on motor enclosure. All motor external electrical connections shall be terminated within a single terminal housing.

j. The dynamic balance, overspeed withstand capability, and sound power levels of the motor shall conform with NEMA standard requirements.

k. The pump manufacturer shall furnish the Contracting Officer with the recommended minimum run time for the motor.

l. Pump motor shall be provided with temperature limiting thermostats within the motor frame when required to meet Class I, Group D requirements.

m. Pump motor shall be furnished with lifting lugs on the motor casing.

n. Unless indicated otherwise, motors for conventional applications over 15 horsepower shall be the premium efficient type. This requirement is not applicable to hermetically sealed motors, integrally mounted motors, motors specified as part of energy efficient equipment, wound rotor motors, or any application involving special construction or performance. Guaranteed minimum full load efficiencies shall be (based on 3600, 2 pole, totally enclosed):

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<td>25</td>
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<td>125</td>
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<td>60</td>
<td>92.5 percent</td>
<td>600</td>
<td>94.5 percent</td>
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</table>

n. Other motors of different speed or housing classification shall also be of the premium efficient type, as advertised by the motor manufacturer, with efficiency greater than the standard line. Motor efficiencies shall have been verified in accordance with NEMA MG 1, 12.53.a., and determined using the dynamometer method as described in IEEE 112, Method B. All shop drawing submittals on motor driven equipment shall include the motor efficiency.
2.3 FUEL TRANSFER PUMP (FTP-1)

2.3.1 Capacity

Capacity shall be 50 gpm against a total head of 102 feet for the Fuel Transfer Pump, when driven at 1800 rpm. Overall efficiency at design conditions of pump and driver, connected, shall be minimum 68 percent. Pump head capacity shall be continually rising and shall be free of dips and valleys from design point to shut-off head. Pump shall be capable of at least 10 percent head increase at rated conditions by installing a new impeller.

2.3.2 Assembly

The pump for this service shall meet the requirements of API Std 610, latest edition, seventh edition for vibration. Wherever the information contained herein conflicts with said standard, the information herein shall govern. The pump for this service shall run at a nominal 1800 rpm and shall be a multi-stage, vertical turbine pump. Pump and motor shall be furnished as a complete unit as herein specified. Pump assembly shall be statically and dynamically balanced for all flow rates from minimum flow to 120 percent of design flow.

2.3.3 Materials

The materials of construction for the pump shaft and the impeller shall be stainless steel. All other materials shall be material class S-1 with the wetted ferrous parts such as the bowl interiors enamel-lined, bowl exteriors, column interior and exterior, discharge head interior epoxy-coated per MIL-PRF-4556, and discharge head exterior epoxy-coated per MIL-DTL-24441.

2.3.3.1 Mechanical Seal

API STD 682, balanced type, API Class Code BSTHN.

2.3.4 Construction

Castings used for any part of pumps shall be sound and free of shrink or blow holes, scale, blisters, and other similar casting defects. The surfaces of casting shall be cleaned by sand or shot blasting, pickling, or other standard methods used by the manufacturer. All mold parting fins and remains of gates and risers shall be either chipped, filed, or ground flush with the surface of the casting. The repair of casting leaks and defects by peening or by the use of cement compounds is prohibited by ASME BPVC SEC VIII D1.

2.3.4.1 Couplings

Couplings shall be flanged, rigid spacer type, CPAT or equal. The couplings shall be of the spacer-type with a spacer of sufficient length to permit replacement of the mechanical seal assembly without removing the motor. The pump half coupling shall be of such design that it can be removed without the use of heat. Coupling halves shall fit tightly to the shafts of the pump and the driver so as not to become loose during operation. The coupling shall be provided with an OSHA approved coupling guard.
2.3.4.2 Impeller

Impeller shall be keyed to the shaft for radial loads and fixed in the axial position by shaft sleeve nuts, or other positive positioning device. Impellers shall be held to the shaft so that the impeller will not become loose should the pump accidentally rotate in reverse direction. The impeller shall be statically and dynamically balanced.

2.3.4.3 Wear Rings

Renewable wearing rings shall be positively locked on the impeller. Wearing rings shall fit with close tolerances so as to permit a minimum of recirculation. Positive locking case wearing rings shall be provided so that the case wearing rings will not rotate or change position in the case.

2.3.4.4 Shaft

Shaft shall be designed with a high safety factor to easily withstand the torsional loads and other stresses to which it may be subjected. It shall be so designed that there will be no detrimental vibration stresses. Surfaces shall be ground to accurate dimensions. Shaft deflection shall be limited to 0.0020 inch maximum when measured at the face of the mechanical seal under the operating condition of zero flow at shut off head. Shaft shall be protected through the mechanical seal by means of a shaft sleeve. Seal piping from the discharge to the mechanical seal shall be provided.

2.3.4.5 Finishing

Passageways and impellers shall be finished to permit maximum efficiency and provide noise reduction. Overall sound levels shall not exceed OSHA limits.

2.3.4.6 Bearings

Bearings shall be product-lubricated. Sleeve type, carbon graphite shall be provided. Bearing spacing shall be per API Std 610.

2.3.4.7 Drilling and Tapping

Casting shall be drilled and tapped for drain and seal recirculation lines. All connections shall be provided with plugs.

2.3.4.8 Mounting Flange

Mounting flange shall be coordinated with the tank's mounting flange, and shall be ANSI or API pattern.

2.3.4.9 Special Tools

Pumps shall be furnished with special tools necessary to dismantle and reassemble the unit.

2.3.4.10 Service Nameplate

A pump service nameplate, of type 18-8 stainless steel or monel, securely attached by stainless steel pins at an easily accessible point on the pump, shall be furnished in addition to the identification nameplate. The pump service nameplate shall be stamped with the following information:
Manufacturer's name
Serial number of pump
Capacity, gpm
Pumping head, ft
Maximum specific gravity of fluid to be pumped
Revolutions per minute
Horsepower of driver

2.3.4.11 Identification Nameplate

A pump identification nameplate of Type 18-8 stainless steel or monel shall be provided and securely attached by stainless steel pins to a conspicuous place on the pump head. Tagging in letters 1/4 inch high shall be the equipment number as shown on the drawings.

2.3.4.12 Exterior Primer Coat

Exterior surfaces of the pump and baseplate shall be primed by the manufacturer. Surface cleaning shall meet requirements of SSPC SP 10. Metal primer shall be zinc rich paint conforming to specification MIL-DTL-24441 Type 1, Class 3. Dry film thickness shall be 2 to 4 mils.

2.3.4.13 Exterior Topcoat

Manufacturer's standard exterior topcoat shall be factory applied and shall be white.

2.3.5 Motor

Refer to paragraph, "Motors" for the Fueling Pumps (FP-1 thru FP-3).

PART 3 EXECUTION

3.1 PREPARATION FOR SHIPMENT

3.1.1 Rust Preventative

Exterior machine surfaces shall be coated with a rust preventative. Pumps shall be disassembled after the shop running tests and inspected, and internal parts shall be coated with a rust preventative before reassembling.

3.1.2 Closure of Openings

Threaded openings shall be provided with metallic plugs or caps. Flanges shall be gasketed with rubber and closed with 3/16-inch thick plate of the same outside diameter as the match flange. A minimum of four full-diameter bolts shall hold closure in place.

3.1.3 Assembly

Pumps shall be shipped assembled or a field service engineer shall be furnished to supervise the field assembly at no additional cost to the Government.

3.1.4 Bracing

Each unit shall be suitably prepared for shipment, supported and braced, with auxiliary equipment secured to prevent damage during shipment.
3.2.5 Vapor Inhibiting Wraps

Exposed shafts and shaft couplings shall be wrapped with waterproof moldable waxed cloth or vapor inhibitor paper. The seams shall be sealed with adhesive tape.

3.2.6 Shipping Identification

Each pump shall be identified with a metal tag showing the item number. Material shipped separately shall be marked with a metal tag indicating the item number for which it is intended.

3.2 INSTALLATION

Install equipment and components true to line, level and plumb, and measured from established benchmarks or reference points. Follow manufacturer's recommended practices for equipment installation. Provide required clearances between equipment components. Equipment, apparatus, and accessories requiring normal servicing or maintenance shall be easily accessible.

3.2.1 Anchoring

Anchor equipment in place as indicated on the drawings or per manufacturer's recommendations. Minimum anchor bolt size is 5 inch. Check alignment of anchor bolts and/or bolt holes before installing equipment and clean-out associated sleeves. Do not cut bolts due to misalignment. Notify the Contracting Officer of errors and obtain the Contracting Officer's acceptance before proceeding with corrections. Cut anchor bolts of excess length to the appropriate length without damage to threads.

3.2.2 Grouting

Equipment which is anchored to a pad shall be grouted in place. Before setting equipment in place and before placing grout, clean surfaces to be in contact with grout, including fasteners and sleeves. Remove standing water, debris, oil, rust, coatings and other materials which impair bond. Clean contaminated concrete by grinding. Clean metal surfaces of mill scale and rust by hand or power tool methods. Provide formwork for placing and retaining grout. Grout to be non-metallic, non-shrink, fluid precision grout of a hydraulic cementitious system with graded and processed silica aggregate, portland cement, shrinkage compensating agents, plasticizing and water reducing agents; free of aluminum powder agents, oxidizing agents and inorganic accelerators, including chlorides; proportioned, pre-mixed and packaged at factory with only the addition of water required at the project site. Grouting to meet requirements of ASTM C827. Perform all grouting in accord with equipment manufacturer's and grout manufacturer's published specifications and recommendations.

3.2.3 Leveling and Aligning

Level and align equipment in accord with respective manufacturer's published data. Do not use anchor bolt, jack-nuts or wedges to support, level or align equipment. Install only flat shims for leveling equipment. Place shims to fully support equipment. Wedging is not permitted. Shims to be fabricated flat carbon steel units of surface configuration and area not less than equipment bearing surface. Shims to provide for full equipment support. Shim to have smooth surfaces and edges, free from burrs and slivers. Flame or electrode cut edges not acceptable.
3.2.4 Direct Drives

Alignment procedure follows.

3.2.4.1 Rotation Direction and Speed

Check and correct drive shaft rotation direction and speed.

3.2.4.2 End Play

Run drive shafts at operational speed. Determine whether axial end play exists. Run drive shaft at operational speed and mark drive shaft axial position when end play exists. Block drive shaft in operating position when aligning drive shaft with driven shaft.

3.2.4.3 Shaft Leveling and Radial Alignment

Check shaft leveling by placing a straightedge across the two coupling half faces in both horizontal and vertical planes.

3.2.4.4 Angular Alignment and End Clearance

Pump alignment shall be accomplished by the factory technician or a millwright trained in pump alignment, and with the use of dial gauges or laser alignment equipment.

3.2.4.5 Final Recheck

Check adjustments with dial indicator after completing recheck. Align shafts within 0.002 inch tolerance, except as otherwise required by more stringent requirements of equipment manufacturer.

3.2.5 Start-up Representative

A manufacturer's field service representative shall be provided at no additional cost to the Government to check the pumps for proper operation prior to start-up and also to witness, as a minimum, the first two days of operation. Any additional time required due to delays or corrections shall be provided at no additional cost to the Government. The manufacturer's field service representative shall also instruct the required personnel in the proper operation and maintenance of the pumps.

-- End of Section --
PART 1  GENERAL

1.1  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASME INTERNATIONAL (ASME)


ASME B31.3  (2014) Process Piping

ASME BPVC SEC VIII D1  (2015) BPVC Section VIII–Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM C827  (2010) Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures

ENERGY INSTITUTE (EI)


SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-P-5315  (2013, Rev B) Butadiene - Acrylonitrile (NBR) Rubber For Fuel-Resistant Seals 60 To 70

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK-831  (2013; Rev A) Preparation of Test Reports

MIL-PRF-4556  (1998; Rev F; Am 1 1999; CANC Notice 1 2011) Coating Kit, Epoxy, for Interior of Steel Fuel Tanks

MIL-STD-130  (2007; Rev N; Change 1 2012) Identification Marking of U.S. Military Property

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1923  (Rev A; Notice 2) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt
1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Filter Separator; G

SD-03 Product Data
Filter Separator; G

SD-07 Certificates
Filter Separator

SD-10 Operation and Maintenance Data
Filter Separator; G

1.3 PREPRODUCTION TESTING

Prior to construction of filter separators (FSI-1 THROUGH FSI-3, FSR-1, THROUGH FSR-2) for the Project, preproduction tests shall have been conducted in the presence of Det 3, WR-ALC/AFTH Technical Assistance Team Air Force Petroleum Office Wright-Patterson AFB, OH representative. Notify the Contracting Officer 30 days prior to conductance of factory tests in order to schedule witnessing by representative.

1.3.1 Inspection and Testing

The inspection and testing of the preproduction filter separator shall be conducted on a full-scale test system in accordance with EI 1581 and as specified herein. The test sample shall consist of a complete filter separator with elements installed. Elements shall be representative of a production lot. The filter separator, coalescers, and separator screens shall be identified with the manufacturer's part number.

1.3.2 Deviations from EI 1581

No deviations are allowed.

1.3.3 Data Required Prior to Tests

Submit installation data to enable Government representative to verify that the equipment has been installed and operated correctly. Submit certification from the manufacturer that the test vessel has passed a
hydrostatic pressure test, and that the design conforms to EI 1581, Category M, Type S. Submit two sets of assembly drawings of the test vessel and accessories for approval.

1.3.4 Submittal of Test Documents

The test report shall be submitted to the Command Fuel Facilities Engineer or Det 3, WR-ALC/AFT for Government approval. Prepare report in accordance with MIL-HDBK-831. In addition to results, the report shall contain complete records of the tests including data sheets, performance curves, chronological test records, photographs, sample calculations, test procedures, and a description of the test apparatus. Submit color photographs of the sample elements before and after tests. Submit one new coalescer element and one new separator element.

1.3.5 Required Preproduction Tests

a. Examination. A visual examination of the filter separator housing and each element shall be performed to ensure compliance with the Drawings and verify workmanship requirements.

b. Hydrostatic Pressure Tests. The filter separator shall be subjected to a hydrostatic pressure test in accordance with EI 1581, Section 3.2.2.11.1.

c. Full Scale Performance Test. EI 1581. The filter(separator with a full set of coalescer and separator elements shall be tested in accordance with EI 1581 Section 4.4 at 900 gpm (FSI-1 through FSI-3; FSR-1 and FSR-2).

d. Coalescer Structural Test. A coalescer structural test shall be conducted in accordance with EI 1581 Section 4.5.

e. Disassembly Inspection. Upon completion of the tests specified above, the filter separator shall be disassembled and inspected to determine the condition of the coalescer and separator elements. Defects in the element such as swelling of the elements, or damaged gaskets shall be noted. Swelling of or damage to the elements or other parts shall be cause for rejection.

1.4 WORKMANSHP

Each filter separator, including all parts and accessories, shall be free from blemishes, defects, burrs and sharp edges. The vessel shall exhibit accuracy of dimensions, accurate radii of fillets and complete marking of parts and assemblies.

1.5 CLEANING

Components of the filter separators shall be cleaned to remove dirt; excess soldering; brazing, and welding flux; welding slag; loose, spattered, or excess solder; metal chips; and other foreign materials before, during and after assembly.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine
fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 WELDING

Welding shall be in accordance with ASME B31.3.

2.3 MATERIALS AND EQUIPMENT

2.3.1 Housing

a. Carbon steel with internal epoxy coating (FSR-1 and FSR-2) and Type 304 or 316 stainless steel (FSI-1 Thru FSI-3).

b. Float Assembly. Stainless steel.


d. Sight Glass. Armored clear Pyrex with nickel-copper alloy ball checks.


f. Separators. 200 mesh stainless steel wire cloth, polytetrafluoroethylene (PTFE) coated on both sides, or synthetic mesh cloth.

2.4 FILTER SEPARATOR CONSTRUCTION

2.4.1 Housing Vessel

Each receipt filter separator (FSR-1 Thru FSR-2, and FSI-1 Thru FSI-3) housing shall be fabricated from carbon steel and shall be internally coated with an epoxy coating in accord with MIL-PRF-4556. Coat the carbon steel exterior with alkylid resin primer (universal metal primer). Each unit shall be constructed and labeled in accordance with ASME BPVC SEC VIII D1. The housing shall be designed for a working pressure of 275 psig. Each unit shall be horizontal, end-opening type with coalescers and separators mounted side-by-side (coalescers at the bottom of the vessel and separators at the top). The head opening shall be equipped with a hinged or pivoting device to facilitate swinging the head to one side for servicing. The hinges or pivots shall support the head during servicing without distortion or misalignment. Swing-type bolts shall be used on all main closures. Unit shall be provided with 3 inch inside diameter lifting eyes spaced to support a weight of 2-1/2 times the gross weight of the filter separator. The configuration of the pressure vessel shall be as shown on the Drawings. The housing shall be provided with a 3/4 inch inlet compartment fuel drain plug. A hand hole access plate shall be provided in the inlet compartment. The head shall be sealed to the body by means of an O-ring, meeting requirements of SAE AMS-P-5315, mounted in a circular groove at the point of closure. Threaded base mounting adapters shall be provided for the coalescers. The separators shall be mounted on adapters with blunted Vee-type knife edges. Height of Vee section to be 0.06 inches, plus or minus 10 percent. Weld ridges shall not prevent liquid from draining. The filter separator vessel shall be able to withstand a force of 2,400 pounds and a moment of 2,400 foot-pounds at the
2.4.2 Legs

Four 3 by 3 by 1/4 inch angle-shaped legs shall be welded to the housing. Each leg shall be fitted with a 4 by 4 by 1/2 inch base plate drilled through with a 3/4 inch hole.

2.4.3 Inlet and Outlet Connections

The inlet and outlet connections shall be 6 inch nominal pipe size and shall be located parallel to each other as shown on the Drawings. Inlet connection shall be provided with raised face flanges, faced and drilled in compliance with ASME B16.5, Class 150. Outlet connection flange face shall match Filter Separator Control Valve (FSCV).

2.4.4 Manual Drain Valve

As specified in Paragraph "Accessories".

2.4.5 Sight Gauge

As specified in Paragraph "Accessories".

2.4.6 Differential Pressure Gauge

As specified in Paragraph "Accessories".

2.4.7 Automatic Air Eliminator and Pressure Relief Valves

As specified in Paragraph "Accessories".

2.4.8 Sampling Connections

As specified in Paragraph "Accessories".

2.4.9 Spider Assembly

Each filter separator shall contain a spider assembly to hold the coalescers and separators in position, to support them firmly against vibration. The method of stabilization shall assure an electrical bond between the spider and the vessel.

2.4.10 Coalescer and Separator Cartridges

Each filter separator shall be provided with coalescers and separators that have been qualified to the performance requirements of EI 1581, Category M, Type S. Issue filter separators (FSI-1 Thru FSI-3) shall use coalescers 6 inches in diameter and 56 inches long for a flow-rate of 900 gpm. Receipt Filter Separators (FSR-1 and FSR-2) shall use coalescers 6 inch in diameter and 56 inches long for a flow rate of 900 GPM.

2.4.11 Control Valve Accessories

Provide each filter separator with a control valve (FSCV), manual water drain valve, and float control valve (FC) with manual tester as specified in Section 33 52 43.14 AVIATION FUEL CONTROL VALVES and shall be of the same manufacturer.
2.4.11.1 Float Control Pilot and Tester

Each housing sump shall be fitted with a float control pilot and tester specified in Section 33 52 43.14 AVIATION FUEL CONTROL VALVES and shall be of the same manufacturer as the control valves. The drain port "D" shall be piped to the drain piping to the product recovery tank.

2.4.12 Identification of Product

Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130. The main equipment nameplate shall be mounted on the housing, and in addition to the usual MIL-STD-130 requirements, shall include the following markings in letters 3/32 inch high or larger:

<table>
<thead>
<tr>
<th>Filter Separator, Liquid Fuel</th>
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<tbody>
<tr>
<td>Design Flow-Rate</td>
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<tr>
<td>Design Pressure</td>
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<tr>
<td>Elements</td>
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<tr>
<td>First Stage</td>
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<tr>
<td>Mfg. Part No. *</td>
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<tr>
<td>Manufacturer *</td>
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<td>Specification*</td>
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*Applicable information shall be entered by the Contractor.

*Applicable information shall be stenciled by LFM personnel.

2.4.13 Assembly

Each filter separator shall come assembled with all accessories and shall be ready for use. The functions of all components shall be tested prior to shipment and no assembly or field adjustment of valves or components shall be required.

2.5 ACCESSORIES

2.5.1 Manual Drain Valve

Each filter separator shall be equipped with a 1 inch stainless steel manual ball valve water and fuel drain. The valve shall be capable of draining all water, fuel and sediment from the filter separator by gravity. The valve shall be installed below the sump of the housing as shown on the Drawings.

2.5.2 Sight Gauge

A 1/2 inch armored, clear borosilicate (Pyrex) liquid level gauge shall be provided for observing the water accumulation in the sump. The gauge shall
be equipped with stainless steel ball checks in both the upper and lower fittings, an upper and lower shutoff valve, and a bottom blowoff cock. The gauge will contain a colored density sensitive ball. Liquid level gauges shall be rated for a maximum pressure of 275 psi.

2.5.3 Differential Pressure Gauge

The housing shall be equipped with a direct-reading, piston type differential pressure gauge that measures the differential pressure across both coalescers and separators. The gauge shall consist of a spring-supported, corrosion resistant piston moving inside a glass cylinder, with high pressure applied on top of the piston and low pressure applied below it. The gauge shall have a peak-hold reading that locks the piston to indicate the maximum differential pressure that is measured until the piston is released by turning a knob, a push button test valve to relieve pressure under the piston, and a pressure relief feature set at 300 psi to protect the gauge if isolation valves have been left closed. Under a differential pressure of 30 psi, leakage past the piston shall not exceed 120 drops per minute. The cylinder shall have stainless steel and flanges with fluoroelastomer (FKM), commonly referred to as Viton, O-ring seals. The high pressure inlet of the gauge shall have a 10 micron pleated paper filter and the low pressure connection shall have a fine mesh stainless steel strainer. The gauge shall have an operating pressure of 300 psi. Differential pressure range of the gauge through approximately 3 inches of piston movement shall be 0-30 psi with an accuracy of ± 0.5 psi, calibrated linearly with 1 PSI scale graduations. High and low pressure connections shall be 1/4 inch NPT female with a stainless steel bar stock valve at each connection. Construction of the gauge shall be such that a 3-valve manifold is not necessary. If only one bar stock valve is closed, the gauge shall not be damaged by up to 300 psi differential pressure in either direction. The differential pressure gauge shall be attached to the filter separator by a gauge panel. A pressure gauge shall be attached to the differential pressure gauge to indicate the high pressure and have a range of 300 psi.

2.5.4 Automatic Air Eliminator and Pressure Relief Valves

A 1 inch angle pattern pressure relief valve shall be provided on top of each vessel. An automatic air eliminator shall be installed on the highest point of the vessel and shall have check valve feature. The air eliminator shall release at pressures up to 150 psi with no fuel leakage allowed. The relief valve piping shall be routed to the product recovery tank, with all manual valve in the relief path locked open. Relief valve pressure shall be as indicated on the Drawings and shall be a BPVC Section VIII stamped valve. Air Eliminator piping shall be routed to the product recovery tank.

2.5.5 Sampling Connections

Sampling connections shall be provided at the inlet and outlet connections to the housing. Each sampling connection shall consist of a 1/4 inch sampling probe where the probe faces upstream, ball valve, a quick disconnect coupling and aluminum dust cap. The sampling connections shall be capable of accepting a sampling kit for drawing the samples required to assure fuel quality.
PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and components in position, true to line, level and plumb and measured from established benchmarks or reference points. Follow manufacturer's recommended practices for equipment installation. Provide required clearance between equipment components. Equipment apparatus, and accessories requiring normal servicing or maintenance to be accessible.

3.1.1 Anchoring

Anchor equipment in place. Check alignment of anchor bolts before installing equipment and cleanout associated sleeves. Do not cut bolts because of misalignment. Notify Contracting Officer of errors and obtain the Contracting Officer's acceptance before proceeding with corrections. Cut anchor bolts of excess length to the appropriate length without damage to threads. Where anchor bolts or like devices have not been installed, provide appropriate self-drilling type anchors for construction condition. Expansion bolt anchors provided shall be in accordance with CID A-A-1923, Type 4, Class One, 1/2 inch size.

3.1.2 Grouting

Equipment, which is anchored to a pad, shall be grouted in place where applicable. Before setting equipment in place and before placing grout, clean surfaces to be in contact with grout, including fasteners and sleeves. Remove standing water, debris, oil, rust, coatings and other materials which impair bond. Clean contaminated concrete by grinding or other acceptable means. Provide necessary formwork for placing and retaining grout. Grout to be nonmetallic, nonshrink, fluid precision grout of a hydraulic cementitious system with graded and processed silica aggregate, Portland cement, shrinkage compensating agents, plasticizing and water reducing agents; free of aluminum power agents, oxidizing agents and inorganic accelerators, including chlorides; proportioned, premixed and packaged at factory with only the addition of water required at the project site. Grouting to meeting requirements of ASTM C827. Perform grouting in accord with ACI, equipment manufacturer's, and grout manufacturer's published specifications and recommendations.

3.1.3 Leveling and Aligning

Level and align equipment in accordance with respective manufacturer's published data. Do not use anchor bolts, jack-nuts or wedges to support, level or align equipment. Install only flat shims for leveling equipment. Place shims to fully support equipment. Wedging is not permitted. Shims to be fabricated flat carbon steel units of surface configuration and area not less than equipment bearing surface. Shims to provide for full equipment support. Shims to have smooth surfaces and edges, free from burrs and slivers. Flame or electrode cut edges not acceptable.

3.1.4 Painting and Labeling

Equipment painting shall be as specified in Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES. Equipment labeling shall be as specified in Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT.

-- End of Section --
C-17 Type III Fuel System & Ramp Expansion
145th Airlift Wing, North Carolina Air National Guard

SECTION 33 52 80

LIQUID FUELS PIPELINE COATING SYSTEMS

02/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)


AWWA C209 (2013) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines


AWWA C213 (2015) Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines


ASTM INTERNATIONAL (ASTM)

ASTM D3276 (2007) Painting Inspectors (Metal Substrates)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)


NACE INTERNATIONAL (NACE)

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PA 1 (2016) Shop, Field, and Maintenance Coating of Metals


SSPC SP 10 (2007) Near-White Blast Cleaning

SSPC SP COM (2004) Surface Preparation Commentary for Steel and Concrete Substrates


U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1000 Air Contaminants

29 CFR 1910.134 Respiratory Protection

1.2 SYSTEM DESCRIPTION

This section specifies the requirements for interior and exterior coating of aboveground and buried, carbon steel, liquid fuel pipelines. This Section specifies the requirements for exterior coating of buried stainless steel, liquid fuel pipelines. The exterior coating system for aboveground pipelines is specified with the same requirements as the exterior coating system for the exterior of fuel tanks, Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES. The exterior coating system for buried pipelines is fusion bonded epoxy coating. Fusion bonded epoxy coating is specified for the interior of carbon steel aviation fuel pipe to protect fuel from iron contamination.

1.3 SUBMITTALS

Submittals are for Contractor Quality Control approval only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

External Pipe Coating
Internal Pipe Coating
Field-Applied External Pipe Coating

SD-06 Test Reports
Qualification Testing of Shop-Applied External Pipe Coating
Acceptance Testing of Shop-Applied Internal Pipe Coating
Qualification Testing of Field-Applied External Pipe Coating
Inspection Report Forms
Daily Inspection Reports

SD-07 Certificates
Contract Errors, Omissions, and Other Discrepancies
Corrective Action Procedures
Coating Work Plan
Qualifications of Certified Industrial Hygienist (CIH)
Qualifications of Pipe Coating Shop
Qualifications of Certified Protective Coatings Specialist (PCS)
Qualifications of Coating Inspection Company for Field Coating
Qualifications of Coating Inspector for Field Coating
Qualifications Of Individuals Performing Abrasive Blasting for Field Coating
Qualifications of Individuals Performing Coating Application for Field Coating
Qualifications of Individuals Performing Coating Application for Field Coating
Qualifications of Individuals Operating Plural Component Equipment (Pump Tenders) for Field Coating
Qualifications of Coating Contractors

SD-11 Closeout Submittals
Inspection Logbook

1.4 QUALITY ASSURANCE

1.4.1 Contract Errors, Omissions, and Other Discrepancies
Submit all errors, omissions, and other discrepancies in contract documents to the Contracting Officer within 30 days of contract award for all work covered in this Section, other than the work that will not be uncovered
until a later date. All such discrepancies shall be addressed and resolved, and the Coating Work Plan modified, prior to beginning the Initial and Follow-Up phases of work. Discrepancies that become apparent only after work is uncovered shall be identified at the earliest discoverable time and submitted for resolution. Schedule time (Float) should be built into the project schedule at those points where old work is to be uncovered or where access is not available during the first 30 days after award, to allow for resolution of contract discrepancies.

1.4.2 Corrective Action (CA)

CA shall be included in the Quality Control Plan.

1.4.2.1 Corrective Action Procedures

Develop procedures for determining the root cause of each non-compliance, developing a plan to eliminate the root cause so that the non-compliance does not recur, and following up to ensure that the root cause was eliminated. Develop Corrective Action Request (CAR) forms for initiating CA, and for tracking and documenting each step.

1.4.2.2 Implement Corrective Action

The Contractor shall take action to identify and eliminate the root cause of each non-compliance so as to prevent recurrence. These procedures shall apply to non-compliance in the work, and to non-compliance in the QC System. Corrective actions shall be appropriate to the effects of the non-compliance encountered. Each CAR shall be serialized, tracked in a Log to completion and acceptance by the Contracting Officer, and retained in project records. The Corrective Action Log, showing status of each CAR, shall be submitted to the Contracting Officer monthly. A CAR may be initiated by either the Contractor or the Contracting Officer. The Contracting Officer must approve each CAR at the root cause identification stage, the plan for elimination stage, and the closeout stage after verification that the root cause has been eliminated.

1.4.3 Coating Work Plan

Provide procedures for reviewing contract documents immediately after award to identify errors, omissions, and discrepancies so that any such issues can be resolved prior to project planning and development of detailed procedures.

Provide procedures for verification of key processes during Initial Phase to ensure that contract requirements can be met. Key processes shall include surface preparation, coating application and curing, inspection, and documentation, and any other process that might adversely impact orderly progression of work.

Provide procedures for all phases of coating operations, including planned work, rework, repair, inspection, and documentation. Address mobilization and setup, surface preparation, coating application, coating initial cure, tracking and correction of non-compliant work, and demobilization. Coordinate work processes with health and safety plans and confined space entry plans. For each process, provide procedures that include appropriate work instructions, material and equipment requirements, personnel qualifications, controls, and process verification procedures. Provide procedures for inspecting work to verify and document compliance with contract requirements, including inspection forms and checklists, and
acceptance and rejection criteria.

Provide procedures for correcting non-compliant work. Detailed procedures are required in advance to avoid delays in meeting overcoat windows as well as to avoid delays in production. Provide procedures for repairing defects in the coating film, such as runs, drips, sags, holidays, overspray, as well as how to handle correct coating thickness non-compliance, any other areas of repair or rework that might be adversely affected by delays in preparing and approving new procedures.

If a procedure is based on a proposed or approved request for deviation, the deviation shall be referenced. Changes to procedures shall be noted by submittal number and date approved, clearly delineating old requirements and new requirements, so that the records provide a continuous log of requirements and procedures.

1.4.4 Qualifications

The qualifications specified in this paragraph must be met throughout the duration of this contract. No work that is subject to specified qualifications shall be provided by personnel or corporate entities unless all specified qualifications are met.

1.4.4.1 Qualifications of Certified Industrial Hygienist (CIH)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party CIH. Submit documentation that hygienist is certified by the American Board of Industrial Hygiene in comprehensive practice, including certification number and date of certification/recertification. Provide evidence of experience with hazards involved in industrial coating application work.

1.4.4.2 Qualifications of Certified Protective Coatings Specialist (PCS)

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party PCS. Submit documentation that specialist is certified by SSPC: The Society for Protective Coatings (SSPC) as a PCS, including certification number and date of certification/recertification. If the PCS is employed by the same coating inspection company to which the coating inspector is employed, this does not violate the independent third-party requirements. The PCS shall not be the designated coating inspector.

1.4.4.3 Qualifications of Coating Inspection Company for Field Coating

Submit documentation that the selected coating inspection company is certified by SSPC to the requirements of SSPC QP 5 prior to contract award. The coating inspection company must remain so certified for the duration of the project.

1.4.4.4 Qualifications of Coating Inspector for Field Coating

Submit documentation that each coating inspector is employed, and qualified to SSPC QP 5, Level III, by the selected coating inspection company.

1.4.4.5 Qualifications Of Individuals Performing Abrasive Blasting for Field Coating

All individuals performing abrasive blasting shall be certified by SSPC to
the SSPC C-7 Dry Abrasive Blaster Qualification Program, and shall remain certified during the entire period of coating application. Submit name, address, telephone number, and evidence of certification of each person that will be performing abrasive blasting.

This requirement applies to all manual abrasive blasting performed in shop and field locations. This requirement does not apply to automated abrasive blasting performed in the shop.

1.4.4.6 Qualifications of Individuals Performing Coating Application for Field Coating

All individuals performing coating application shall be certified by SSPC to either the SSPC C-12 Marine/Industrial Airless Spray Program or to the SSPC C-15 Plural Component Spray Program; Spray Painter Category, and shall remain certified during the entire period of coating application. Submit name, address, telephone number, and evidence of certification of each person that will be performing coating application by any method.

1.4.4.7 Qualifications of Individuals Operating Plural Component Equipment (Pump Tenders) for Field Coating

All individuals operating plural component equipment shall be certified by SSPC to the SSPC C-15 Plural Component Spray Program; Equipment Operator Category, and shall remain certified during the entire period of coating application. Submit name, address, telephone number, and evidence of certification of each person that will be operating plural component equipment.

1.4.4.8 Qualifications of Pipe Coating Shop

Each shop that applies coatings to pipe shall be certified to either ISO 9001 or SSPC QP 3, Class A prior to contract award.

1.4.4.9 Qualifications of Coating Contractors for Field Coating

All Contractors and Subcontractors that perform surface preparation or coating application shall be certified to either ISO 9001 or SSPC QP 1 and SSPC QS 1 prior to contract award.

1.4.5 Protective Coating Specialist (PCS)

The PCS shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00.00 20 QUALITY CONTROL. The PCS shall approve all submittals prior to submission to the QC Manager for approval or submission to the government for approval.

1.4.6 Pre-Application Meeting For Field Coating

After approval of submittals but prior to the initiation of coating work, Contractor representatives, including at a minimum, project superintendent and QC manager, paint foreman, coating inspector, and PCS shall have a pre-application coating preparatory meeting. This meeting shall be in addition to the pre-construction conference. Specific items addressed shall include: Corrective action requirements and procedures, coating work plan, safety plan, coordination with other Sections, inspection standards, inspection requirements and tools, test procedures, environmental control system, safety plan, and test logs. Notify Contracting Officer at least ten days prior to meeting.
1.5 DELIVERY AND STORAGE

Ship, store, and handle materials in accordance with SSPC PA 1, applicable standards, and as modified in this Section. Maintain temperature in storage spaces between 40 and 75 degrees F, and air temperature more than 5 degrees F above the dew-point at all times. Inspect materials for damage and return non-compliant materials to manufacturer. Remove materials with expired shelf life from government property immediately and notify the Contracting Officer. Expired materials may be returned to manufacturer, tested, and if compliant, issued a shelf life extension.

1.6 COATING HAZARDS

Ensure that employees are trained in all aspects of the safety plan. Specified coatings may have potential health hazards if ingested or improperly handled. The coating manufacturer's written safety precautions shall be followed throughout mixing, application, and curing of the coatings. During tank cleaning, cleanup, surface preparation, and paint application phases, ensure that employees are protected from toxic and hazardous chemical agents which exceed concentrations in 29 CFR 1910.1000. Comply with respiratory protection requirements in 29 CFR 1910.134. The CIH shall approve work procedures and personal protective equipment.

1.7 JOB SITE REFERENCES - SHOP

Make available to the Contracting Officer a copy of each standard to which the shop will be applying coating under this Section.

1.8 JOB SITE REFERENCES - FIELD

Make available to the Contracting Officer at least one copy each of AWWA C203, AWWA C209, AWWA C210, AWWA C215, AWWA C216, AWWA C217, ISO 9001, SSPC PA 1, SSPC QP 1, SSPC QP 3, SSPC QS 1, SSPC SP COM, SSPC SP 10, and an SSPC Certified Contractor Evaluation Form at the job site.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 SHOP-APPLIED COATING FOR BURIED PIPING

2.2.1 External Pipe Coating

Fusion-Bonded Epoxy Coating: AWWA C213, minimum 15 mils, maximum 20 mils.

2.2.2 Internal Pipe Coating (Lining)

Fusion-Bonded Epoxy Coating: AWWA C213, minimum 15 mils, maximum 20 mils, and certification from the coating manufacturer that the coating is suitable for immersion service in aviation fuel.
2.3 SOURCE QUALITY CONTROL

2.3.1 Test Requirements

Qualification testing of coating materials and coating system performance requirements shall be based on laboratory testing of identical materials used in production, tested within the last two years. All required and optional tests shall be performed. Acceptance of each batch of production coating materials may be based on laboratory testing or manufacturer's certificate of conformity.

Acceptance testing of Fusion Bonded Epoxy coated pipe shall be based on all required and optional production verification testing required by AWWA C213. Perform optional production verification testing described in paragraph OPTIONAL COATING PERFORMANCE TESTING OF COATED PIPE of AWWA C213, including cross-section porosity, interface porosity, thermal analysis (DSC), permanent strain (bendability), and interfacial contamination. Perform production verification testing on a minimum of one pipe joint in the first half hour of production each day, and on a minimum of one pipe joint in the last half hour of production each day. Perform additional testing as required to segregate any non-compliant material. Testing may be performed using qualified in-house personnel and facilities, or by independent laboratory. Submit results of tests as proof of compliance. Document compliance with the approved Coating Work Plan.

2.3.2 Coating Inspector for Shop Coating

The coating inspector shall be the shop Quality Manager or appropriate designee. The coating inspector shall be considered a QC Specialist and shall report to the prime Contractor's QC Manager, as specified in Section 01 45 00.00 20 QUALITY CONTROL. The Coating Inspector shall be present during all pre-preparation testing, surface preparation, coating application, initial cure of the coating system, and during all coating repair work required of the shop. The Coating Inspector shall provide complete documentation of conditions and occurrences on the job site, and be aware of conditions and occurrences that are potentially detrimental to the coating system.

2.3.3 Shop Inspection

2.3.3.1 Inspection Requirements

Provide all tools and instruments required to perform the required testing, as well as any tools or instruments that the inspector considers necessary to perform the required inspections and tests. Document each inspection and test, including required hold points and other required inspections and tests, as well as those inspections and tests deemed prudent from on-site evaluation to document a particular process or condition, as follows:

a. Location or area;

b. Purpose (required or special);

c. Method;

d. Criteria for evaluation;

e. Results;
f. Determination of compliance;

g. List of required rework;

h. Observations.

Collect and record Environmental Conditions as described in ASTM D3276 on a 24 hour basis, from beginning of surface preparation through initial curing of coating, as follows:

a. During surface preparation, every two hours or when changes occur;

b. During coating application and the first four days of initial cure, every hour, or when changes occur;

c. Note location, time, and temperature of the highest and lowest surface temperatures each day;

d. Use a non-contact thermometer to locate temperature extremes, then verify with contact thermometers.

Document all equipment used in inspections and testing, including manufacturer, model number, serial number, last calibration date and future calibration date, and results of on-site calibration performed.

Document Contractors compliance with the approved Coating Work Plan.

2.3.3.2 Inspection Report Forms

Develop project-specific report forms as required to report measurements, test results, and observations being complete and conforming to contract requirements. This includes all direct requirements of the contract documents and indirect requirements of referenced documents. Show acceptance criteria with each requirement and indication of conformity of each inspected item. The data may be in any format, but must be legible and presented so that entered data can be quickly compared to the appropriate requirement.

2.3.3.3 Daily Inspection Reports

Submit one copy of daily inspection report completed each day when performing work under this Section, to the Contracting Officer. Note all non-compliance issues, and all issues that were reported for rework in accordance with QC procedures of Section 01 45 00.00 20 QUALITY CONTROL. Each report shall be signed by the coating inspector and the QC Manager. Submit report within 24 hours of date recorded on the report.

2.3.3.4 Inspection Equipment

All equipment shall be in good condition, operational within its design range, and calibrated as required by the specified standard for use of each device.

PART 3 EXECUTION

3.1 FIELD EXTERIOR COATING OF ABOVEGROUND PIPING

Coat aboveground carbon steel piping in accordance with Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES.
3.2 FIELD REPAIRS TO EXTERNAL COATING OF BURIED PIPING

3.2.1 Field-Applied External Pipe Coating

Use one or more of the following repair methods, as modified herein, to repair shop applied coatings and coat external girth welds:

a. Fusion-Bonded Epoxy (FBE) Coating: NACE RP0402, coating material to be same as applied to pipe in shop.


3.2.2 Surface Preparation

Prepare girth welds, and repairs to bare steel, to SSPC SP 10 immediately prior to coating application. Verify that prepared surfaces comply with SSPC VIS 1 at time of coating application. All other surfaces shall be prepared in accordance with the appropriate coating standard referenced herein.

Block or suspended pipeline at a height that will allow the blast nozzle to be perpendicular to the surface being blasted, and at the proper standoff distance, at all times.

3.2.3 Soluble Salt Testing

3.2.3.1 Test Kit for Measuring Chloride, Sulfate and Nitrate Ions on Steel and Coated Surfaces

Provide test kits called CHLOR*TEST CSN Salts, as manufactured by CHLOR*RID International Inc., of Chandler, Arizona (www.chlor-rid.com) or equal. An "equal" test kit shall meet the following requirements:

a. Kit contains all materials, supplies, tools and instructions for field testing and on-site quantitative evaluation of chloride, sulfate and nitrate ions;

b. Kit extract solution is acidic, factory pre-measured, pre-packaged, and of uniform concentration;

c. Kit components and solutions are mercury free and environmentally friendly;

d. Kit contains new materials and solutions for each test extraction;

e. Extraction test container (vessel, sleeve, cell, etc.) creates a sealed, encapsulated environment during salt ion extraction;

f. Test extract container is suitable for testing the following steel surfaces: Horizontal (up/down configuration), vertical, flat, curved, smooth, pitted, and rough;

g. All salt ion concentrations are directly measured in micrograms per square centimeter.

3.2.3.2 Pre-Preparation Testing for Soluble Salts Contamination

Test surfaces for soluble salts, and wash as required, prior to abrasive
3.2.5 Testing for Soluble Salts Contamination

The acceptance test of prepared surfaces after abrasive blasting, and successful completion of this phase does not negate that requirement. This phase is recommended since pre-preparation testing and washing are generally more advantageous than attempting to remove soluble salt contamination after abrasive blasting. Effective removal of soluble salts will require removal of any barrier to the steel surface, including rust. This procedure may necessitate combinations of wet abrasive blasting, high pressure water rinsing, and cleaning using a solution of water washing and soluble salts remover. The soluble salts remover shall be acidic, biodegradable, nontoxic, noncorrosive, and after application, will not interfere with primer adhesion. Delays between testing and preparation, or testing and coating application, may allow for the formation of new contamination. Use potable water, or potable water modified with soluble salt remover, for all washing or wet abrasive blasting. Test methods and equipment used in this phase are selected at the Contractor’s discretion.

3.2.3.3 Pre-Application Testing for Soluble Salts Contamination

Test girth welds and areas to be repaired for chloride contamination using the Test Kit described in paragraph TEST KIT FOR MEASURING CHLORIDE, SULFATE AND NITRATE IONS ON STEEL AND COATED SURFACES. One or more readings greater than 3 micrograms per square centimeter of chlorides or 10 micrograms per square centimeter of sulfates or 5 micrograms per square centimeter of nitrates is evidence of soluble salt contamination. Reject contaminated surfaces, wash as discussed in paragraph PRE-PREPARATION TESTING FOR SOLUBLE SALTS CONTAMINATION, allow to dry, and re-test until all required tests show allowable results. Reblast tested and cleaned areas as required. Label all test tubes and retain for test verification.

3.2.4 Coating Application

Apply coatings in accordance with SSPC PA 1 and as specified herein. Apply coatings to surfaces that meet all stated surface preparation requirements.

3.2.5 Final Inspection of Pipeline Prior to Burial

Verify that all surfaces of the pipeline are holiday-free at time of placement of backfill over pipe. Use holiday inspection requirements and acceptance criteria of the standards applicable to the coatings being tested.

3.3 PROJECT IDENTIFICATION

At the completion of the work, affix pertinent coating data on structure at a location that is readily accessible and visible from the ground. Use either stencils or nameplates. The following list generally describes the pertinent coating data, but should be modified as required to describe the coating systems.

Date coated/accepted: __________/__________
Project Number: ____________________________
Contractor: ________________________________
Address: __________________________________
Coating System
Manufacturer: ______________________________
Surface Prep: SSPC SP ____ Profile: ______
Primer: __________________________ Thickness: ___
3.3.1 Stencils

Use stencils on piping 8 in or larger. Use stencils with 3/4 to one inch Helvetica style letters and acrylic stencil paint of contrasting color.

3.3.2 Nameplates

Use nameplates for piping smaller than 8 in. Construct plates of stainless steel. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates shall be one by 2.5 in. Lettering shall be the normal block style with a minimum 0.25 in height. Accurately align all lettering on nameplates.

3.4 FIELD QUALITY CONTROL

For marking of surfaces, use chalk for marking bare steel, and water based markers for marking coated surfaces, and remove marks prior to coating. Do not use any wax or grease based markers, or any other markers that leave a residue or stain.

3.4.1 Coating Inspector

The coating inspector shall be considered a QC Specialist and shall report to the QC Manager, as specified in Section 01 45 00.00 20 QUALITY CONTROL. The Coating Inspector shall be present during all pre-preparation testing, surface preparation, coating application, initial cure of the coating system, during all coating repair work, and during completion activities as specified in Section 01 45 00.00 20. The Coating Inspector shall provide complete documentation of conditions and occurrences on the job site, and be aware of conditions and occurrences that are potentially detrimental to the coating system. The requirements for inspection listed in this Section are in addition to the QC inspection and reporting requirements specified in Section 01 45 00.00 20 QUALITY CONTROL.

3.4.2 Field Inspection

3.4.2.1 Inspection Requirements

Perform field inspection in accordance with ASTM D3276 and the approved Coating Work Plan. Document Contractor's compliance with the approved Coating Work Plan.

Provide all tools and instruments required to perform the required testing, as well as any tools or instruments that the inspector considers necessary to perform the required inspections and tests. Document each inspection and test, including required hold points and other required inspections and tests, as well as those inspections and tests deemed prudent from on-site evaluation to document a particular process or condition, as follows:

a. Location or area;

b. Purpose (required or special);

c. Method;
3.4.2.2 Inspection Report Forms

Develop project-specific report forms as required to report measurements, test results, and observations being complete and conforming to contract requirements. This includes all direct requirements of the contract documents and indirect requirements of referenced documents. Show acceptance criteria with each requirement and indication of conformity of each inspected item. The data may be in any format, but must be legible and presented so that entered data can be quickly compared to the appropriate requirement.

3.4.2.3 Daily Inspection Reports

Submit one copy of daily inspection report completed each day when performing work under this Section, to the Contracting Officer. Note all non-compliance issues, and all issues that were reported for rework in accordance with QC procedures of Section 01 45 00.00 20 QUALITY CONTROL. Each report shall be signed by the coating inspector and the QC Manager. Submit report within 24 hours of date recorded on the report.

3.4.2.4 Inspection Logbook

A continuous record of all activity related to this Section shall be maintained in an Inspection Logbook on a daily basis. The logbook shall be hard or spiral bound with consecutively numbered pages, and shall be used to record all information provided in the Daily Inspection Reports, as well as other pertinent observations and information. The Coating Inspector's Logbook that is sold by NACE is satisfactory. Submit the original Inspection Logbook to the Contracting Officer upon completion of the
project and prior to final payment.

3.4.2.5 Inspection Equipment

All equipment shall be in good condition, operational within its design range, and calibrated as required by the specified standard for use of each device.

3.5 FINAL CLEANUP

Following completion of the work, remove debris, equipment, and materials from the site. Remove temporary connections to Government or Contractor furnished water and electrical services. Restore existing facilities in and around the work areas to their original condition.

-- End of Section --
PART 1   GENERAL

1.1   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT SNT-TC-1A (2016) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

AMERICAN WELDING SOCIETY (AWS)


AWS A3.0M (2010) Standard Welding Terms and Definitions


AWS A5.22 (2012) Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods

AWS A5.32 (2011) Specification for Welding Shielding Gases


AWS A5.9 (2012) Specification for Bare Stainless Steel Welding Electrodes and Rods

AWS D1.1 (2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel

1.2 DEFINITIONS

Definitions shall be in accordance with AWS A3.0M except as follows:

a. Weld slag is defined as the crystalline residue remaining on the weld surface following a weld procedure which uses flux as a shielding method.

b. POL service piping consists of piping and components used for petroleum, oil and lubricants (POL) under pressure or gravity force including modifications to existing hydrant fueling systems.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Welding procedure qualification; G
Welding Operations; G
Detailed procedures which define methods of compliance to contract drawings and specifications.

SD-02 Shop Drawings
POL Service Piping; G
Weld Maps; G

SD-05 Design Data
Welding Procedure Specification (WPS); G

SD-06 Test Reports
Inspection Reports
Procedure Qualification Records (PQR); G
Welder and Welding Operator Qualification Records (WQR); G

Examinations, Inspections and Tests

SD-07 Certificates
Welder and Welding Operator Certifications
Inspector Qualifications; G
NDE Personnel; G
Testing Agency; G

1.4 GENERAL REQUIREMENTS

This section covers the welding of Petroleum, Oil and Lubricant (POL) Service systems. Deviations from applicable codes, approved procedures, and approved detail drawings will not be permitted without prior written approval by the Contracting Officer. Materials or components with welds made offsite will not be accepted if the welding does not conform to the requirements of this specification, unless otherwise specified. Procedures shall be developed by the Contractor for welding all metals included in the work. Welding shall not be started until welding procedures, welders, and welding operators have been qualified. Qualification testing shall be performed by an approved testing laboratory, or by the Contractor if approved by the Contracting Officer. Costs of such testing shall be borne by the Contractor. The Contracting Officer shall be notified at least 1 week in advance of the time and place of the tests. If the Contracting Officer elects to witness the tests, the qualification tests shall be performed at or near the worksite. The Contractor shall maintain current records of the test results obtained in the welding procedure, welding operator, welder performance qualifications, and nondestructive examination (NDE) procedures readily available at the site for examination by the Contracting Officer. The procedures for making transition welds between different materials or between plates or pipes of different wall thicknesses
shall be qualified. Unless otherwise specified, the choice of welding process shall be the responsibility of the Contractor.

1.5 PERFORMANCE

The Contractor shall be responsible for the quality of all joint preparation, welding, and examination. All materials used in the welding operations shall be clearly identified and recorded. The inspection and testing defined in this specification are minimum requirements. Additional inspection and testing shall be the responsibility of the Contractor when he deems it necessary to achieve the quality required.

1.6 QUALIFICATIONS

Welding procedures, welders, and welding operators previously qualified by test may be accepted for the work without requalification, provided that all of the following conditions are fulfilled:

a. Copies of the welding procedure specifications, the welding procedure qualification record, and the welder and welding operator certifications are submitted and approved in accordance with paragraph SUBMITTALS.

b. Testing was performed by an approved testing laboratory or approved technical consultant or by the Contractor's approved quality assurance organization.

c. The welding procedures, welders, and welding operators were qualified in accordance with ASME B31.3 and base materials, filler materials, electrodes, equipment, and processes conformed to the applicable requirements of this specification.

d. The requirements of paragraph "Renewal of Qualification" below are met and records showing name of employer and period of employment using the process for which qualified are submitted as evidence of conformance.

1.6.1 Welding Operations

The Contractor shall provide a description of how the critical welding operations will be accomplished. Provide the welding procedures to be used for each operation, the sequence of welding to minimize heat distortion, sequence of welding piping sections both in the trench and outside, machine welding if used, and multiple welders on same pipe weld.

1.6.2 Welding Procedure Specification (WPS) and Procedure Qualification Records (PQR)

The Contractor shall record in detail and shall qualify the Welding Procedure Specifications (WPS) for every proposed welding procedure. Qualification for each welding procedure shall conform to the requirements of ASME B31.3 and to this specification. The welding procedures shall specify back purge gas requirements, end preparation for butt welds including cleaning, alignment, and root openings. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified. Copies of the Welding Procedure Specifications (WPS) and Weld Procedure Qualification Record (PQR) results for each type of welding required shall
be submitted in accordance with paragraph SUBMITTALS. Approval of any procedure does not relieve the Contractor of the sole responsibility for producing acceptable welds. Welding procedures shall be identified individually and shall be referenced on the POL service piping shop drawings. Submit Welding Procedure Specifications (WPS) and Procedure Qualification Record (PQR) on forms contained within Appendix A of ASME BPVC SEC IX.

1.6.3 Welder and Welding Operator Qualification Records (WQR)

Each welder and welding operator assigned to work shall be qualified in accordance with ASME B31.3. Submit Welder and Welding Operator Performance Qualifications (WPQ) on forms contained within Appendix A of ASME BPVC SEC IX. Qualification testing shall be performed specifically for this project, on-site, after award of contract.

1.6.3.1 Welder and Welding Operator Certifications

Before assigning welders or welding operators to the work, the Contractor shall provide the Contracting Officer with their names together with certification that each individual is performance-qualified as specified. The certification shall state the type of welding and positions for which each is qualified, the code and welding procedure specification under which each is qualified, date qualified, and the firm and individual certifying the qualification tests and shall include the Welder and Welding Operator Qualification Records (WQR). The Contractor shall provide a summary table showing all welders and the Welding Procedure Specifications (WPS) with which they are qualified to weld.

1.6.3.2 Identification

Each particular weld shall be identified with the personal number, letter, or symbol assigned to each welder or welding operator. To identify welds, written records indicating the location of welds made by each welder or welding operator shall be submitted, and each welder or welding operator shall apply the personal mark adjacent to the welds using a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the Contracting Officer that do not deform the metal. Identification by die stamps or electric etchers will not be allowed.

1.6.3.3 Renewal of Qualification

Requalification of a welder or welding operator shall be required under any of the following conditions:

a. When a welder or welding operator has not used the specific welding procedure for a period of 3 months; the period may be extended to 6 months if the welder or welding operator has been employed on another welding procedure.

b. When a welder or welding operator has not welded with any procedure during a period of 3 months, all the personal qualifications shall be considered expired, including any extension by virtue of a., above.

c. There is specific reason to question the person's ability to make welds that will meet the requirements of the specifications.
d. The welder or welding operator was qualified by an employer, other than those firms performing work under this contract, and a qualification test has not been taken within the preceding 12 months.

e. Renewal of qualification for a specific welding procedure under conditions a., b., and d., above, needs to be made on only a single test joint or pipe of a thickness, position, or material required by the welding procedure specifications to reestablish the welder's or welding operator's qualification for the previous qualification.

1.6.4 Inspection Reports

Inspection reports shall consist of the following:

a. Records made by the AWS certified inspector for all duties performed per paragraph 4.2 of AWS QC1.

b. All NDE (radiograph, ultrasound, etc.) reports with unique weld ID for each weld tested.

1.6.5 Inspection and NDE Personnel

All inspection and NDE personnel shall be qualified in accordance with the following requirements. The contractor shall submit the qualifications of all the testing personnel that will perform all field tests for review by the Contracting Officer. The qualifications of all personnel on the job site that will perform welding inspections and NDE shall be submitted for approval. All inspectors and NDE personnel shall have a minimum of one (1) year experience inspecting the piping material being used and five (5) years in military or commercial aircraft hydrant fueling systems or truck fueling systems, petroleum refineries, power generating plants, or chemical process plants.

1.6.5.1 Inspector Certification

Welding inspectors shall be qualified in accordance with AWS QC1 and ASME B31.3, Chapter VI.

1.6.5.2 NDE Personnel

NDE personnel shall be certified in accordance with Chapter VI, ASME B31.3 for each NDE procedure he is required to use, and a written procedure for the control and administration of NDE personnel training, examination, and certification shall be established. The procedures shall be based on appropriate specific and general guidelines of training and experience recommended by ASNT SNT-TC-1A.

1.6.5.3 Testing Agency

The testing agency, testing laboratory, technical consultant or contractor's approved quality assurance organization shall meet the requirements of ASTM E329.

1.7 SHOP DRAWINGS

1.7.1 POL Service Piping
Submit detailed drawings showing location and length of piping and type of welds. Indicate preweld and postweld heat treatment and NDE as required. The drawings shall show the Welding Procedure Specification (WPS) to be used at each weld location.

1.7.2 Weld Maps

Submit shop drawings providing the location of each weld, the procedure used for each weld, and the unique weld identification number which correlates to the NDE test report numbers.

1.8 DELIVERY, STORAGE, AND HANDLING

All filler metals, electrodes, and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to ensure safe handling.

1.8.1 Material Control

Materials shall be stored in a controlled access and clean, dry area that is weathertight and is maintained at a temperature recommended by the manufacturer. The materials shall not be in contact with the floor and shall be stored on wooden pallets or cribbing.

1.8.1.1 Damaged Containers

Low-hydrogen steel electrodes shall be stored in their sealed shipping container. If the seal is damaged during shipment or storage, and the damage is not immediately detected, the covered electrodes in that container shall be rebaked in accordance with the manufacturer's instructions prior to issuance or shall be discarded. If a container is damaged in storage and the damage is witnessed, the electrodes from that container shall be immediately placed in a storage oven. The storage oven temperature shall be as recommended by the manufacturer or the welding material specification.

1.8.1.2 Partial Issues

When a container of covered electrodes is opened and only a portion of the content is issued, the remaining portion shall, within the limits established by AWS D1.1 be placed in a storage oven.

1.8.2 Damaged Materials

Materials which are damaged shall be discarded. Covered electrodes which are oil or water-soaked, dirty, or on which the flux has separated from the wire shall be discarded.

1.9 SYMBOLS

Symbols shall be in accordance with AWS A2.4.

1.10 SAFETY

Safety precautions shall conform to AWS Z49.1.
PART 2   PRODUCTS

2.1 WELDING MATERIALS

Welding materials for carbon steel, stainless steel and aluminum shall comply with AWS WHB-4.8. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures. All field girth root pass welds shall be made with non-covered electrodes or welding wire. External welds on the pipe such as attaching pipe supports may be made with covered electrodes or welding wire. Electrodes, welding wire and/or fluxes shall be in accordance with Table 1.

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Note(1): The consumable material designations shown are examples only and are not intended to limit the Contractor's selection of consumable materials.

PART 3   EXECUTION

3.1 WELDING OPERATIONS

Welding shall be performed in accordance with qualified procedures using qualified welders and welding operators. Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions. The Contracting Officer shall determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall conform to Section 05 12 00 STRUCTURAL STEEL.

Welding shall be performed in accordance with ASME B31.3 and the applicable portions of AWS D10.4.
All joints unless indicated otherwise, in carbon steel, aluminum and stainless steel piping systems shall be welded. Unless otherwise approved, all girth welds shall be complete penetration groove welds made in accordance with qualified welding procedures. The root pass on stainless steel and carbon steel pipe shall be by the GMAW or GTAW process.

a. Weld Preparation shall comply with the requirements of ASME B31.3 and the qualified Welding Procedure Specification. The use of "rice paper" as purge blocks is not permitted. Contractor shall submit alternate method for approval.

b. Backing Rings. The use of backing rings for making or repairing welds will not be permitted.

3.1.1 Base Metal Preparation

Oxy-fuel cutting shall not be used on austenitic stainless steel or nonferrous materials.

Mechanical grinding of thermal cut ends shall be used to remove the heat affected area but should be limited to maximum 1/8 inch.

3.1.2 Weld Joint Fit-Up

Parts that are to be joined by welding shall be fitted, aligned, and retained in position during the welding operation by the use of bars, jacks, clamps, or other mechanical fixtures. End welds shall be properly aligned prior to welding in accordance with Chapter V of ASME B31.3. Welded temporary attachments shall not be used except when it is impractical to use mechanical fixtures. When temporary attachments are used, they shall be the same material as the base metal, and shall be completely removed by grinding or thermal cutting after the welding operation is completed. If thermal cutting is used, the attachment shall be cut to not less than 1/4 inch from the member and the balance removed by grinding. After the temporary attachment has been removed, the area shall be visually examined.

3.1.3 Preheat and Interpass Temperatures

Preheat temperatures shall meet the requirements specified by ASME B31.3. However, in no case shall the preheat be below 50 degrees F for ferritic steel or austenitic stainless steel, or 32 degrees F for nonferrous alloys. The maximum interpass temperatures shall not exceed 300 degrees F for austenitic stainless steels, nickel alloys, and copper alloys; and 500 degrees F for carbon steels. Preheat techniques shall be such as to ensure that the full thickness of the weld joint preparation and/or adjacent base material, at least 3 inches in all directions, is at the specified temperature. Preheating by induction or resistance methods is preferred. When flame heating is used, only a neutral flame shall be employed. Oxy-fuel heating shall not be used on austenitic stainless steel; however, air-fuel heating is acceptable if controlled to ensure that the surface temperature does not exceed 150 degrees F. Interpass temperatures shall be checked on the surface of the component within 1 inch of the weld groove and at the starting location of the next weld pass, and for a distance of about 6 inches ahead of the weld, but not on the area to be welded.

3.1.4 Production Welding Instructions
a. Welding shall not be done when the ambient temperature is lower than 0 degree F.

b. Welding is not permitted on surfaces that are wet or covered with ice, when snow or rain is falling on the surfaces to be welded, or during periods of high winds, unless the welders and the work are properly protected.

c. Gases for purging and shielding shall be welding grade and shall have a dew point of minus 40 degrees F or lower.

d. Back purges are required for austenitic stainless steels and nonferrous alloys welded from one side and shall be set up such that the flow of gas from the inlet to the outlet orifice passes across the area to be welded. The oxygen content of the gas exiting from the purge vent shall be less than 2 percent prior to welding. The flow rate shall be that required by the approved weld procedure specification.

e. The purge on groove welds shall be maintained for at least two passes or 3/16 inch whichever is greater.

f. Removable purge dam materials shall be made of expandable or flexible plugs, such as Plexiglas, plywood (which shall be dry when used), etc. Wood dams shall be kiln-dried quality. Nonremovable purge dams and purge dam adhesives shall be made of water soluble materials. Purge dams shall not be made of polyvinyl alcohol.

g. Any welding process which requires the use of external gas shielding shall not be done in a draft or wind unless the weld area is protected by a shelter. This shelter shall be of material and shape appropriate to reduce wind velocity in the vicinity of the weld to a maximum of 5 mph (440 fpm).

h. Tack welds to be incorporated in the final welds shall have their ends tapered by grinding or welding technique. Tack welds that are cracked or defective shall be removed and the groove shall be retacked prior to welding. Temporary tack welds shall be removed, the surface ground smooth, and visually inspected. For low-alloy and hardenable high-alloy steels, the area shall be magnetic particle examination inspected.

i. Grinding of completed welds is to be performed only to the extent required for NDE, including any inservice examination, and to provide weld reinforcement within the requirements of ASME B31.3. If the surface of the weld requires grinding, reducing the weld or base material below the minimum required thickness shall be avoided. Minimum weld external reinforcement shall be flush between external surfaces.

j. Each qualified welder shall be assigned an identification symbol. All welds shall be permanently marked with the symbol of the individual who made the weld.

k. Direct welded connection of carbon steel and stainless steel shall not be made.
3.1.5 Postweld Heat Treatment

a. Postweld heat treatment shall be performed in accordance with ASME B31.3. Temperatures for local postweld heat treatment shall be measured continuously by thermocouples in contact with the weldment.

b. Postweld heat treatment of low-alloy steels, when required, shall be performed immediately upon completion of welding and prior to the temperature of the weld falling below the preheat temperature. However, postweld heat treatment may be postponed after the completion of the weld, if, immediately after the weld is completed, it is maintained at a minimum temperature of 300 degrees F or the preheat temperature, whichever is greater, for 2 hours per inch of weld thickness.

3.2 EXAMINATIONS, INSPECTIONS, AND TESTS

Weld inspection and NDE shall be performed by the Contractor to detect surface and internal discontinuities in completed welds. The services of a qualified commercial inspection or testing laboratory or technical consultant meeting the requirements of paragraph "Inspection and NDE Personnel," approved by the Contracting Officer, shall be employed by the Contractor. All tack welds, weld passes, and completed welds shall be visually inspected. In addition, liquid penetrant examination shall be performed on root passes. Radiographic, liquid penetrant, magnetic particle, or ultrasonic examination shall be required as indicated below. When inspection and testing indicates disqualifying defects in a weld joint, the weld shall be repaired by a qualified welder in accordance with paragraph CORRECTIONS AND REPAIRS. The Contractor shall submit weld inspection and NDE field testing reports to the Contracting Officer.

The person performing the weld inspection shall perform the following:

a. Verify that the base materials and consumable welding materials conform to the specifications and that welding filler metals used are as specified for each base material.

b. Verify that the welding equipment to be used for the work is appropriate for use with the welding procedure specification and has the capability to meet the applicable requirements of the welding procedure.

c. Verify that only approved or qualified welding procedures are used for the work.

d. Verify that the edge preparation or joint geometry meet the requirements of the welding procedure and drawings.

e. Verify that the specified filler metals are used and that filler metals are maintained in proper condition, per requirements, or as recommended by the manufacturer.

f. Verify that the technique and performance of each welder, welding operator, and tack welder are as specified.

g. Verify that the work conforms to requirements of the applicable standards, drawings, or other documents.
h. Verify that the work inspected is identified and documented in accordance with specified requirements.

i. Prepare clear and concise reports and verify that records of the results of examinations are maintained.

j. Verify the approved WPS pre-heat and post heat procedures are being used.

Welders found making defective welds shall be removed from the work or shall be required to be requalified in accordance with ASME B31.3.

3.2.1 Visual Inspection

Weld joints shall be inspected visually as follows:

a. Before welding - for compliance with requirements for joint preparation, alignment and fit-up, and cleanliness.

b. During welding - for cracks and conformance to the approved welding procedure.

c. After welding - for cracks, contour and finish, bead reinforcement, undercutting, overlap, weld slag on the interior of the pipe and size of welds. Visual examination of the interior of the pipe may be performed by any of the remote means allowed by ASME BPVC SEC V, visual inspection.

3.2.2 NDE Testing Frequency

All pipe field welds, including high point vent pipe tees, weld-o-lets, sock-o-lets and low point drain pipe, shall be examined by radiographic methods to determine conformance to the paragraph "Acceptance Standards." The services of a qualified commercial or testing laboratory approved by the Contracting Officer shall be employed by the Contractor for testing of piping welds. Costs of testing, including retesting of repaired welds, shall be borne by the Contractor.

Provide 100 percent radiographic testing for all underground piping and aboveground piping down-stream of the hydrant issue pumps. Provide random radiographic testing in accordance with ASME B31.3 for all aboveground piping. The inspection shall include an examination of welds made by each welding operator or welder. If the testing reveals that any welds fail to meet minimum quality requirements, an additional percent of the welds in that same group shall be inspected in accordance with ASME B31.3. If all of the additional welds inspected meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds inspected also fail to meet the quality requirements, that entire group of welds shall be rejected. The rejected welds shall be removed and rewelded, or the rejected welds shall be 100 percent inspected and all defective weld areas removed and rewelded.

3.2.3 NDE Testing

NDE shall be as required by ASME B31.3 and in accordance with written procedures. Procedures for radiographic, liquid penetrant, magnetic
particle, or ultrasonic tests and methods shall conform to ASME BPVC SEC V. The approved procedure shall be demonstrated to the satisfaction of the Contracting Officer. In addition to the information required in ASME BPVC SEC V, the written procedures shall include the timing of the NDE in relation to the welding operations and safety precautions.

The services of a qualified testing agency approved by the Contracting Officer shall be employed by the Contractor for testing of piping welds. Costs of testing, including retesting of repaired welds, shall be borne by the Contractor. Procedures for radiographic inspection shall be in accordance with NAVSEA T9074-AS-GIB-010/271 or ASTM E94. Weld ripples or surface irregularities that might mask or be confused with the radiographic image of any objectionable defect shall be removed by grinding or other suitable mechanical means. The weld surface shall be merged smoothly with the base metal surface.

3.2.4 Inspection and Tests by the Government

The Government may perform inspection and supplemental nondestructive or destructive tests as deemed necessary. The cost of supplemental NDE will be borne by the Government. The correction and repair of defects and the reexamination of weld repairs shall be performed by the Contractor at no additional cost to the Government. Inspection and tests will be performed as required for visual inspection and NDE, except that destructive tests may be required also. When destructive tests are ordered by the Contracting Officer and performed by the Contractor and the specimens or other supplemental examinations indicate that the materials and workmanship do not conform to the contract requirements, the cost of the tests, corrections, and repairs shall be borne by the Contractor. When the specimens or other supplemental examinations of destructive tests indicate that materials or workmanship do conform to the specification requirements, the cost of the tests and repairs will be borne by the Government. When destructive tests are made, repairs shall be made by qualified welders or welding operators using welding procedures which will develop the full strength of the members cut. Welding shall be subject to inspection and tests in the mill, shop, and field. When materials or workmanship do not conform to the specification requirements, the work may be rejected at any time before final acceptance of the system containing the weldment.

3.3 ACCEPTANCE STANDARDS

Acceptance standards shall be in accordance with ASME B31.3 paragraph 341.3.2, Chapter VI in addition to the following specified items.

Interpretation of test results and limitations on imperfections in welds shall comply with the requirements of 100 percent radiography, per ASME B31.3, paragraph 341.3.2, Chapter VI. For hydrant systems and stainless steel systems the evaluation shall be based on severe cyclic conditions in addition to the following-specified items.

3.3.1 Visual

The following indications are unacceptable:

a. Weld Slag on the interior of the pipe.
3.3.2 Magnetic Particle Examination

The following relevant indications are unacceptable:

a. Any cracks and linear indications.

b. Rounded indications with dimensions greater than 3/16 inch.

c. Four or more rounded indications in a line separated by 1/16 inch or less edge-to-edge.

d. Ten or more rounded indications in any 6 square inches of surface with the major dimension of this area not to exceed 6 inches with the area taken in the most unfavorable location relative to the indications being evaluated.

3.3.3 Liquid Penetrant Examination

Indications with major dimensions greater than 1/16 of an inch shall be considered relevant. The following relevant indications are unacceptable:

a. Any cracks or linear indications.

b. Rounded indications with dimensions greater than 3/16 inch.

c. Four or more rounded indications in a line separated by 1/16 inch or less edge-to-edge.

d. Ten or more rounded indications in any 6 square inches of surface with the major dimension of this area not to exceed 6 inches with the area taken in the most unfavorable location relative to the indications being evaluated.

3.4 CORRECTIONS AND REPAIRS

Disqualifying defects shall be removed and repaired as specified in ASME B31.3, unless otherwise specified. Disqualifying defects discovered between weld passes shall be repaired before additional weld material is deposited. After defect removal is complete and before rewelding, the area shall be examined by the same test method which first revealed the defect to ensure that the defect has been eliminated. After rewelding, the repaired area shall be reexamined by the same test method originally used for that area. Any indication of a defect shall be regarded as a defect unless reevaluation by NDE or by surface conditioning shows that no disqualifying defects are present.

3.4.1 Defect Removal

Defective or unsound weld joints shall be corrected by removing and replacing the entire weld joint, or for the following defects corrections shall be made as follows:

a. Excessive Convexity and Overlap: Reduce by removal of excess metal.

b. Excessive Concavity of Weld, Undersized Welds, Undercutting: Clean and deposit additional weld metal.
c. Excessive Weld Porosity, Inclusions, Lack of Fusion, Incomplete Penetration: Remove defective portions and reweld.

d. Crack in Weld or Base Metal: Remove crack throughout its length, including sound weld metal for a distance of twice the thickness of the base metal or 2 inches, whichever is less, beyond each end of the crack, followed by the required rewelding. Complete removal shall be confirmed by magnetic particle inspection for carbon steel or liquid penetrant inspection for stainless steel. Inspection procedures shall comply with the requirements of ASME B31.3.

e. Poor Fit-Up: Cut apart improperly fitted parts, and reweld.

3.4.1.1 Methods of Defect Removal

The removal of weld metal or portions of the base metal shall be done preferably by chipping, grinding, sawing, machining, or other mechanical means. Defects also may be removed by thermal cutting techniques. If thermal cutting techniques are used, the cut surfaces shall be cleaned and smoothed by mechanical means to remove the heat affected zone. In addition, a maximum of 1/8 inch of metal shall be removed by mechanical means from the cut surfaces of stainless steel.

Wherever a defect is removed, and repair by welding is not required, the affected area shall be blended into the surrounding surface eliminating sharp notches, crevices, or corners.

3.4.1.2 Rewelding

Repair welds shall be made using an electrode or filler wire smaller than that used in making the original weld. Rewelding shall be done using qualified welding procedures. The surface shall be cleaned before rewelding. Repair welds shall meet the requirements of this specification.

3.4.1.3 Peening or Caulking

The use of force (peening) or foreign materials to mask, fill in, seal, or disguise any welding defects shall not be permitted.

3.5 MAINTAINING CLEANLINESS OF PIPING

The Contractor shall keep the interior and ends of all new piping affected by the Contractor's operations thoroughly cleaned of foreign matter and water before and after being installed. Piping systems shall be kept clean during installation by means of plugs or other approved methods. When work is not in progress, open ends of piping and fittings shall be closed so that no water or other foreign substance will enter the pipes or fittings. Piping shall be inspected before placing into position. The interior of each length of pipe shall be cleaned after welding; A swab, with a leather or canvas belt disc to fit the inside diameter of pipe, shall be pulled through each length of pipe after welding in place. It shall be the Contractor's responsibility for ensuring that the interior of the piping is free of foreign matter including weld slag when it is connected into the system.

3.6 COMMISSIONING
For start-up and commissioning of POL service piping and hydrant systems, see Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP, FUELING SYSTEM.

-- End of Section --
PART 1  GENERAL

1.1  SUMMARY

This Section defines the requirements for factory-fabricated fuel storage tanks.

1.2  REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)


API RP 2003  (2008; 7th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

API RP 540  (1999; R 2004) Electrical Installations in Petroleum Processing Plants

API Std 2000  (2014) Venting Atmospheric and Low-Pressure Storage Tanks

ASME INTERNATIONAL (ASME)


ASTM INTERNATIONAL (ASTM)


ASTM A194  (2016) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both


and Alloy Steel Nuts


ASTM D3308 (2012) PTFE Resin Skived Tape

ASTM F844 (2007a; R 2013) Washers, Steel, Plain (Flat), Unhardened for General Use

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)


NFPA 70 (2017) National Electrical Code

NFPA 77 (2014) Recommended Practice on Static Electricity

NFPA 780 (2017) Standard for the Installation of Lightning Protection Systems

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

AFLP-3747 (2013; Rev 9) Guide Specifications (Minimum Quality Standards) for Aviation Turbine Fuels (F-24, F-27, F-34, F-35, F-37, F-40 And F-44)

STEEL TANK INSTITUTE (STI)

STI 700-50-5007 (2010) Installation Instructions for Shop Fabricated Aboveground Tanks for Flammable, Combustible Liquids

UNDERWRITERS LABORATORIES (UL)

UL 142 (2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation;
Submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
   Product Recovery Tank; G
   Grounding and Bonding
   Water Draw-Off Pump (WDP-1)

SD-03 Product Data
   Product Recovery Tank; G
   Pressure/Vacuum Conservation Vent; G
   Emergency Vent; G
   Sampling/Gauge Hatch; G
   Mechanical Level Indicator; G
   Tank Protective Coatings; G
   Water Draw-Off Pump (WDP-1); G
   Automatic Tank Gauging (ATG); G
   Level Alarm Switches; G
   Spill Containment Basin; G
   Tank Anchoring; G
   Tank Manway Ladder; G

SD-05 Design Data
   Calculations for Tank Anchorage; G
   Emergency Venting Calculations; G

SD-06 Test Reports
   Aboveground Storage Tank Tightness Tests; G
   STI Inspection Report
   Tank Manufacturer's Tests
   Tank Fill Tests
   Water Draw-Off Pump (WDP-1) Certified Test Curves

SD-07 Certificates
   Single System Supplier Qualifications and Experience; G
Licensed Tank Installer
Permitting
Registration
Demonstrations
UL 142
Certified Tank Calibration Chart
Certified System Inventory
Water Draw-Off Pump (WDP-1)
SD-10 Operation and Maintenance Data
Product Recovery Tank
Pressure/Vacuum Conservation Vent
Emergency Vent
Mechanical Level Indicator
Tank Protective Coatings
Water Draw-Off Pump (WDP-1)
Automatic Tank Gauging (ATG)
Level Alarm Switches
Spill Containment Basin
Tank Anchoring
Tank Manway Ladder

1.4 QUALITY ASSURANCE

1.4.1 Contractor Qualifications

Each installation Contractor shall have successfully completed at least 3 projects of the same scope, and the same size or larger within the last 6 years, and demonstrated specific installation experience in regard to the specific system installation to be performed. Each installation Contractor shall have taken, if applicable, manufacturer's training courses on the installation of storage tanks and shall meet all applicable licensing requirements in the State. Submit a letter listing prior projects, the date of construction, a point of contact for each prior project, the scope of work of each prior project, and a detailed list of work performed. The letter shall also provide evidence of prior manufacturer's training, State licensing, and other related information.
1.4.2 Regulatory Requirements

1.4.2.1 Permitting

Obtain necessary permits in conjunction with the installation of underground storage tanks as required by Federal, State, or local authority.

1.4.2.2 Registration

Obtain and complete all required tank registration forms required by Federal, State, and local authorities. Submit all tank registration forms within 30 days after Contract Award. The Contracting Officer will submit the forms to the proper regulatory agencies.

1.4.2.3 Licensed Personnel

Tank installers shall be licensed/certified by the State when the State requires licensed installers.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 PROJECT/SITE CONDITIONS

Exposed moving parts, parts that produce high operating temperatures and pressures, parts that may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired.

PART 2 PRODUCTS

2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 MATERIALS AND EQUIPMENT

2.2.1 General

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design, and workmanship. Provide materials and equipment that have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. The 2 year period shall include applications of the equipment and materials under similar circumstances and of similar size. Provide materials and equipment that have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.
2.2.2 Nameplates

Attach nameplates to all specified equipment defined herein. List on each nameplate the manufacturer's name, address, contact number, component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled. Construct plates of stainless steel. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be the normal block style with a minimum 0.25 inch height. Accurately align all lettering on nameplates.

2.3 MATERIALS

Internal parts and components of equipment, piping, piping components, and valves that could be exposed to fuel during system operation shall not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.4 ELECTRICAL WORK

Provide controllers, integral disconnects, contactors, controls, and control wiring with their respective pieces of equipment. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide switches and devices necessary for controlling and protecting electrical equipment. Controllers and contactors shall have a maximum of 120-volt control circuits and shall have auxiliary contacts for use with the controls provided.

2.4.1 Underground Wiring

Enclose underground electrical wiring in PVC coated conduit. Dielectrically isolate conduit at any steel storage tank connection.

2.4.2 Grounding and Bonding

Grounding and bonding shall be in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.5 PRODUCT RECOVERY TANK AND ACCESSORIES

2.5.1 Steel Tank with Integral Steel Supports

Provide a factory-welded, single wall carbon steel or single wall stainless-steel tank that conforms to NFPA 30, NFPA 30A, and UL 142. Tank shall be designed and manufactured for a horizontal cylindrical installation. Tank shall be mounted on the tank manufacturer's standard UL listed tank saddles that elevates the tank above the underlying concrete slab a minimum of 12 inches. Capacity shall be 4,000 gallons nominal with the dimensions of 6 feet-0 inches in diameter by 19 feet-0 inches in length. Tanks shall have lifting lugs that allow for tank relocation.

a. The tank shall be suitable for installation in an open-top concrete vault.

b. Lifting lugs shall be located at the balance points of the tank and shall be sized with an appropriate safety factor.
c. Tank appurtenances and fittings shall be provided as indicated. Nozzles for appurtenances shall be installed plumb with all above grate flange faces level.

d. Provide two saddle supports designed and constructed in accordance with UL 142 and Section 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. Provide anchorage as necessary to hold down an empty tank should the vault be flooded and the tank completely submerged.

e. Provide insulating flanges kits or di-electric unions between any carbon steel to stainless steel interface, aluminum to carbon steel interface, or aluminum to stainless steel interface.

2.5.2 Tank Protective Coatings

2.5.2.1 Interior Surfaces

Coat 100 percent of a metal tank's interior surfaces including all metal piping and metal appurtenances as specified in Section 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS. Interior tank coating only required for carbon steel tank.

2.5.2.2 Exterior Surfaces, Aboveground Tanks

Protect the exterior surfaces of each aboveground tank as specified in Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES. Exterior tank coating only required for carbon steel tank.

2.5.3 Tank Components

2.5.3.1 Tank Manway

Tank manway shall have an internal diameter of 30 inches. Provide each manway with a matching flanged watertight manway cover. Manway covers shall be UL listed, be constructed of pressed or mild steel, and include a UL listed gasket.

2.5.3.2 Tank Piping Penetrations

Provide the size and type of tank piping connection shown in the Drawings. For double flanged and single flanged connections provide ASME B16.5, Class 150, raised face flanges. For threaded connections, provide welded in place double tapered NPT full couplings, except when noted otherwise. Unless otherwise noted, tank connections will be made on top of the tank.

2.5.3.3 Tank Striker/Impact Plates

Provide an interior striker/impact plate under each tank manway and pipe connection. Each plate shall be a minimum of 1/4 inch in thickness, be larger in diameter than the tank penetration, fit the curvature of the tank bottom, and be completely coated in the same fashion as the interior tank bottom coating. Each plate shall be welded to the tank bottom at the factory (full circumference connection).

2.5.3.4 Tank Internal Ladder

Provide interior tank ladders constructed of stainless steel. The two stringers shall be a minimum 3/8 inch thick and a minimum 2 inches wide.
The rungs shall be a minimum 3/4-inch rod on 12 inches centers. Members of
the ladder shall be securely affixed. Ladder shall be of sufficient length
to extend from the bottom of the tank to the top surface of the tank.
Ladder shall be rigidly connected to the tank bottom in accordance with the
tank manufacturer's standard. Ladder shall be connected to the top of the
tank with pipe guides or slip bars to accommodate expansion of the two
stringers.

2.5.3.5 Tank Fill

Provide a 2 inch double flanged nozzle in the top of the tank with a drop
tube and diffuser for tank fill. Provide an internal aluminum drop tube
with a chambered end terminating 6 inches above the tank floor and an
isolating gasket for dissimilar metal protection.

2.5.3.6 Tank Withdrawal

Provide a 12 inch single flanged nozzle in the top of the tank for the
installation of the product recovery tank pump.

2.5.3.7 Water Draw-Off and Sump

Provide 1 inch double tapered NPT full coupling for water draw-off.
Provide a sump at the low end of the tank for water collection. Sump shall
be a minimum of 12 inches in diameter and 6 inches deep. Include an
internal stainless steel draw-off line extended into the sump with the
opening 1 inch above the sump floor. Provide an isolating gasket for
dissimilar metal protection.

2.5.3.8 Spare Nozzles

Provide a 4 inch and 8 inch single flanged nozzle in the top of the tank as
a spares. Include a blind flange.

2.5.3.9 Float Pilot Manway

Provide a 12 inch single flanged nozzle in the top of the tank. Modify
blind flange to allow for the installation of the float pilot tubing.

2.5.3.10 Level Switch Nozzle

Provide a 12 inch single flanged nozzle in the top of the tank. Modify
blind flange to allow for the installation of the tank and water level
switches.

2.5.3.11 Mechanical Level Gauge Connection

Provide a 2 inch double tapered NPT full coupling for level indication in
the top of the tank.

2.5.3.12 Normal Vent Connection

Provide a 2 inch double tapered NPT full coupling for level indication in
the top of the tank.

2.5.3.13 Manual Gauging Nozzle

Provide a 4 inch double flanged nozzle in the top of the tank with an
internal slotted stilling well.

SECTION 33 56 10 Page 8
2.5.3.14 Tank ATG Nozzle

Provide a 6 inch single flanged nozzle in the top of the tank. Provide with a fabricated blind flange.

2.5.4 Tank Accessories

2.5.4.1 Pressure/Vacuum Conservation Vent

Size and construct vent pipe in accordance with NFPA 30, NFPA 30A, and UL 142. Provide a Pressure/Vacuum Conservation Vent at the termination point of each vent pipe. Vent to be sized to maintain a maximum of 1/2 ounce per square inch pressure or vacuum. Vent body shall be constructed of 316 Stainless Steel. Seats to be replaceable and comprised of Teflon. Provide a minimum 40-mesh stainless steel insect screen. The vent hood shall prevent rain, snow, or ice from entering the vent piping. Vent opening shall be a minimum of 12 ft above grade.

2.5.4.2 Emergency Vent

Provide emergency vent for the primary tank. Emergency vent shall be UL-listed and meet the requirements of NFPA 30, UL 142, and API Std 2000. Vent body shall be aluminum with a flat face flange connection in accordance with ASME B16.5, Class 150. Cover shall be aluminum and rest on a Viton 0-ring seal. Size shall be determined by the manufacturer to meet the requirements of NFPA 30 and API Std 2000. Provide an isolating flange gasket between the emergency vent and the tank nozzle.

2.5.4.3 Sampling/Gauge Hatch and Stilling Well

A sampling and gauging hatch shall be provided and shall consist of a foot-operated, hinged cover with a flexible sealing ring and provision for padlocking. The hatch shall be non-sparking and shall have a flanged connection for installation on 4 inch steel flange. Provide an isolating flange gasket for dissimilar metal protection. Provide a striker plate beneath gauge opening, and stencil reference height on gauge/sampling hatch piping.

Provide an internal aluminum slotted stilling well to within 3 inches of the tank bottom for manual gauging.

2.5.4.4 Mechanical Level Indicator

Provide a clock gauge type liquid level indicator. Gauge body shall be aluminum with a 2 inch NPT connection. Gauge face shall be 6 inches in diameter with a standard 12-hour clock face with the small hand indicating feet and the large hand indicating inches to an accuracy of 1/8 of an inch. Float and cable shall be stainless steel and install through a 2 inch double tapered NPT full coupling.

2.5.4.5 Tank High Level Shutoff Valve

Refer to Spec Section 33 52 43.14 AVIATION FUEL CONTROL VALVES for overfill prevention valve (OV-1). Provide a 2 inch diameter internal drop tube of stainless steel. Provide a stainless steel slotted diffuser, 6 inches above the tank floor, at the end of the fill drop tube. Provide a striker plate under the fill connection and drop tube. Provide an isolating flange gasket for dissimilar metal protection.
2.5.4.6 Product Recovery Tank Pump

Refer to Spec Section 33 52 43.23 AVIATION FUEL PUMPS for product Recovery Tank Pump (FTP-1).

2.5.4.7 Water Draw-off Pump (WDP-1)

The water draw-off pump shall be a rotary gear type pump. The pump construction shall permit the removal of the rotor and gears without disconnecting the pump. Pump capacity shall be 10 gpm with a differential head of 50 feet. The pump and motor shall be mounted on a cast iron or steel subbase. The motor shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for available electric service, shall be totally enclosed, fan cooled, TEFC, and shall conform to the requirements specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Pump shall be provided with stainless suction screen, foot valve, stainless steel drop tube, and aluminum 1-1/2 inch cam type quick disconnect with dust cap. The gear pump shall include an internal and external pressure relief valve between the discharge and suction piping to protect the pump from overloading. Internal relief valve shall be set at 40 PSI and external relief valve shall be as specified in under Safety Relief Valves in spec Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT.

2.5.4.8 Automatic Tank Gauging (ATG)

Liquid-level indicator shall be the mechanically or electronically actuated type that can continuously monitor a tank's usable liquid level and temperature. The system shall provide a digital readout of a tank's liquid level in terms of inches and gallons. The system shall be accurate to plus or minus 1/16 inch. The system shall measure water accumulation in inches from 3/4 to 5 inches off the bottom of a storage tank. Construct system components to be chemically compatible with the fuel to be handled. For each tank monitored, provide a sending unit that transmits the digital readout from a tank to the same electronic monitoring/alarm panel used for the leak detection system. Panel shall be a standard industrial enclosure. Panel doors shall swing left or right. The panel shall display the digital readout of each monitored tank on an LCD mounted exterior to the panel. The panel shall also have external controls to allow operators to toggle between information on the LCD without having to open the panel. Unit shall be Veeder-Root ATG TLS, or Government approved equal and compatible with the Base Fuels Automated System (PAS).

2.5.4.9 Tank Level Switches

The switches shall be an external mount liquid level switch with four-stage (High-High, High, Low, Low-Low) stainless steel shaft and four stainless steel, type 304 or 316, floats and stop collars. Switch contacts shall be double pole double throw switches factory mutual approved or UL-listed for use in Class I, Division 1, Group D hazardous location with a maximum temperature rating of T3 (392 degrees F). Units shall have provisions to check High-High level switch operation without increasing the fuel level in the tanks as shown on the contract drawings. Provide with a fabricated blind flange mounted on a 12-inch single flanged tank nozzle. Nozzle shall be shared with water level switch.
2.5.4.10 Water Level Switch

The switch shall be an external mount liquid level switch with single-stage (High) stainless steel shaft and single stainless steel, Type 304 or 316, float and stop collar. Switch contacts shall be double pole double throw and factory mutual approved or UL-listed for use in Class I, Division 1, Group D hazardous location with a maximum temperature rating of T3 (392 degrees F). Switch shall be mounted on a 12 inch single flanged tank nozzle. Nozzle shall be shared with Tank Level Switches.

2.5.4.11 Vault Liquid Sensor

Vault shall be provided with a continuously and automatically monitored electronic capacitance type liquid sensor. Sensor shall be continuously monitored by tank ATG. Sensor shall be non-discriminating. Sensor shall detect liquids within a minimum of 1 inch off the concrete vault floor (located on the lowest end of the vault).

2.5.4.12 Lockable Cap

Provide a lockable cap for the 2 inch gravity fill line.

2.5.4.13 Spill Containment Basin

Container shall be constructed of fiberglass reinforced plastic, be compatible with the type of fuel being handled, have a minimum 3 gal fuel storage capacity, and form a water-tight seal around the fuel piping to prevent spilled fuel from entering the soil. Container shall be provided with a drain and have an easily removable cover constructed of either cast aluminum or cast iron. Covers shall be weather-resistant and shall prevent the influx of water.

2.5.4.14 Vault Vapor Sensor

Vault shall be provided with a continuously and automatically monitored vapor sensor with integral liquid sensor. Sensor shall be continuously monitored by tank ATG. Sensor shall detect vapors that reach or exceed 25 percent of the lower flammable limit of the liquid stored. Vapor sensor shall be located no higher than 12 inches off the concrete vault floor (located on the lowest end of the vault).

2.5.5 Tank Gauges

2.5.5.1 Stick Gauge

For each tank, provide 2 wooden stick gauges. Gauge length shall allow the measurement of the entire level of fuel in the corresponding tank. Gauges shall be compatible with the fuel to be measured (no swelling or damage from fuel contact). Provide gauge with non-sparking caps on each end. Mark gauges in feet and inches. The smallest unit of measure on the gauge shall be 1/16 inch.

2.5.5.2 Tank Strapping Table

Furnish 2 API MPMS 2.2E certified strapping tables (calibration charts) for each tank. Tables shall indicate the liquid contents in gallons for each 1/16 inch of tank depth. For each tank, provide an electronic media file of each strapping table.
2.6 ACCESSORIES

2.6.1 Concrete Anchor Bolts

Concrete anchors shall conform to ASTM A307, Grade C, hot-dipped galvanized.

2.6.2 Bolts and Studs

Carbon steel bolts and studs shall conform to ASTM A307, Grade B, hot-dipped galvanized. Stainless steel bolts and studs that conform to ASTM A193, Grade 8.

2.6.3 Nuts

Carbon steel nuts shall conform to ASTM A563, Grade A, hex style, hot-dipped galvanized. Stainless steel nuts shall conform to ASTM A194, Grade 8.

2.6.4 Washers

Provide flat circular washers under each bolt head and each nut. Washer materials shall be the same as the connecting bolt and nut. Carbon steel washers shall conform to ASTM F844, hot-dipped galvanized. Stainless steel washers shall conform to ASTM A194, Grade 8.

2.6.5 Polytetrafluoroethylene (PTFE) Tape

Tape shall conform to ASTM D3308.

2.7 FINISHES

2.7.1 Factory Coating

Unless otherwise specified, provide equipment and components fabricated from ferrous metal with the manufacturer's standard factory finish. Each factory finish shall withstand 500 hours exposure to the salt spray test specified in ASTM B117. For test acceptance, the test specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark immediately after completion of the test. For equipment and component surfaces subject to temperatures above 120 degrees F, the factory coating shall be appropriately designed for the temperature service. Stainless steel tank shall not undergo this performance test.

PART 3 EXECUTION

3.1 INSTALLATION

Install work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Handle storage tanks with extreme care to prevent damage during placement and install in accordance with the manufacturer's installation instructions and NFPA 30 or NFPA 30A, as applicable. Inspect the exterior surface of each tank for obvious visual damage prior to and during the placement of each storage tank. Repair surface damage to a storage tank according to manufacturer's requirements before proceeding with the system installation. Provide the termination of fill lines within a tank with an antisplash deflector. Provide nylon dielectric bushings on pipe connections to a steel tank.
3.1.1 Equipment

Properly level, align, and secure equipment in place in accordance with manufacturer's instructions. Provide supports for equipment, appurtenances, and pipe as required. Install anchors, bolts, nuts, washers, and screws where required for securing the work in place. Sizes, types, and spacings of anchors and bolts not indicated or specified shall be as required for proper installation.

3.2 FIELD QUALITY CONTROL

3.2.1 Aboveground Storage Tank Tightness Tests

Perform tightness tests on each aboveground storage tank prior to making piping connections. Perform testing in accordance with STI 700-50-5007 except as modified herein. Gauges used to monitor the tests shall have a scale with a maximum limit of 10 psig. Repair leaks discovered during the tightness tests in accordance with tank manufacturer's instructions. Following any repair, re-test the tank until the tank successfully passes the testing requirements of this Paragraph.

3.2.2 Tank Manufacturer's Tests

In addition to the tests required herein, perform any additional tests (i.e., leak tests, cathodic protection verification tests, etc.,) on each storage test that is required by the tank manufacturer's written test procedures. Manufacturer's tests that are redundant to tests already required by this specification will only be performed once per tank. Repair all leaks discovered during the tests in accordance with manufacturer's instructions. Following tank repairs, re-test the tank until the tank successfully passes the manufacturer's testing requirements.

3.2.3 System Commissioning

System commissioning shall conform to Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS.

3.3 DEMONSTRATIONS

Conduct a training session for designated Government personnel in the operation and maintenance procedures related to the equipment/systems specified herein. Include pertinent safety operational procedures in the session as well as physical demonstrations of the routine maintenance operations. Furnish instructors who are familiar with the installation/equipment/systems, both operational and practical theories, and associated routine maintenance procedures. The training session shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed, but prior to final system acceptance. Submit a letter, at least 14 working days prior to the proposed training date, scheduling a proposed date for conducting the onsite training.

3.4 TANK FILL TESTS

Tank fill tests shall not be performed until after the flushing, cleaning, and adjusting requirements defined in Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS. For the tank fill tests, initially fill each storage tank with fuel in order to verify the tank level alarm system operates properly and the tank overfill protection device functions as
designed. Stop filling each tank immediately once the overfill devices operate. Do not overfill any storage tank more than the 98 percent level. Drain the system below the low liquid level setpoint to verify operation of the low level alarm. Correct and retest any problems with the level alarm system or the overfill device until each operate as specified herein. During the tests, verify that all tank gauges are calibrated and operating appropriately.

3.5 FIELD PAINTING

Painting required for surfaces not otherwise specified shall be field painted as specified in Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES. Do not paint stainless steel and aluminum surfaces. Do not coat equipment or components provided with a complete factory coating. Prior to any field painting, clean surfaces to remove dust, dirt, rust, oil, and grease.

3.6 STI INSPECTION

Just prior to tank being put into service, the tank shall be be inspected by a STI Registered Inspector with Level 1 and 2 Certification. The inspector shall use the standard STI-SP001 checklist for completing the inspection and submit the inspection checklist along with any recommendations or requirements prior to the tank being placed into service.

-- End of Section --
PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

**AMERICAN IRON AND STEEL INSTITUTE (AISI)**

AISI E 1 (2011) Steel Plate Engineering Data Series - Design of Plate Structures, Volumes I & II

**AMERICAN PETROLEUM INSTITUTE (API)**


API MPMS 2.2D (2003; R 2009) Manual of Petroleum Measurement Standards Chapter 2: Tank Calibration - Section 2D: Calibration of Upright Cylindrical Tanks Using the Internal Electro-Optical Distance Ranging Method


API Std 650 (2013; Errata 1 2013; Addendum 1 2014; Errata 2 2014; Addendum 2 2016) Welded Tanks for Oil Storage

API Std 653 (2014) Tank Inspection, Repair, Alteration, and Reconstruction
AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT SNT-TC-1A (2016) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

AMERICAN WELDING SOCIETY (AWS)


AWS QC1 (2016) Specification for AWS Certification of Welding Inspectors

ASME INTERNATIONAL (ASME)

ASME B16.11 (2011) Forged Fittings, Socket-Welding and Threaded


ASME B31.3 (2014) Process Piping

ASTM INTERNATIONAL (ASTM)


NACE INTERNATIONAL (NACE)


NORTH ATLANTIC TREATY ORGANIZATION (NATO)

AFLP-3747 (2013; Rev 9) Guide Specifications
(Minimum Quality Standards) for Aviation Turbine Fuels (F-24, F-27, F-34, F-35, F-37, F-40 And F-44)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.23 Guarding Floor and Wall Openings and Holes
29 CFR 1910.24 Fixed Industrial Stairs
29 CFR 1910.27 Fixed Ladders

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Copies of API Publications; G
NACE Visual Comparator; G
Acknowledgement of Surface Finish Requirements; G
Acknowledgement of API Std 650; G

SD-02 Shop Drawings

Steel Tank; G
Tank Bottom Shimming and Grouting Plan; G
Floating Pan; G
Overflow/Circulation Vents; G
Channel Mounting Pads; G

SD-03 Product Data

Carbon Steel, Pipe Fittings, Flanges, Gaskets, and Bolting; G
Structural Steel; G
Tank Bottom to Foundation Gasket; G
Tank Grout; G
Tank Shims; G
Floating Pan; G
Sample Gauge Hatch; G
Mechanical Tape Level Gauge; G
Center Roof Vent; G
Stairway Step and Platform Tread Grating; G
Gaskets for Manhole Covers and Stilling Well Flanges; G
Aluminum Piping; G
Aluminum Flanges; G
Antiseize Compound; G
Stairway Bolting; G
Floating Seal and Retrieval Winch; G

SD-04 Samples
Tank Bottom to Foundation Gasket; G

SD-05 Design Data
Steel Tank Design; G
Floating Pan Design; G

SD-06 Test Reports
Visual Examination of Vertical Shell-Seam Tack Welds
Visual Examination of Initial Pass of Internal Shell-to-Bottom Weld
Vacuum Box Testing of Internal Shell-to-Bottom Initial Weld Pass
Visual Examination of Completed Internal and External Shell-to-Bottom Welds
Radiographic Examination of Shell Butt Weld
Visual Examination of Shell Butt Welds
Visual Examination of Fillet Welds
Visual Examination of Tank Bottom Plates
Vacuum Box Testing of Tank Bottom Fillet Weld
Pneumatic Tests of Reinforcing Plates
Hydrostatic Testing
Shell Settlement Measurements Taken Before, During, and After Hydrostatic Testing
Internal Bottom Elevation Readings Taken Before and After Hydrostatic Testing
Shell Plumbness
Shell Roundness
Maximum Local Deviations, Shell
Tightness Test Records
Tank Bottom Puddle Test
Roof Puddle Test
Stilling Well Plumbness Test
Submit reports for inspection of welds and radiographs to the Contracting Officer.

SD-07 Certificates
Welding Procedure Specifications (WPS)
Welding Procedure Qualification Records (PQRs)
Welder Performance Qualification Records (WPQ)
Qualifications of Tank Erector
Qualifications of Floating Pan Manufacturer
Qualifications of API Std 653 Inspector
Weld Inspector Certification
NDE Personnel Certification
Qualifications of Testing Agency
Tank Calibration Experience

SD-09 Manufacturer's Field Reports
Floating Pan Prototype Fire Test; G
Mill Test Reports; G
Impact Test Data; G

SD-10 Operation and Maintenance Data
Tank Calibration Table
Electronic Calibration Table
API Std 653 Inspection Reports
Maintenance Instructions,
Operator Instructions
1.3 COPIES OF API PUBLICATIONS

Provide four copies of API RP 2009, API Std 650, and API MPMS 2.2A, API MPMS 2.2B, API MPMS 2.2C and API MPMS 2.2D to the Contracting Officer.

1.4 RELATED REQUIREMENTS

Materials, design, fabrication, welding, erection, testing, and appurtenances shall be in accordance with API Std 650 and as indicated and specified herein. Submit acknowledgement of API Std 650 as required standard. Product to be stored in the tank is AFLP-3747 Jet A (F-24). Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM apply to this section except as specified otherwise.

1.5 DESIGN REQUIREMENTS

Design tank to resist the following loads and forces listed on the structural drawings and for the following:

a. Wind: 120 mph (Risk Category IV per ASCE 7-10).

b. Design specify gravity of liquid is 0.7 to 1.0.

c. Design shell and nozzles for a design liquid level equal to overflow condition.

1.5.1 Seismic Design Requirements

Seismic loads and forces shall be in accordance with API Std 650 Annex E.

a. \( SS = 0.241, S_1 = 0.103 \) per ASCE 7-10.

b. Site Class C.

c. Risk Category IV.

1.5.1.1 Shell Height

Shell height shall provide clearance between the pan at full overflow (bottom of pan at top of overflow) and the fixed roof that includes an allowance of at least 12 inches for sloshing due to seismic event.

1.5.2 Tank Nozzles

Design tank nozzles to accommodate external piping loads in accordance with API Std 650.

1.5.3 Tank Roof

Provide tank roof plates, lap welded with inner plates on top, and at least 1/4 inch thick (includes 1/16 inch corrosion allowance). Support beams shall be designed so as to minimize uncoatable surfaces. Provide solid web or HSS (Hollow Structural Section) type roof beams. Open web trusses shall not be permitted. Do not attach roof support members to the roof plate. Provide a roof with every part having a slope of 1-1/2:12.
1.5.3.1 Emergency Ventilation

Provide emergency ventilation by a frangible roof design. The weld attaching the roof plate to the top angle shall not be greater than 3/16 inch.

1.5.4 Corrosion Allowance

Provide corrosion allowance of 1/16 inch in thickness of steel for the interior of the shell, roof, and interior structural members.

1.5.5 Design Metal Temperature

API Std 650 20 degrees F.

1.5.6 Tank Bottom

Tank bottom and annular ring shall be 5/16 inch (includes 1/16 inch corrosion allowance). Bottom plates shall be lap welded with inner plates on bottom.

1.6 QUALIFICATIONS OF TANK ERECTOR

The Contractor shall be regularly engaged in the erection of API Std 650 tanks. The Contractor shall certify successful completion of at least 12 field erected API Std 650 aboveground tanks in the past three years. The information provided in the Contractor's certification shall include the date of the notice to proceed, date of completion, location of tank, Owner, Owner's point of contact, tank size, configuration (e.g., vertical AST, horizontal AST), product stored, and material of construction.

1.6.1 Welding Qualifications

Submit Welding Procedure Specifications (WPS), Welding Procedure Qualification Records (PQRs), and Welder Performance Qualification Records (WPQ). Qualify all welders on site. Complete all WPQs specifically for this project. Give the Contracting Officer notice and opportunity to witness each of the welder performance qualification tests 24 hours in advance of the performance of each of the tests.

1.7 TANK CALIBRATION EXPERIENCE

Perform calibration of the tank using a qualified organization that can certify to having performed successful and accurate calibration of at least eight tanks of comparable type and size within the last two years. Submit certified data on tank calibration experience.

1.8 QUALIFICATIONS OF FLOATING PAN MANUFACTURER

The floating pan manufacturer shall be regularly engaged in the manufacture and installation of floating pans in API Std 650 tanks. The manufacturer shall certify successful manufacture and installation by the manufacturer of at least 10 floating pans of the type specified in field erected API Std 650 aboveground tanks within the past five years. A minimum of five of those installations shall have been performed on US military installations. The information provided in the manufacturer's certification shall include the date of the notice to proceed, date of completion, location of tank, customer project number or construction
contract number, Owner's point of contact, tank size, and construction type.

1.9 QUALITY ASSURANCE

1.9.1 Delivery and Storage Handling

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.9.2 Steel Tank Drawing Requirements

Drawings for the steel tank and floating pan shall be prepared, sealed, signed, and dated by a registered professional engineer. Include erection diagrams and detail drawings of the tank roof, shell plates, wind girders, openings, and connections for fittings and appurtenances. The steel tank drawings shall include the following:

a. Tank erection details showing dimensions, sizes, thickness, gauges, materials, finishes, and erection procedures.

b. Tank component details to include as a minimum:

(1) Floating pan (including details of support legs, manways, periphery seals, joint attachments, anti-rotation cables, and grounding cables).

(2) Locations of floating pan pressure/vacuum vents and rim seals.

(3) Internal pipe and fittings, including supports and bearing plates.

(4) Tank Bottom to foundation gasket.

(5) Tank Bottom Shimming and Grouting plan and details.

(6) Tank Anchors and Tank Foundation Anchor Bolt drawings and details.

(7) Location of alarm and control switches.

(8) Location of nozzles including nozzles for gauges and alarms.

(9) Roof support system details.

(10) Roof manhole.

(11) Circulation vents/inspection hatches.

(12) Center roof vent.

(13) Overflow port/circulation vent.

(14) Shell manholes and davits.

(15) Stairway, including replaceable stair tread installation and platforms.

(16) Channel mounting pads.
(17) Tank Data Plate Plan and Information.
(18) Shell to bottom connection.
(19) Tank bottom to ringwall interface.
(20) Stilling wells.
(21) Grounding lugs.
(22) Sump.
(23) Scaffold Cable Support.
(24) Shell circulation vents.

1.9.3 Data Requirements

Calculations for the steel tank design and floating pan design shall be prepared by a State registered Professional Engineer. Include calculations for the buoyancy of the floating pan and the structural stability of the floating pan when resting on the support legs. Steel tank design calculations shall include calculations for the design of the shell, as well as calculations for the design of the roof frangible roof connection, tank anchorage (as required) and roof support.

1.9.4 Weld Inspector Certification

Contractor shall arrange for the services of an independent (not employee) weld inspector certified by the American Welding Society to oversee all weld tests and examinations required by API Std 650.

1.9.5 Test Reports

Test Reports shall consist of the following:

a. Records made by the AWS certified inspector for all duties performed per paragraph 4.2 of AWS QC1.

b. All Nondestructive Examination (NDE) (e.g., radiograph, ultrasound, etc., ) reports with unique weld ID for each weld tested.

c. "Weld Map". These maps/drawings correlate the shop drawings submitted to the NDE reports. The NDE report that shows a weld number as acceptable is correlated with weld number on the drawings.

Provide the location of each weld, what procedure was used, which welder made the weld, the results of the visual test, and the results of the NDE.

1.9.6 Inspection and NDE Personnel

All inspection and NDE personnel shall be qualified in accordance with the following requirements. The contractor shall submit the qualifications of all the testing personnel that will perform all field tests for review by the Contracting Officer. The qualifications of all personnel on the job site that will perform welding inspections and NDE shall be submitted for approval. All inspectors and NDE examiners shall have a minimum of one (1) year experience inspecting the piping or plate material being used and five (5) years in military or commercial fueling systems or petroleum
refineries, power generating plants, or chemical process plants.

1.9.6.1 NDE Personnel Certification

A written procedure/quality assurance program for the training, examination, certification, control and administration of NDE personnel shall be established. The procedures shall be based on appropriate specific and general guidelines of training and experience recommended by ASNT SNT-TC-1A. Submit proof of compliance of nondestructive test examiners with API Std 650 including, but not limited to, examiners performing radiographic (RT), visual (VT), penetrant (PT), ultrasonic (UT), and/or magnetic particle (MT) testing.

1.9.6.2 Qualifications of Testing Agency

The testing agency, testing laboratory, technical consultant or contractor's approved quality assurance organization shall meet the requirements of ASTM E329.

1.9.7 Qualifications of API Std 653 Inspector

Contractor shall arrange for the services of an independent (not employee) API Std 653 inspector. API Std 653 Inspector shall have a minimum of five years of experience. Submit copy of current certificate.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the following requirements except that materials not definitely specified shall conform to API Std 650.

2.1.1 Materials for Equipment, Pipe, and Fittings

a. All piping and fittings inside the tank shall be exterior and interior epoxy coated carbon steel except for piping 2 inches and smaller which shall have an uncoated interior. Stilling well and ladder material shall be as indicated. All bolts within the tank shall be of stainless steel construction.

b. Do not weld stainless steel to carbon steel, except where specifically indicated or specified.

c. If materials for equipment are not specified, they shall be stainless steel.

d. Provide stainless steel HLV float control chamber, pilot, level switch housings, and level switch probe holders.

2.2 STRUCTURAL STEEL

API Std 650. Provide mill test reports for shell plates, shell nozzle reinforcing plates, shell insert plates, and all steel plate used in construction of shell penetrations. Provide impact test data when required by API Std 650 for the material group and thickness provided.

2.3 CARBON STEEL, PIPE FITTINGS, FLANGES, GASKETS, AND BOLTING

Carbon steel, pipe fittings, flanges, gaskets, and bolting shall be
provided in accordance with Section 33 52 43.13 AVIATION FUEL PIPING, except gaskets inside tank and on roof nozzles shall be non-asbestos, fuel resistant composition, or preformed type. Flanges shall be weld-neck type in accordance with ASME B16.5. Threaded fittings shall conform to ASME B16.11 (3,000 lb), and butt-welded fittings shall conform to ASME B16.9.

2.4 STAINLESS STEEL PIPE, FITTINGS, FLANGES, GASKETS, AND BOLTING

Stainless steel pipe, pipe fittings, flanges, gaskets, and bolting shall be provided in accordance with Section 33 52 43.13 AVIATION FUEL PIPING and API Std 650, except: Flanges shall be weld-neck type in accordance with ASME B16.5, threaded fittings shall conform to ASME B16.11 (3,000 lb), and butt-welded fittings shall conform to ASME B16.9.

2.5 ALUMINUM PIPING FOR STILLING WELLS

Aluminum pipe shall be ASTM B241, alloy 6061-T6, Schedule 40 for pipe sizes 2 inches through 12 inches; Schedule 80 for pipe sizes 2 inches and smaller.

2.6 BOLTING AND ALUMINUM FLANGES FOR STILLING WELLS

Aluminum flanges shall be ASME B16.5, Class 150 or Class 300 where indicated, Flat Face Type, except aluminum shall conform to ASTM B247, alloy 6061-T6 or alloy 356-T6. Aluminum flanges may be welding neck or slip-on type. Provide bolting in accordance with Section 33 52 43.13 AVIATION FUEL PIPING. Provide electrical isolation for separation of dissimilar metals.

2.7 WELDING FOR ALUMINUM PIPING

2.7.1 Process for Aluminum


2.7.2 Aluminum Welding Electrodes and Rods

AWS A5.10, ER5356 electrodes.

2.8 BOLTING FOR SHELL MANHOLE COVERS

Bolting for shell manholes shall be in accordance with Section 33 52 43.13 AVIATION FUEL PIPING.

2.9 GASKETS FOR MANHOLE COVERS AND STILLING WELL FLANGES

Provide composition asbestos-free, fuel and fire-resistant gaskets for shell manhole covers and stilling well flanges.

2.10 TANK BOTTOM TO FOUNDATION SEAL

2.10.1 Tank Bottom to Foundation Gasket - Self Anchored Tanks

Tank bottom to foundation gasket for self anchored tanks shall be 1/2 inch thick, nonporous Buna-N with a Shore A Durometer Hardness of not more than 40 and a rated tensile strength of at least 1,500 psi. The inside and outside edge of the gasket shall be cut on a radius. Provide gasket in segments at least 8 feet long. Provide three samples of the tank bottom-to-foundation gasket material measuring 1/2 inch by 3 inches by 9
2.10.2 Tank Shims and Tank Grout - Anchored Tanks

Grout shall be non-shrink type and consist of 1 part Portland cement to 1-1/2 parts sand by volume. Do not use calcium chloride admixtures. When the ambient temperature is expected to fall below 60 degrees F within the next 48 hours, the cement used shall be "high early strength" type.

2.11 INTERIOR PROTECTIVE COATING SYSTEM

Section 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS.

2.12 EXTERIOR PROTECTIVE COATING SYSTEM

Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES.

2.13 APPURTENANCES

2.13.1 Floating Pan Installation Hatch

Provide permanent floating pan installation hatch on the tank roof. Provide with bolted cover and water tight gasket.

2.13.2 Floating Pan

The floating pan shall be naturally buoyant by means of honeycomb cell aluminum sandwich panels, be suitable for operation with liquids having a specific gravity of 0.70, be internal to the tank, have full surface contact with the fuel, be equipped with a seal at each penetration, and meet the requirements of API Std 650 Annex H. A rim shall be provided around the floating pan periphery and extend a minimum of 6 inches above the free liquid surface. The rim shall contain turbulence and prevent fuel from splashing up onto the top surface of the floating pan.

2.13.2.1 Pan Integrity

The floating pan shall support the following loading conditions without causing damage to the pan, sinking the pan, or allowing product to spill onto the top surface of the pan in the event the pan is punctured.

a. A uniform load of three times the weight of the pan.

b. A point load of 500 pounds on a one square foot area anywhere on the floating pan while it is floating or resting on the legs.

2.13.2.2 Floating Pan Prototype Fire Test

Perform a fire test on another floating pan design of the same manufacturer that is constructed from the same materials and joining method of the pan being proposed and that meets the floating pan specification in aviation turbine fuel or motor gasoline with a flash point of less than 20 degrees F. Submit manufacturer's certification of fire test indicating the manufacturer's floating pan design has been successfully fire tested and that both of the following tests were successfully performed, without significant damage to the pan, sinking the pan or the fire spreading to the whole surface of the fuel.
a. Hole Fire: The test-floating pan shall have a 12 inch or larger diameter hole cut through it. After being lit, the fuel in the hole shall burn for a minimum of 2 hours.

b. Rim Fire: After being lit, the fuel around the test rim section shall burn for a minimum of 2 hours.

2.13.2.3 Joint Connections

Aluminum sandwich panels shall be joined together by means of a gasketed joint that transmits loads without structural failure or leakage.

2.13.2.4 Aluminum Extrusions

Extrusions shall be made from alloy 6063-T6 in accordance with ASTM B209.

2.13.2.5 Aluminum Sandwich Panels

Panels shall be made from alloy 3003 H14, 3003 H16, 3105 H14, or 5010 H24 in accordance ASTM B209. The skin of the panels shall have a minimum thickness of 0.014 inches. The core of the panels shall be one inch aluminum honeycomb.

2.13.2.6 Support Legs

Floating pan shall be provided with two position self-draining legs that are designed to support a uniform load of 12.5 pounds per square foot. The legs shall be tubular structural members at least 2 inches in diameter and ride with the pan when the fuel level is above the high leg position. The low position shall be as indicated and the high position shall be 78 inches above the shell-to-bottom joint. The exact location and number of the support legs shall be as recommended by the floating pan manufacturer. Provide each support leg with a 2.5 inch polytetrafluoroethylene (PTFE) foot securely fastened to the bottom end of the leg. The portion of the PTFE foot below the metal leg shall be 1 inch thick. The PTFE foot shall be slotted on one side to allow for drainage. The legs shall be capable of allowing a person, standing on top of the floating pan while the tank is in service, to perform the following functions:

a. Change from the high to the low position.

b. Change from the low to the high position.

c. Completely remove the legs.

d. Adjust the legs vertically a distance equal of plus or minus 3 inches.

2.13.2.7 Modification to Support Legs of Existing Tanks

The floating pans of the existing tanks shall be modified to provide two position self-draining legs designed as specified in the above paragraph. The low level switches of the existing tank and tank nozzles associated with the low level switches shall be adjusted consistent with the new low leg positions.

2.13.2.8 Periphery Seals

Periphery seals shall be flexible wiper squeegee and made of closed cell cast urethane. The periphery seal shall fit the space between the tank
shell and the outer edge of the floating pan with two flexible seals, a primary and a secondary. The seals, primary and secondary as a unit, shall accommodate a deviation between the path of the floating pan relative to the tank shell of an additional 4 inches of compression and an additional extension of 2 inches from its normal compressed position at any fluid level. The primary seal shall be above the liquid level. Foam filled coated-fabric seals shall not be accepted. The secondary seal shall be above the primary seal. Seals shall be capable of being replaced during tank operations, be durable in the tank’s environment, be abrasion resistant, and not discolor or contaminate the liquid stored in the tank.

2.13.2.9 Penetrations

All penetrations shall have a rim that extends a minimum of 6 inches above the free liquid to contain product turbulence and prevent the tank product from splashing up onto the top surface of the floating pan.

2.13.2.10 Manhole

Provide one (1) 36 inch floating pan manhole. Manhole shall have a clear inside diameter of at least 36 inches. Manhole shall have a rim that extends a minimum of 6 inches above the free liquid to contain product turbulence and prevent the tank product from splashing up onto the top surface of the floating pan. The manhole cover shall be equipped with a ground cable connected to the floating pan.

2.13.2.10.1 Pressure/Vacuum Vent

The pressure/vacuum (pv) vent shall be sized by the internal floating pan manufacturer for the maximum fill rate of 2,700 gpm and the maximum withdrawal rate of 2,700 gpm. When the pv vent is in the open position, the float shall hang from a strap.

2.13.2.11 Grounding Cables

Provide two or more 1/8-inch diameter, stranded, extra-flexible, stainless steel, wire rope ground cables. Each cable shall extend from the top of the floating pan to the fixed roof and shall be long enough to accommodate the full travel of the pan. The exact location, number, and size of grounding cables shall be as recommended by the floating pan manufacturer.

2.13.2.12 Anti-Rotation Cable

Provide a minimum of two 1/4-inch diameter anti-rotation cables made of 304 stainless steel conforming to ASTM A492. Fittings for anti-rotation cables including cable clamps, pins, sockets, turnbuckles, U-bolts and nuts, etc., shall be 304 stainless steel. Cable shall be made taut by means of the turnbuckle. The exact location, number, and size of the anti-rotation cables shall be as recommended by the floating pan manufacturer.

2.13.3 Sample Gauge Hatch

Provide sample gauge hatch on top of stilling well where indicated for manual gauging. Equip hatch with a self-closing, foot-operated, lockdown cover of nonferrous metal. Provide gasket for dissimilar metal protection.

2.13.3.1 Floating Seal and Retrieval Winch

Provide a floating seal, retrieval cable, weight, and a retrieval winch on
sample gauge roof nozzle equipped with fully slotted stilling well. Floating seal shall move freely inside the stilling well with the rise or fall in liquid level while providing a double seal against the escape of vapors from the stilling well. Seal elastomers shall be Buna-N and shall seal at approximately the same level as the stilling well floating pan penetration seal (approximately 6 inches above the level of the liquid). Retrieval winch and cable shall be capable of retrieving floating seal into a storage compartment mounted on top of the stilling well nozzle. All fasteners shall be stainless steel; all other metallic components of float and seal shall be aluminum. Storage compartment and components, except for bearings, shall be stainless steel. The retrieval cable shall be 1/8 inch stainless steel. Storage compartment shall be equipped with a latch and hinge so that the compartment (with a fully retrieved float, cable, and weight) and winch can be temporarily moved out of the way to provide access to the stilling well. Latch and hinge shall be designed to hold the compartment securely to the nozzle in winds up to 125 mph. Storage compartment flange shall also be provided with a rain lip to provide a weather tight seal around the top of the roof nozzle. Winch shall be hand operated, shall require no more than 5 pounds of force to operate, and shall be equipped with an anti-reverse mechanism and operator that may be disengaged from the retrieval spool when not being operated manually. When disengaged from the winch, the retrieval spool shall maintain tension on the retrieval cable not exceeding the weight of the cable and the weight.

2.13.4 Mechanical Tape Level Gauge

The mechanical tape level gauge shall be complete with all necessary incidental pipe, pulleys, fittings, supports, support brackets, tension springs, and guide wire assemblies. The gauge shall automatically provide the location of the floating pan within plus or minus 1/8 inch of the actual liquid level. The head shall be made of aluminum and shall be mounted on the exterior of the tank shell approximately 54 inches above the tank bottom. The head shall contain a glass covered window complete with an inside wiper. The seals shall be made of Teflon. The shafts, graduated tape, and tape drum assembly shall be made of stainless steel. The tape shall be of sufficient length to measure the liquid level from the bottom to the top of the storage tank. Gauge measurements shall be graduated in 1/16 inch increments. The tape shall be carried over pulleys housed in elbow assemblies at each change of direction.

2.13.5 Venting

Provide tank venting as indicated.

2.13.5.1 Overflow/Circulation Vents

Provide open overflow/circulation vents on the upper shell as indicated and in accordance with API Std 650, Annex H. Provide vents with stainless steel bird screen with 2.0 square feet of net open area minimum. Insect screens shall not be allowed.

2.13.5.2 Center Roof Vent

Provide open vent at the center or at the highest elevation of the roof. Open vent shall have a weatherhood as indicated and stainless steel bird screen as indicated on the drawings with openings welded in place. Weatherhood shall be removable. Insect screens shall not be allowed.
2.13.6 Circumferential Stairway and Platforms

OSHA 29 CFR 1910.24 and 29 CFR 1910.23. Provide circumferential stairways as indicated. Coat stairway in accordance with the tank exterior coating specification. Provide one approach step on the secondary containment concrete as indicated. Provide shell mounted metal bar stairway step and platform tread grating with non-slip nosings. Support the stairway and platforms completely on the shell of the tank with bottom-of-shell-mounted portion clear of and not structurally supported or connected to the ground or approach steps. Provide rise and run of stairway steps as indicated, adjusting slightly to suit final layout of the tank and its appurtenances, but with rise and run consistent from the ground level to the top platform. Construct stairway entirely of steel. Provide landings for accessing the upper manhole, high level alarm switches, level control float pilot chamber, and tank roof. Railings shall be continuous around the platforms, except for access openings, and shall be constructed similar to the roof perimeter guardrail. At access openings, any space wider than one inch between the tank and the platform shall be floored. Ends of handrails, guardrails, and posts shall be sealed by welding. Guardrails shall be constructed in welded sections and their posts seal welded or bolted to the stringers. Continuously butt-weld platform guardrail toeboards to guard rail posts.

2.13.7 Roof Perimeter Guardrail

Construction of roof perimeter guardrail shall be as-detailed on the drawings and in accordance with OSHA. Finishing of roof perimeter guardrail shall be similar to the stairway.

2.13.8 Internal Ladders

OSHA 29 CFR 1910.27. Provide an internal ladder extending from the roof manhole to the tank bottom as indicated. Provide with aluminum safety rail as indicated. Provide removable aluminum safety rail extension as indicated. Refer to drawings for additional details. Weld one of the pipes (align vertically) to the top rail of the roof perimeter guardrail near the roof manhole. Weld the second pipe (align vertically) to the toeboard directly below the first for storing the removable safety rail extension.

2.13.9 Roof Manhole

Provide roof manhole and 3/16 inch cover with rain lip as indicated for access to the interior of the tank through the roof. Provide with stainless steel hardware (flat bar, round bar, eyebolt, etc.).

2.13.10 Roof Circulation Vent/Inspection Hatches

Provide roof vent/inspection hatches in the fixed roofs of aboveground storage tanks as indicated and in accordance with API Std 650, Annex H. Each roof vent/inspection hatch shall be provided with a roof reinforcing plate the same thickness as the roof plate. Provide with stainless steel bird screen as indicated on the drawings and 2.0 square feet of net open area minimum. Insect screens shall not be allowed.

2.13.11 Water Draw-Off System

Refer to Specification Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT for water draw-off system.
2.13.12 Shell Manholes

Provide shell manholes, manhole covers with filler drums, and davits as indicated. Hinged covers shall not be allowed.

2.13.13 Scaffold Cable Support

Provide two scaffold cable supports on the tank roof in accordance with API Std 650. Locate the support near the center of the tank and in a manner that supported cables will have maximum range and flexibility of operation with minimum interference with other tank fittings.

2.13.14 Antiseize Compound

Provide marine grade antiseize compound for fasteners on tank exterior flanges and bolted connections and covers. On tank interior fasteners, use oil only.

2.13.15 Channel Mounting

Provide seal welded channel mounting pads with seal welded stainless steel bolting studs for mounting channel to support conduit, tubing, and level alarm test/drain piping. Rack tubing, small piping, and conduit parallel to the shell as indicated. Do not mount within 7 feet above stairway.

2.13.16 Anchors

When anchors are required by API Std 650 provide with anchor bolt chairs conforming to AISI E 1 Steel Plate Engineering Data and as indicated.

2.13.17 Slip Resistant Coating

Provide slip resistant coating on the roof at the sample gauge well, the automatic tank gauging nozzle and the roof access manway.

PART 3 EXECUTION

3.1 SAFETY PRECAUTIONS

API RP 2009 for fire and explosion hazard areas.

3.2 API Std 653 INSPECTION REPORTS

The API Std 653 inspector shall inspect the completed tank in accordance with API Std 653 and deliver a full report to the Contracting Officer. The report shall include a record of ultrasonic thickness measurements (UTMs), exclusive of the coating, of each tank bottom plate, each bottom shell course plate at 5 random locations per plate, the shell along the circumferential stairway at 5 locations per shell course. The record of UTMs shall include sketches of the tank bottom plate and shell plate layouts. The location on each plate, where each ultrasonic thickness measurement (UTM) is taken, shall be recorded. Five UTMs shall be recorded on each tank bottom plate and on each lowest shell course plate. Five UTMs shall be recorded for each of the shell courses above the lowest shell course and shall be taken along the circumferential stairway. The report shall include the tank dataplate information and photograph of the tank data plate. Provide electronic copies of the tank inspection reports to MAJCOM, Service Headquarters, Service Control Points, and DLA-Energy. The
paper and electronic copies of the report and UTMs shall be provided to the Contracting Officer for filing with the tank's "as-built drawings." Refer to Section 01 45 00.00 20 QUALITY CONTROL for API Std 653 inspector certification requirements.

3.3 CONSTRUCTION

3.3.1 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access in locations freely accessible through access doors.

3.3.2 Tank Erector Site Superintendent

Tank erector site superintendent shall be on site at all times during any work by that crew.

3.3.3 Floating Pan Superintendent

Floating pan superintendent shall be on site at all times during any work by the crew.

3.3.4 Tank

Provide tank of welded construction and support tank on a concrete ring wall. On the side of the tank furthest from the sump, slope the tank bottom down to the sump approximately 6 inches for each 10 feet of tank radius. Butt weld or lap weld bottom plates with the outer plates on top. Lap annular ring on top of bottom plates or butt weld to the bottom plates. Reinforce openings larger than 2 inches in diameter through plating of the tank shell and roof. Provide structural stiffening, consisting of rings, thicker plates, or other approved means, to maintain roundness when the tank is subjected to wind or seismic loads.

3.3.5 Roof Plate Seams

Tank roof plate shall be lap welded with the plates closer to the center of the tank on top.

3.3.5.1 Prohibition of Protective Coatings on Surfaces to be Welded

Remove protective coatings on surfaces to be welded and on surfaces within one inch from weld preparation. "Weld-through" inorganic zinc coatings and similar coatings will not be permitted.

3.3.6 Roof Supports

Roof support columns shall not be allowed.

3.3.7 Surface Finishing

Provide Contracting Officer with NACE visual comparator as described in NACE SP0178 Section 4. Finish interior surfaces before hydrotesting, in accordance with Section 4 of NACE SP0178 and accompanying Visual Comparator, to the condition described and shown for NACE Weld Designation "C" welds. Finish exterior surfaces, in accordance with Section 4 of NACE SP0178 and accompanying Visual Comparator, to the condition described
and shown for NACE Weld Designation "D" welds. Submit acknowledgement of surface finish requirements. Remove all weld splatter, sharp corners, edges and points from all carbon steel surfaces before coating.

3.3.8 Tank Bottom To Foundation Seal

All anchored tanks are to be grouted before loading with water or product and before tightening anchor bolts. Prepare the top of the foundation for shimming and grouting by removing all dirt, sand, and loose material. Provide 1 inch shim on top of foundation at high point and develop all other shim stacks to match the elevation of the shim at the high point of the foundation. Place shims a minimum of 1-1/2 inches inside the perimeter of the tank bottom and under the tank shell. Do not retemper (add water) to a stiffening grout mix. Place grout within 30 minutes after mixing with water or discard the mix.

3.3.9 Attachments

All exterior shell and roof attachments shall be connected to the tank using continuously welded mounting plates. Mounting plates shall exceed the size of the attachment by a minimum of 1 inch. All mounting plate corners shall have a 2 inch radius. Attachment shall be seal welded to the mounting plate with structurally sound welds of sufficient size to support the intended loads.

3.3.10 Nozzles

All shell nozzles shall be flanged type. Shell nozzles sizes 2 inches or larger shall have a reinforcing plate. Nozzles for pipe connections inside the tank shall be flanged inside near the shell. Reinforcing plates for shell nozzles shall be rolled to the curvature of the shell.

3.3.11 Tank Bottom Sump

Weld sump to the underside of the tank bottom at the lowest point of the tank bottom as indicated.

3.4 INSTALLATION OF INTERNAL FLOATING PAN

Install floating pan after coating of the interior of the tank is complete. Protect tank coatings during installation of floating pan to prevent damage. Repair damage to the coating that may occur during the installation of the pan.

3.5 END CONNECTIONS FOR EQUIPMENT, VALVES, PIPE, AND FITTINGS

All valve, equipment, pipe and fitting connections including, but not limited to, piping for the Water Draw-Off System, drains, thermal reliefs, HLV float pilot chamber, and level switches shall be welded or flanged except as indicated. Piping and fittings 2.5 inches and larger shall be butt welded. Piping and fittings 2 inches and smaller may be butt welded or socket welded. Threaded connections shall not be allowed except where welded or flanged connections to appurtenances are not available, e.g., pressure gauges, fuel sample connections, level switch probes, HLV float pilot chamber, etc.

3.6 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field
tests and trial operations specified in this section. The Contractor shall perform all trial operations and field tests and provide all labor, equipment and incidentals required for testing.

3.6.1 Tank Calibration Table

After installation of the tank is complete, provide two calibration tables stamped by a Professional Engineer, one in English units and one in metric units. Tables shall be laminated. Both tables shall show the volume of the fuel for all liquid levels in the tank starting at the bottom of the sump and going up to the level of the overflow. The English unit calibration table shall show the volume of fuel in gallons and in barrels of 42 gallons and the level of the fuel in 1/16-inch increments. The table shall include notes at the bottom indicating 42 gallons = 1 barrel. Volume calculations shall be in the smaller units. Larger units may be obtained by rounding off. The 0 inch level shall be the level of the bottom of the shell. Level below the bottom of the shell shall be shown in negative units starting at the bottom of the shell. The level of the bottom of the shell, alarm set points, high level shut off valve actuation point, and the level of the overflows shall be identified on the calibration table (strapping chart). The table shall not include tank volume above the level of the overflows. Also, provide Electronic Calibration Table compatible with the Electronic Automatic Tank Gauging System. Contact Contracting Officer for direction on required format.

3.6.1.1 Tank Calibration Method

The tank gauging systems shall be calibrated in accordance with the API Manual of Petroleum Measurement Standards (API MPMS) for critical measurement using methods outlined in one of the following chapters.

b. API MPMS 2.2B, Calibration of Upright Cylindrical Tanks Using the Optical Reference Line Method.
c. API MPMS 2.2C, Calibration of Upright Cylindrical Tanks Using the Optical Triangulation Method.
d. API MPMS 2.2D, Calibration of Upright Cylindrical Tanks Using the Internal Electro-Optical Distance Ranging Method.

3.6.1.2 Tank Calibration Tables for Existing Tanks

After modification to the existing Tanks 1 and 2 are complete, provide two new calibration tables stamped by a Professional Engineer, one in English units and one in metric units for the existing tanks as specified above. Work shall include recalibrating the existing automatic tank gauging (ATG) in accordance with the new calibration tables (strapping charts) for the existing tanks.

3.6.2 Weld Inspection

Perform inspection of welds in accordance with API Std 650. Inspect butt welds requiring complete penetration and complete fusion by the radiographic method. Inspect roof support column welds below design liquid level by visual and dye penetrant methods. Submit the following weld inspection reports to the Contracting Officer:
a. Visual examination of vertical shell-seam tack welds, if left in place, in butt welds.
b. Visual examination of initial pass of internal shell-to-bottom weld.
c. Vacuum box testing of internal shell-to-bottom initial weld pass.
d. Visual examination of completed internal and external shell-to-bottom welds.
e. Radiographic examination of shell butt weld.
   (1) Submit reports for inspection of welds and radiographs to the Contracting Officer.
f. Visual examination of shell butt welds.
g. Visual examination of fillet welds.
h. Visual examination of tank bottom plates after welding.
i. Vacuum box testing of tank bottom fillet weld.
j. Pneumatic tests of reinforcing plates.

3.6.3 Reports of Other Tests and Examinations

Submit reports of the results of the following examinations and tests required by API Std 650 to the Contracting Officer:

a. Hydrostatic testing.
b. Shell settlement measurements taken before, during, and after hydrostatic testing.
c. Internal bottom elevation readings taken before and after hydrostatic testing.
d. Shell Plumbness.
e. Shell Roundness.
f. Maximum local deviations, shell.

3.6.4 Tightness Tests

Perform tightness tests described under this paragraph in accordance with API Std 650, as modified herein. Perform the tests after finishing welds in accordance with the paragraph titled SURFACE FINISHING, but prior to blast cleaning and application of the protective coating. Submit tightness test records to the Contracting Officer.

3.6.4.1 Penetrating Oil Test

Inspect tank shell-to-bottom, inside corner welds using the penetrating oil test prior to any vacuum box testing. After the initial inside fillet weld is made, apply No. 2 Diesel to the outside of the inside corner weld (before the outside weld is made). After 4 hours, inspect the inside
fillet weld for oil penetration through defects. The contractor shall correct any defects. Remove oil completely prior to finishing weld joint. Then, complete the remainder of the shell-to-bottom weld joint.

3.6.4.2 Vacuum Box Test of Tank Bottom

Perform a vacuum box test of the tank bottom immediately after installation and after completion of the penetrating oil test. Test seams in bottom of tank and shell-to-bottom joint by applying a commercial soap film and subjecting the seam to a vacuum. Use a glass top vacuum box with hypalon or neoprene sealing gasket. Apply a commercial bubble forming solution to the weld or area to be tested; position the vacuum box over the area and slowly pull a partial vacuum. Observe the solution film for bubble formation between 0-2 psi differential pressure. Continue to open the valve until a differential pressure of 5 psi or 11.5 feet of water or 10.2 inches of mercury is achieved and hold for at least 20 seconds while continuing to observe the solution for bubbles.

3.6.4.3 Hydrostatic Test and Settlement

Perform hydrostatic test with fresh water only. Prior to hydrostatic testing, check the capacity and condition of the tank venting and overflows to insure they are adequate to handle the potential rate of fill. This procedure shall be accomplished prior to application of coatings and before connecting product/operating piping to the tank. Shell settlement shall be measured before, during, and after hydrostatic testing in accordance with API Std 650. Hydrostatic test the shell by filling tank with water and maintaining it full for a period of not less than 72 hours or until the settlement of the tank stabilizes, then inspect shell for leaks. The appearance of damp spots shall be considered evidence of leakage. Minimize water retention time to limit rusting of tank interior. Repair leaks disclosed by the test; then, retest the tank to prove the tank is leak-free. Sufficient water to hydrostatically test the tanks will be provided free of charge by the Government at a maximum rate of 100 gpm. Water used on one tank shall be recycled to the fullest extent possible for use in testing subsequent tanks. No water shall be released to the sanitary or storm sewer systems without the expressed, written approval of the Contracting Officer.

3.6.5 Tank Bottom Puddle Test

Test slope of the tank bottom in the presence of the Contracting Officer by examining the plate immediately after hydrotesting. Puddling deeper than 3/16 inch anywhere on the tank bottom plates shall not be accepted.

3.6.6 Fill Test and Related Miscellaneous Tests

3.6.6.1 Fill Test

After other tightness testing is complete and after application and cure of the interior and exterior coatings, fill test the tank using fuel. Tank piping and appurtenances shall be ready for service. The Government will provide the necessary fuel and labor to fill the tank with fuel. Advise the Contracting Officer, in writing, at least 14 calendar days in advance of the need for this service and provide access to the interior of the tank for the Contracting Officer's inspection to ensure the tank is clean and dry to the Government's satisfaction prior to receiving fuel.

a. Floating Pan Tests
Following the installation of a floating pan, the deck penetrations and rim area shall be subjected to a visual inspection for seal tightness. Leaks or seal deformations shall be corrected according to manufacturer's recommendations. Following the seal inspection, the floating pan shall be subjected to a flotation test. The tank shall be filled to the 10 foot level with fuel and the top of the floating pan shall be visually inspected for fuel leakage. The appearance of damp spots on the top of the floating pan shall be considered evidence of leakage; the Contracting Officer shall be notified and the fuel removed immediately. Leaks shall be repaired and the flotation test performed again.

b. Fill Test Stages

Check to ensure drain valves are closed; fill tank to 50 percent of full capacity; and check tank for leaks. Keep tank half full the first 12 hours of test, then fill tank within 3 inches of the bottom of the overflows; check that drain valves are closed and check tank for leaks. Monitor tank level hourly during the first 24 hours of the fill test and notify the Contracting Officer immediately of any damp spots or leaks detected. Padlock drain valves closed for the duration of the test and provide one set of keys to the Contracting Officer. After the temperature of the fuel has become stabilized, take daily readings of the fuel level for a period of 10 calendar days. If there are no damp spots, discoloration, leaks or a measurable drop in the fuel level during this period, the tank will be accepted. If leakage becomes apparent during the filling or the test period, immediately notify the Contracting Officer and Government personnel will pump the fuel from the tank. Free the tank of vapor, clean it, and then carefully inspect the tank for evidence of failures at the Contractor's expense. Repair defects found and repeat fill tests.

c. Tank High Level Shutoff Valve

Check the operation of the high level shutoff valve on the inlet to the tank to insure that the valve closes completely and as indicated, no later than the high-high level. Check closing by the float valve and the solenoid pilot valve separately. Before the tank high level is reached, verify operation of the valve by the manual operation of the float and solenoid pilot as well as by filling the level switch chamber and again by filling the float chamber with fuel. Check for proper operation when the tank is filled using appropriate safety measures.

d. Water Draw-Off System

Check System Operation

3.6.7 Roof Puddle Test

After coating, test slope of the finished tank roof plate in the presence of the Contracting Officer by applying water for five minutes, evenly in all directions, at a rate of not more than 5 gallons per minute, near the center of the roof, and examining the roof plate for puddling. Puddling deeper than 3/16 inch anywhere on the tank roof plates shall not be accepted.

3.6.7.1 Stilling Well Plumbness Test

All stilling wells shall be aligned vertically and tested with a plumb bob in the presence of the Contracting Officer to ensure that they are plumb.
and are directly centered over the datum plates or sump.

3.6.8 Retesting

Deficiencies found shall be rectified and work effected by such deficiencies shall be completely retested at the Contractor's expense.

3.6.9 Maintenance Instructions

Provide the following instructions in the Operation and Maintenance Data as follows: Schedule periodic recalibration of ATG at 15 year intervals in accordance with API Manual of Petroleum Measurement Standard (API MPMS) Chapter 2.0 for tanks in custody transfer service and at 15-20 year intervals for all others, or when operating variables of the storage tank change, or when internal dimensions and structural variables of the tank change.

3.6.10 Operator Instructions

Provide the following instructions in the Operation and Maintenance Data as follows:

a. Inspect the tank bottom to foundation perimeter mastic seal quarterly for deterioration and request maintenance when deterioration is found.

b. Keep the leak detection tell-tale valve/valves normally closed. Temporarily open the valves to check for tank bottom leaks on a monthly basis.

c. Test the low-low, low, high and high-high level alarm switches semiannually. Test level switches by simulating product levels either manually or by operating the water stripping system pump and level alarm/control test/drain header valves.

d. Examine and clear the tank venting semi-annually to insure the vents have not become plugged.

-- End of Section --
PART 1    GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM D2136 (2002; R 2012) Coated Fabrics – Low-Temperature Bend Test

ASTM D3776 (2009a; R 2013) Standard Test Method for Mass Per Unit Area (Weight) of Fabric

ASTM D413 (1998; R 2013) Rubber Property – Adhesion to Flexible Substrate


ASTM D4632 (2015a) Grab Breaking Load and Elongation of Geotextiles

ASTM D4833 (2007; E 2013; R 2013) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products


Seam Evaluation by Vacuum Chamber

ASTM D5820
(1995; R 2011) Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

ASTM D5884

ASTM D5893

ASTM D6241

ASTM D696

ASTM D7238

ASTM D751
(2006; R 2011) Coated Fabrics

ASTM E228

ASTM E96

ASTM G152

ASTM G153

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Installation; G
Liner Projections; G
As-Built Drawings; G

SD-03 Product Data

Fabric Reinforced Geomembrane Liner; G
Flexible Membrane Liner (FML) Under Storage Tanks; G
Nonwoven Geotextile; G
Liner Fittings; G
Embedment Strips; G
Mounting Strip System; G
Stainless Steel Band Clamp; G
Sealant; G
Permanent Sand Bags; G
Manufacturer's Warranty
Installer's Warranty

SD-04 Samples

Fabric Reinforced Geomembrane Liner; G
Flexible Membrane Liner (FML) Under Storage Tanks; G
Nonwoven Geotextile; G
Liner Fittings; G
Embedment Strips; G
Mounting Strip System; G
Stainless Steel Band Clamp; G
Destructive Field Seam Test Sample; G
Finished Color Sample; G

SD-05 Design Data

Wind Uplift Calculations; G

SD-06 Test Reports

Trial Seam Logs
Non-Destructive Field Seam
Destructive Field Seam

SD-07 Certificates
Field Engineer Qualifications
Installer Qualifications
Fabricator Certification
Liner Manufacturer's Certification
Subgrade and Surface Preparation Acceptance Letter

SD-08 Manufacturer's Instructions
Liner Manufacturer's Installation Instructions

SD-10 Operation and Maintenance Data
Geomembrane Liner; G

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship. Materials and equipment must have been in satisfactory commercial or industrial use for a minimum 2 years prior to bid opening. The 2 year period must include applications of the equipment and materials under similar circumstances and of similar size. Materials and equipment must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

1.3.2 Field Engineer Qualifications

Provide a field engineer who has successfully completed manufacturer's training on handling and installing of the fuel impermeable liner to be installed. Demonstrate that the engineer has at least one million square feet of liner installation experience. Submit a letter providing evidence of the field engineer's experience, training, and licensing. In regard to the field engineer's experience, include in the submittal a point of contact, a phone number, the address, the type of installation, and the current status of each installation mentioned.

1.3.3 Installer Qualifications

The installer is responsible for field handling, deploying, seaming, anchoring, and field Quality Control (QC) testing of the geomembrane. Demonstrate that the installer has installed the proposed geomembrane material for at least 5 completed projects and a total minimum area of 1 million square feet. At least one seamer must have experience seaming a minimum of 500,000 square feet of the proposed geomembrane using the same
type of seaming equipment and same geomembrane specified for this Project.

1.3.4 Factory Seams

Where possible, use geomembrane factory fabricated to Project specific panels in order to minimize field seams. Fabricator must conduct visual inspections on completed seams, as well as non-destructive and destructive testing to verify compliance with the seam strength requirements stated in Table 1. Provide fabricator certification of factory seams, including documentation of and results from quality control testing conducted.

1.3.5 Liner Manufacturer's Certification

Following the successful installation and testing of the liner, an authorized representative from the liner manufacturer must submit a letter certifying that the liner installation and testing results are satisfactory and that each meets the company's quality expectations and warranty. The letter must also certify that the liner installed is compatible with and recommend for use with the fuel to be stored. Include in the letter the representative's name, address, phone number, and qualifications for being a manufacturer's representative.

1.4 DESIGN REQUIREMENTS

Provide certified engineering wind uplift calculations to determine required placement of permanent sandbags based upon the proposed liner and ballast materials.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer.

1.5.1 Delivery

The QC inspector must be present during delivery and unloading of the geomembrane. Label each geomembrane roll/panel with the manufacturer's name, product identification number, roll/panel number, and roll/panel dimensions.

1.5.2 Storage

Store geomembranes and geotextiles elevated off of the ground and covered to provide protection from precipitation, sunlight/ultraviolet light, puncture/abrasion, undesirable chemicals (as recommended by the manufacturer), and flames/welding sparks. Storage in temperatures between 32 degrees F and 160 degrees F, or as recommended by the manufacturer. Storage must not result in crushing the core of roll goods or flattening of the rolls. Do not store rolls more than two high. Store palleted materials on level surfaces and not stacked on top of one another. Remove damaged geomembrane from the site and replace with geomembrane that meets the specified requirements.

1.5.3 Handling

Do not drag, lift by one end, or drop rolls and panels. Use a pipe or solid bar, of sufficient strength to support the full weight of a roll without significant bending but small enough to be easily inserted through
the core of the roll, for all handling activities. Link the ends of the pipe or bar to the ends of a spreader bar with chains. Use a spreader bar wide enough to prevent the chains from rubbing against the ends of the roll. Alternatively, a stinger bar protruding from the end of a forklift or other equipment may be used. Use a stinger bar at least three-fourths the length of the core and capable of supporting the full weight of the roll without significant bending. If recommended by the manufacturer, a sling handling method utilizing appropriate loading straps may be used.

1.6 AMBIENT CONDITIONS

Do not deploy or field-seam geomembrane in the presence of excess moisture (i.e., rain, fog, dew), in areas of ponded water, or in the presence of winds above 12 mph. The relative humidity must be less than 80 percent, and temperature above the dew point. Unless authorized by the Contracting Officer, do not attempt placement or seaming at ambient temperatures below 40 degrees F or above 104 degrees F. Measure ambient temperature at a height no greater than 6 inches above the ground or geomembrane surface. Seaming is only allowed below 40 degrees F if recommended by the geomembrane manufacturer and if destructive tests of trial seams at the proposed temperature meet the seam property requirements listed in Table 1.

1.7 WARRANTY

State in the manufacturer's warranty that the installed geomembrane liner is warranted for 10 years against deterioration as installed for containment of the intended liquid. State in the installer's warranty that the geomembrane liner won't fail due to improper installation within 2 years.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Fabric Reinforced Geomembrane Liner

In the dike containment areas, provide a flexible, internally fabric reinforced geomembrane liner that is factory fabricated into widths that are designed to minimize field fabricated seams. Make factory seams with a 2 inch overlap plus or minus 1/4 inch. Provide liner that, as a minimum, meets the physical properties in Table 1. Include liner's routine maintenance requirements as well as procedures for liner repair and troubleshooting. Color of liner for use in the dike area exposed to view shall be off white/light cream. Submit proposed finished color sample for approval.

| TABLE 1 - FABRIC REINFORCED GEOMEMBRANE PROPERTIES (ENGLISH) |
|-----------------|-------------------|----------------|
| PROPERTY        | TEST VALUE        | TEST METHOD    |
| Overall Finished Thickness (minimum) | 30 mils           | ASTM D751 or ASTM D5199 |
| Base Fabric Material | aramid fibre, polyester, or nylon |               |
| Base Fabric Weight (minimum) | 7.5 oz/yd2 | ASTM D3776 |
### TABLE 1 - FABRIC REINFORCED GEOMEMBRANE PROPERTIES (ENGLISH)

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST VALUE</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Coating Adhesion (minimum)</td>
<td>15 lbf/inch</td>
<td>ASTM D751 or ASTM D413</td>
</tr>
<tr>
<td>Tensile Strength, Grab (minimum)</td>
<td>600 lbf in both warp and fill directions</td>
<td>ASTM D751, Grab Test Method</td>
</tr>
<tr>
<td>Bursting Strength (minimum)</td>
<td>800 lbf</td>
<td>ASTM D751, Ball Tip Method</td>
</tr>
<tr>
<td>Hydrostatic Resistance (minimum)</td>
<td>800 psi</td>
<td>ASTM D751, Procedure A</td>
</tr>
<tr>
<td>Trapizoid Tearing Strength (minimum)</td>
<td>50 lbf in both the warp and fill directions</td>
<td>ASTM D4533 or ASTM D751, Trapazoidal Tear Method</td>
</tr>
<tr>
<td>Puncture Strength (minimum)</td>
<td>250 lbf</td>
<td>ASTM D4833</td>
</tr>
<tr>
<td>Tearing Resistance (minimum)</td>
<td>120 lbf</td>
<td>ASTM D5884</td>
</tr>
<tr>
<td>Low Temperature Bend (minimum)</td>
<td>-30 degrees F</td>
<td>ASTM D2136</td>
</tr>
<tr>
<td>Vapor Transmission (maximum)</td>
<td>0.0119 oz/ft2 over 24 hours</td>
<td>ASTM E96, Procedure BW, Inverted Water Method, using kerosene instead of water</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion (maximum)</td>
<td>0.000021 in/in/degree F</td>
<td>ASTM E228 or ASTM D696</td>
</tr>
<tr>
<td>Weathering Resistance</td>
<td>No appreciable changes, stiffening or cracking of coating for a minimum of 8000 hours</td>
<td>ASTM G152 or ASTM G153</td>
</tr>
<tr>
<td>Bonded Seam Shear Strength (minimum)</td>
<td>525 lbf</td>
<td>ASTM D751</td>
</tr>
<tr>
<td>Bonded Seam Peel Strength (minimum)</td>
<td>20 lbf</td>
<td>ASTM D413</td>
</tr>
<tr>
<td>Dead Load Seam Shear Strength (minimum)</td>
<td>250 lbf at 70 degrees F; 125 lbf at 160 degrees F</td>
<td></td>
</tr>
</tbody>
</table>

2.1.2 Flexible Membrane Liner (FML) Under Storage Tanks

Under fuel storage tanks, provide membrane liner that is resistant to permanent fuel exposure. The FML shall demonstrate the acceptable limits of the properties listed under Table 2. The FML shall be factory produced from a base fabric that is completely covered with a polymer. The base fabric shall weigh no less than 13 ounces per square yard and be made of aramid (kevlar), polyester, or nylon. The FML shall have an overall finished weight no less than 30 ounces per square yard. Factory seams shall be made with a 2 inch overlap plus or minus 1/4 inch by an automatic thermal high-pressure welding process. The FML shall retard the growth of mildew and be capable of containing the liquid stored, withstanding temperatures up to 180 degrees F, withstanding humidity up to 99 percent relative humidity, and withstanding direct exposure to sunlight.
2.1.2.1 Job Lot of FML

A job lot of FML is defined by this specification as the amount of FML product that can be produced from a singular mixture of chemicals. Any FML material created from a new or altered mixture of chemicals shall be considered a new job lot.

2.1.2.2 FML Samples

Twenty four samples shall be cut from every job lot of FML. Each sample shall be approximately 8-1/2 by 11 inches in size. Eight of the samples shall be cut across factory seams.

2.1.2.3 FML Factory Test

Each manufacturer's job lot of FML shall have each of the FML properties verified by the factory test procedures and methods listed below. No substitute methods shall be allowed for verification of any property. Each separate verification of a property shall be made on a separate sample. The FML shall demonstrate through factory testing the acceptable limits of the following properties listed in Table 2. The properties shall be verified by each of the test standards listed.

<table>
<thead>
<tr>
<th>Property</th>
<th>Acceptable Limits</th>
<th>Test Standards</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Overall</td>
<td>32 mils</td>
<td>ASTM D 751</td>
<td></td>
</tr>
<tr>
<td>Finished Thickness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Tear Strength</td>
<td>40 pounds (ibd)</td>
<td>ASTM D 751</td>
<td>(Warp &amp; Fill)</td>
</tr>
<tr>
<td>Minimum Adhesion Strength</td>
<td>20 pounds per inch</td>
<td>ASTM D 751</td>
<td></td>
</tr>
<tr>
<td>Minimum FML (MTS)</td>
<td>1000 pounds (ibd)</td>
<td>ASTM D 751</td>
<td>(Warp &amp; Fill)</td>
</tr>
<tr>
<td>Minimum FML (MTS)</td>
<td>600 pounds (ibd)</td>
<td>ASTM D 751</td>
<td>(Warp &amp; Fill)</td>
</tr>
<tr>
<td>Minimum FML Seam</td>
<td>See Note 1</td>
<td>ASTM D 751</td>
<td></td>
</tr>
<tr>
<td>Shear Strength</td>
<td>Section 53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Abrasion Resistance</td>
<td>5,000 cycles</td>
<td>ASTM D 3389</td>
<td>See Note 2</td>
</tr>
<tr>
<td>Withstanding of</td>
<td>1,000 hours</td>
<td>ASTM D 2565</td>
<td>See Note 3</td>
</tr>
<tr>
<td>Accelerated Weathering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Bursting</td>
<td>1,500 pounds</td>
<td>ASTM D 751</td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>Ball Tip Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Stiffness</td>
<td>30,000 pounds (ibd)</td>
<td>ASTM D 747</td>
<td></td>
</tr>
<tr>
<td>Hydrostatic Resistance</td>
<td>500 pounds per square inch</td>
<td>ASTM D 751</td>
<td></td>
</tr>
</tbody>
</table>
Maximum Permeability | 0.10 ounces per square foot per 24 hours | ASTM E 96 Procedure BW | See Note 4
---|---|---|---
Fuel Compatibility | No Delamination, No Bubbles, No Discoloration | See Note 5
Maximum Volume Swell (Coating Compound Only) | 15 percent of original | See Note 6
Maximum Weight Gain or Loss | 10 percent of original | See Note 5

Table Abbreviations:
(ibd) in both direction
(MTS) Material Tensile Strength

Notes:
1. The acceptable limit for the seam shear strength shall be 95 percent of the minimum (MTS) property using the Strip Method.
2. Test until fabric exposure with a H-22 wheel loaded to 1,000 grams.
3. Manufacturer's certification of the FML, instead of actual factory testing, may be considered acceptable for the Minimum Withstanding of Accelerated Weathering if the certification verifies that the acceptable limits listed were previously achieved using the test standard listed. Data from either a manufacturer's certification or an actual factory test shall verify that no visible cracking or appreciable changes resulted as a result of the testing.
4. The test shall be performed using the Inverted Water Methods with ASTM Fuel B.
5. Testing shall be performed in accordance with ASTM D543 by immersion in ASTM Fuel B for 14 continuous days at room temperature.
6. Testing shall be performed in accordance with ASTM D471.

2.1.3 Nonwoven Geotextile

Provide a nonwoven, polypropylene, needle punched geotextile fabric. Provide geotextile having the following physical properties as a minimum. No substitute methods are allowed for verification of any property.

2.1.3.1 General Properties

Retard the growth of mildew and be compatible with the soil in contact.

2.1.3.2 Nominal Unit Weight

Provide a nominal unit weight of 12 oz/yd2 as measured in accordance with ASTM D5261.

2.1.3.3 Grab Tensile Strength

Provide a minimum grab tensile strength of 300 lbf when tested in accordance with ASTM D4632.

2.1.3.4 Grab Tensile Elongation

Provide a minimum grab tensile elongation of 50 percent when tested in accordance with ASTM D4632.
2.1.3.5 Puncture Strength

Provide a minimum puncture strength of 140 lbf when tested in accordance with the pin strength methods of ASTM D4833, or 800 lbf when tested in accordance with the CBR methods of ASTM D6241.

2.1.3.6 Trapezoid Tear Strength

Provide a minimum trapezoid tear strength of 115 lbf when tested in accordance with ASTM D4533.

2.1.3.7 Ultraviolet (UV) Resistance

Maintain 70 percent of its original strength after 500 hours of testing in accordance with ASTM D7238.

2.2 ACCESSORIES

2.2.1 Liner Fittings

Provide liner fittings (for example, boots and sleeves) that are factory prefabricated components produced from the same manufacturer that produces the fuel impermeable liner and having the same fabrication characteristics as the liner.

2.2.2 Embedment Strip

Provide embedment strips for attachment to new cast-in-place concrete structures by the same manufacturer as the geomembrane, and made of the same materials as the geomembrane to be used or otherwise be certified by the manufacturer for use with the geomembrane.

2.2.3 Batten / Mounting Strip System

Provide minimum 1/4 inch thick by 2 inches wide stainless steel mounting strips. Provide pre-punched bolt holes in the strip at maximum 12 inches on center to accommodate the concrete anchor bolts.

2.2.3.1 Gasket

Provide a minimum 1/4 inch thick by 2 inches wide nitrile gasket on one or both sides of the geomembrane as indicated or recommended by the geomembrane manufacturer at mounting strip locations to seal and protect the geomembrane from the concrete and the mounting strip.

2.2.3.2 Concrete Anchor Bolts

Use minimum 3/8 inch diameter mechanical wedge-type concrete anchors, constructed of type 304 or 316 stainless steel. Provide nuts, washers, and other accessories of the same materials.

2.2.4 Sealant

Use sealant conforming to ASTM C920, Type S, Grade NS, Class 25 or better, or ASTM D5893, Type NS, or other sealant recommended by the geomembrane manufacturer. Sealant used must be compatible with the material being stored, as recommended by the sealant manufacturer.
2.2.5 Temporary Ballast

Temporary ballast used during geomembrane installation may include sandbags, tires, or other material as recommended by the geomembrane manufacturer. Use non-abrasive material, free of sharp edges or other features that may damage the geomembrane liner.

2.2.6 Permanent Ballast

Provide permanent ballast as indicated below.

2.2.6.1 Sand Bags

Permanent sand bags fabricated of the same material as the liner. Provide approximately 50 lbs of dry, clean sand inside of each bag. Completely seal each bag using the same field seam weld procedures used on the liner's field seams.

2.3 EQUIPMENT

Utilize equipment in performance of the work in accordance with the geomembrane manufacturer's recommendations and maintain in satisfactory working condition.

PART 3 EXECUTION

3.1 INSTALLATION OF FABRIC REINFORCED GEOMEMBRANE LINER

Make equipment/parts subject to degradation or requiring adjustment, inspection or repair accessible and capable of convenient removal. Prior to any fabrication or erection, submit detailed installation drawings that show the proposed panel layout of the liner over the entire containment area. As a minimum, indicate the direction and location of factory and field fabricated seams, the termination of the panels at the perimeter of lined areas, details and methods of sealing around penetrations, details and methods for anchoring, placement of permanent sandbags for ballast, and any applicable site specific installation instructions.

3.1.1 Field Engineer

Provide a field engineer to supervise the complete installation of the liner and perform each liner inspection and test.

3.1.2 Surface Preparation and Geotextile Fabric Installation

Prepare surfaces in accordance with Section 31 00 00 EARTHWORK. Surfaces to be covered by liner must be free of vegetation, gravel, rocks, debris, etc., graded true, compacted, and be smooth with no abrupt projections. For the existing storage tank containment areas, install the geotextile fabric directly over the existing concrete containment slabs. Install the geotextile fabric in strict accordance with manufacturer's recommendations. Install geotextile fabric to closely fit around projections (for example, pipe penetrations, concrete foundations/pads, conduit penetrations, etc.). Submit a signed letter from the field engineer, prior to placing any geotextile or liner, that states the subgrade and surface preparation were adequate and in accordance with the liner manufacturer's recommendations.
3.1.3 Embedment Strip Installation

Install embedment strips in new cast-in-place concrete structures using methods and materials recommended by the embedment strip/geomembrane manufacturer. Extrusion weld all joints and intersections of embedment material together or otherwise join as recommended by the manufacturer to provide a continuous surface for attachment of the geomembrane. Fill any holes through the face of the embed material resulting from the concrete forming or placement process with material recommended by the manufacturer.

3.1.4 Liner Installation

See Paragraph "Ambient Conditions". Place the liner over the prepared surface in accordance with the liner manufacturer's installation instructions. The procedures and equipment used cannot elongate, wrinkle, scratch, or otherwise damage the geomembrane, geotextile, or the underlying subgrade. Place the liner in such a manner as to require only minimum handling and field seams. Use sand bags (or other manufacturer approved means) to hold the liner down in position during installation. Do not drag or slide materials, equipment or other items across the surface of the liner at anytime. Do not allow personnel walking or working on the lining to damage it. Replace or repair geomembrane damaged during installation. Allow adequate slack in the geomembrane to prevent the creation of tensile stress and avoid "trampolining" or "bridging". Do not exceed a wrinkle height to width ratio of 0.5 for installed geomembrane. In addition, geomembrane wrinkles must not exceed 3 inches in height. Cut and repair wrinkles that do not meet the above criteria in accordance with Paragraph "Repairs".

3.1.4.1 Liner Projections

Install lining sheets to closely fit around liner projections (for example, pipe penetrations, concrete foundations/pads, conduit penetrations, etc.). Install and center manufacturer supplied sleeves/boots around liner projections in strict accordance with manufacturer's recommendations. Compress the end of pipe sleeves to a pipe with two stainless steel band clamp assemblies. For liner anchorage to precast or existing concrete, install a batten / mounting strip around the liner edge and mount with concrete anchor bolts. Apply sealant to the perimeter edge of exposed liner to include the edge of sleeves/boots. For liner anchorage to new cast-in-place concrete, install an embedment strip in the concrete using methods and materials recommended by the embedment strip/geomembrane manufacturer.

3.2 FIELD SEAMING (FABRIC REINFORCED GEOMEMBRANE LINER)

3.2.1 Trial Seams

Make trial seams under field conditions on strips of excess geomembrane. Make trial seams each day prior to production seaming, whenever there is a change in seaming personnel or seaming equipment settings, whenever environmental conditions change significantly (more than 25 degrees), and at least once every four hours, by each seamer and each piece of seaming equipment used that day. Collect and test trial seam samples in accordance with ASTM D751 and ASTM D413 for fabric-reinforced liner. Obtain one sample from each trial seam. This sample must be at least 18 inches long by 12 inches wide with the seam centered lengthwise. Cut ten random specimens from the sample, 1 inch wide. Field test five seam specimens for seam shear strength and field test 5 seam specimens for seam peel.
adhesion. To be acceptable, 4 out of 5 replicate test specimens must meet seam strength requirements specified in Table 1. If the field tests fail to meet these requirements, repeat the entire operation. If the additional trial seam fails, do not use the seaming apparatus or seamer until the deficiencies are corrected by the installer and 2 consecutive successful trial seams are achieved. Maintain logs of trial seams, which include date, time, weather, seaming personnel, seaming equipment, equipment settings, and trail seam field test results. Submit trial seam logs following the completion of installation.

3.2.2 Field Seams

Seam panels in accordance with the geomembrane manufacturer's recommendations. Comply with the geomembrane manufacturer's recommendation for the overlap between panels being seamed together; however, in no overlap less than 2 inches. In sumps, corners and odd-shaped geometric locations, minimize the number of field seams. Extend seaming to the outside edge of panels. Compact soft subgrades prior to seaming. Provide a clean and free of moisture, dust, dirt, debris, markings, and foreign material area at the time of seaming. Completely unroll and layout adjacent liner panels/sheets before performing field seam welds. Repair fish mouths in seams.

3.3 FIELD QUALITY CONTROL (FABRIC REINFORCED GEOMEMBRANE LINER)

3.3.1 Visual Inspection of Field Seams

Visually inspect each field seam to confirm that the seams are tightly bonded. Perform the inspection of a seam within 30 hours after the manufacturer's suggested application, curing, and cooling time. Repair and re-inspect seams found to be defective in accordance with manufacturer's recommendations.

3.3.2 Non-Destructive Field Seam Testing

Perform non-destructive testing on all field seams over the full seam length and on any other areas showing damage or other distresses. Allowable methods are stated below. Alternate methods approved by the geomembrane manufacturer may be submitted upon approval by the Contracting Officer. Submit non-destructive field seam test reports following the completion of installation and prior to covering the geomembrane liner.

3.3.2.1 Liner Vacuum Box Test

Perform a vacuum box test in accordance with ASTM D5641 on each field seam, the area around the seams, and each liner surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade. If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested is considered damaged and must be repaired and retested. Perform repairs in accordance with manufacturer's recommendations.

3.3.2.2 Liner Air Lance Test

Perform an air lance test on seams to detect an unbonded area in accordance with ASTM D4437. Perform the test using a minimum 50 psig jet of air regulated and directed through a 3/16 inch diameter nozzle. Apply the jet of air to the lip of a seam in a near perpendicular direction to the length of the seam. Hold the nozzle a maximum of 2 inches from the seam and...
travel at a rate of not to exceed 40 fpm. Inflation of any section of the
seam by the impinging air stream is indicative of an unbonded area. Repair
unbonded areas in accordance with manufacturer’s recommendations and retest.

3.3.2.3 Liner Air Pressure Test

Perform air pressure testing in accordance with ASTM D5820. Upon
completion of the test, relieve pressure from the opposite end of the seam
being tested to verify continuity of the seam.

3.3.2.4 Liner Point Stress Test

Where other non-destructive test methods are not possible, perform point
stress testing in accordance with ASTM D4437.

3.3 Destructive Field Seam Testing

Obtain a minimum of one destructive test sample per 500 feet of field seam
at locations specified by the Contracting Officer. Recommended locations
include the ends of seams or anchor trenches, so as to minimize the impact
of required repairs to the geomembrane; however, final sample locations
will be determined by the Contracting Officer. Sample locations will not
be identified prior to seaming. Collect samples a minimum of 12 inches
wide by 36 inches long with the seam centered lengthwise. Cut each sample
into two equal pieces, with one piece retained by the installer for field
testing and the remaining destructive field seam test sample given to the
Contracting Officer for QA testing and/or permanent record. Number each
sample and cross reference to a field log which identifies: (1) panel
number; (2) seam number; (3) date and time cut; (4) ambient temperature
within 6 inches above the geomembrane; (5) seaming unit designation; (6)
name of seamer; and (7) seaming apparatus temperature and pressures (where applicable). Field test in accordance with ASTM D751 and ASTM D413 for
fabric-reinforced liner. Cut ten 1 inch wide replicate specimens from the
installer's sample. Test five specimens for shear strength and 5 for peel
adhesion. Jaw separation speed must be in accordance with the approved QC
manual. To be acceptable, 4 out of 5 replicate test specimens must meet
the seam strength requirements specified in Table 1. If the field tests
fail, repair the seam in accordance with Paragraph "Repairs". Repair holes
for destructive seam samples the same day they are cut. Submit destructive
field seam test reports following completion of installation and prior to
covering the geomembrane liner.

3.4 REPAIRS (FABRIC REINFORCED GEOMEMBRANE LINER)

Patch damaged areas, destructive testing areas, or other areas requiring
repair with the geomembrane material. Round the corners of the patch
material and extend a minimum of 6 inches in each direction from the
damaged area. Small holes or snags less than 1/4 inch in diameter may be
repaired by extrusion welding where such process is approved by the
geomembrane manufacturer.

3.5 PROTECTION AND BACKFILLING (FABRIC REINFORCED GEOMEMBRANE LINER)

Prior to installation of permanent ballast material, the deployed
geomembrane must be in intimate contact with the underlying surface, with
no areas in sufficient tension to form "bridges" or "trampolines". Minimize waves/wrinkles in the geomembrane prior to placement of ballast
materials; in no case allow wrinkles to fold over during placement of
ballast materials.
3.6 PERMANENT BALLAST (FABRIC REINFORCED GEOFABRIC LINER)

3.6.1 Sand Bags

Determine sand bag placement and spacing by wind uplift calculations as specified in Paragraph "Design Requirements".

3.7 INSTALLATION OF FLEXIBLE MEMBRANE LINER UNDER STORAGE TANKS

3.7.1 Field Engineer

The Field Engineer shall supervise the complete installation of the FML and perform each FML inspection and test.

3.7.2 Preparation

Prior to laying out the FML, three sample field seams shall be performed. Each seam shall be 5 feet in length. Seams shall be made only when the ambient temperature and the temperature of the FML are both 25 degrees F or higher.

3.7.3 Surface Preparation

The surfaces to be covered shall be free of vegetation, rocks, debris, etc., graded true, compacted, and be smooth with no abrupt projections of any kind.

Install the geotextile fabric in direct contact with the existing subgrade to be covered. Install the geotextile fabric in strict accordance with manufacturer's recommendations. Install geotextile to closely fit around projections (pipe penetrations, concrete foundations/pads, conduit penetrations, etc.). Submit a signed letter from the field engineer, prior to placing any geotextile or liner, that states the subgrade was adequately prepared per the liner manufacturer's recommendations.

3.7.4 FML Layout and Installation

After successful completion of the FML visual inspection, the FML shall be laid out. Laying out and welding FML shall only be done when the ambient temperature and the temperature of the FML are both 25 degrees F or higher. Field seams shall have a 2 inch overlap plus or minus 1/4 inch, and be made by the FML manufacturer's authorized representative. Panels or sheets of FML to be seam welded together shall be laid out prior to welding field seams. The overlapped areas shall be cleaned and prepared according to the installation instructions and procedures. Welds shall be tightly bonded.

3.8 FIELD QUALITY CONTROL FOR FLEXIBLE MEMBRANE LINER UNDER STORAGE TANKS

The Contracting Officer will conduct field inspections and witness field tests and trial operations specified in this Section. The Contractor shall perform all trial operations and field tests and provide all labor, equipment and incidentals required for testing. The Government will provide water required for field tests, when available.
3.8.1 FML Tests

3.8.1.1 FML Vacuum Box Test

After successful completion of the FML visual inspection, a vacuum box test shall be performed on all field seams, the area around the seams, and all FML surfaces showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade. A glass topped vacuum box which has a neoprene sealing gasket shall be used. The vacuum box test shall be performed as follows:

a. A commercial bubble forming solution shall be applied to the area to be tested.

b. The vacuum box shall be positioned over the area and a vacuum slowly applied until a differential pressure of one psi is achieved and held for at least 5 seconds while observing the solution for bubble formation.

c. If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested shall be considered damaged and shall be repaired and retested.

d. If the vacuum box test do not indicate a leak, then the vacuum shall be slowly increased until a maximum differential pressure of 2 plus 0.0 or minus 0.25 psi is achieved and held for at least 20 seconds. If the test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested shall be considered damaged and shall be repaired and retested. Care must be taken to limit the vacuum to no more than the maximum differential pressure because, if it is exceeded by more than 0.25 psi, the FML shall be considered damaged and shall be replaced and retested.

3.8.1.2 FML Air Lance Tests

After successful completion of the FML vacuum box test, an air lance test shall be performed on all seams not accessible with a vacuum box test (i.e., small seams around penetrations, oddball types of patches, etc.). The air lance test will be performed using a 50 psig jet of air regulated and directed through a 3/16 inch diameter nozzle, applied to the upper edge of an overlapped seam or repaired area to detect an unbonded area. Inflation of any section of the seam by the impinging air stream shall be indicative of an unbonded area. Unbonded areas shall be repaired and retested.

3.8.2 FML Inspections

3.8.2.1 Sample Field Seam Inspection

a. Visual Inspection - Sample field seams shall be subjected to a visual inspection performed within 30 hours after the seam has been made, cured, and cooled.

b. Vacuum Box Inspection - After successful completion of the visual inspection, a vacuum box inspection shall be performed. A glass topped vacuum box which has a neoprene sealing gasket shall be used. The vacuum box test shall be performed as follows:

   (1) A commercial bubble forming solution shall be applied to the area
to be tested.

(2) The vacuum box shall be positioned over the area and a vacuum slowly applied until a differential pressure of one psi is achieved and held for at least 5 seconds while observing the solution for bubble formation.

(3) If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested shall be considered damaged and shall be repaired and retested.

(4) If the vacuum box test do not indicate a leak, then the vacuum shall be slowly increased until a maximum differential pressure of 2 plus 0.0 or minus 0.25 psi is achieved and held for at least 20 seconds. If the test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested shall be considered damaged and shall be repaired and retested. Care must be taken to limit the vacuum to no more than the maximum differential pressure because, if it is exceeded by more than 0.25 psi the FML shall be considered damaged and shall be replaced and retested.

3.8.2.2 FML Initial Inspection

A visual inspection of the FML shall be performed on each FML panel or sheet as it is unrolled. The Contracting Officer shall be notified of any visually detected damage. The visual inspection shall also verify the finished surface to be covered with the FML is properly graded and compacted.

3.8.2.3 FML Seam Inspection

Field seams shall be subjected to a visual inspection performed within 30 hours after the seam has been made, cured, and cooled. Any seams visually found to be defective shall be repaired and reinspected.

3.8.2.4 Acceptance Inspection

As soon as practicable after successful completion of the FML vacuum box test and the air lance tests, an acceptance inspection shall be performed. If the inspection reveals any defects in the work, such defects shall be repaired or the unsatisfactory work replaced before acceptance. The cost of such repairs and replacements shall be borne by the Contractor. The Contractor shall provide materials, facilities, and equipment necessary to permit adequate inspection by the Contracting Officer or his representative.

3.8.3 Manufacturers Field Service

If any problems are noticed in any inspection of a seam, the Contracting Officer shall be notified immediately. The FML manufacturer's point of contact shall also be contacted by telephone and informed that the installation of their product can not be adequately completed. After a solution has been formed, jointly between the FML manufacturer and their authorized representative, as to why the problems were encountered, another set of sample field seams shall be made and reinspected.

3.9 PROJECT CLOSEOUT

Provide As-Built Drawings which show the as constructed panel layout,
factory and field seam locations, penetrations, destructive field seam testing location, and repair locations. Provide operation and maintenance data package for the geomembrane liner to include material cut sheets, liner's routine maintenance requirements as well as procedures for liner repair and troubleshooting.

-- End of Section --
SECTION 33 65 00
CLEANING PETROLEUM STORAGE TANKS

08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 2003  
(2008; 7th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

API RP 500  
(2012; Errata 2014) Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2

API Std 2015  
(2014) Safe Entry and Cleaning of Petroleum Storage Tanks

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 306  
(2014) Standard for Control of Gas Hazards on Vessels

NFPA 70  
(2017) National Electrical Code

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 99-109  
(Latest) Certified Equipment List

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1  

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-680  
(2010; Rev C; Notice 1 2015) Degreasing Solvent

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS O-D-1276  
(Rev B; Notice 1) Disinfectant-Detergent, General Purpose (Pine Oil)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1028  
Benzene

29 CFR 1910.120  
Hazardous Waste Operations and Emergency
Response

29 CFR 1910.1200  Hazard Communication
29 CFR 1910.134  Respiratory Protection
29 CFR 1910.146  Permit-required Confined Spaces
40 CFR 260  Hazardous Waste Management System: General
40 CFR 261  Identification and Listing of Hazardous Waste
40 CFR 262  Standards Applicable to Generators of Hazardous Waste
40 CFR 263  Standards Applicable to Transporters of Hazardous Waste
40 CFR 264  Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265  Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266  Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

UNDERWRITERS LABORATORIES (UL)

UL 844  (2012; Reprint Mar 2016) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-03 Product Data

Cleaning agents
Gasoline-oil-resisting rubber gloves and boots
Cotton coveralls and hard hat
Respiratory protective equipment
Disinfectant
Abrasive for blasting

Submit identification for the items by designated name,
specification number, project contracting number, and intended use.

SD-06 Test Reports
- Blasting abrasive test
- Tank contents tests
- Monitoring Results; G

SD-07 Certificates
- Qualifications of Marine Chemist
- Qualifications of Certified Industrial Hygienist (CIH)
- Testing laboratory
- Safety plan
- Work plan
- Hazardous waste disposal plan
- Tank certification of safety
- Training certification
- Respiratory protective equipment
- Breathing-air supply source
- Combustible gas indicator
- Benzene indicator
- Oxygen meter
- Velometers
- Lighting
- First aid kit
- Tank exhaust blower

Submit certificates for the items listed. Where equipment or materials are specified to conform with the standards of organizations, such as National Institute for Occupational Safety and Health (NIOSH), Underwriters Laboratories (UL), and American Petroleum Institute (API), include a label or listing indicating compliance. In lieu of the label or listing, the Contractor may submit a test report from an approved testing organization stating that the item has been tested in accordance with the specified organization's test methods and that the item conforms with the organization's standard or code.

SD-08 Manufacturer's Instructions
Tank cleaning agents

Submit material safety data sheets for materials to be used at the job site, in accordance with 29 CFR 1910.1200.

SD-11 Closeout Submittals

Safety permits

Submit copies of permits required to comply with local, State, and Federal regulations.

1.3 DEFINITIONS

1.3.1 Certified Industrial Hygienist (CIH)

As used in this section, refers to an Industrial Hygienist employed by the Contractor and is certified by the American Board of Industrial Hygiene in comprehensive practice.

1.3.2 Marine Chemist

The holder of a valid Certificate issued by the National Fire Protection Association in accordance with the "Rules for Certification of Marine Chemists," establishing him as a person qualified to determine whether construction, alteration, repair, or shipbreaking of vessels, which may involve hazards covered by NFPA 306 can be undertaken with safety.

1.3.3 Hazardous Areas

Hazardous areas shall be defined as any area within 100 feet of active aboveground storage tanks, areas within 100 feet of leaking sections of fuel pipelines or other vapor sources, areas within 200 feet of the downwind side of potential vapor emission sources (i.e., pressure-vacuum vents or open vents on active tanks, leaking sections of pipelines), areas within existing tanks, and areas within a dike.

1.3.4 Hot Work Operations

Hot work, for work covered by this section, includes: Flame heating, welding, torch cutting, brazing, carbon arc gouging, or any work which produces heat, by any means, of 400 degrees F or more; or in the presence of flammables or flammable atmospheres, other ignition sources such as spark or arc producing tools (except steel hand tools) or equipment, static discharges, friction, impact, open flames or embers, nonexplosion-proof lights, fixtures, motors or equipment.

1.3.5 Reproductive Hazard

A reproductive hazard is defined as any occupational stressor (biological, chemical, or physical) that has the potential to adversely affect the human reproductive process. For example, it is well known that central nervous system problems often occur in the offspring of mothers exposed to organic mercury during pregnancy. Therefore, based on the example cited, organic mercury can be classified as a reproductive stressor. Many reproductive hazards also cause other adverse health effects; for example, ethylene oxide is also known to be a carcinogen (i.e., produces cancer). Certain reproductive stressors can also have adverse effects on the male reproductive system. (If requested by the Contractor, the Contracting
C-17 Type III Fuel System & Ramp Expansion
145th Airlift Wing, North Carolina Air National Guard

Officer will make available the Navy's standard on reproductive hazards.)

1.4 QUALITY ASSURANCE

1.4.1 Modification of References

Except as modified herein, the work shall conform with the recommendations of API RP 500 and API RP 2003 and API Std 2015. Where the word "should" appears in these publications, substitute "shall."

1.4.2 Copies of Standards

Furnish four copies of API RP 500 AND API RP 2003 and API Std 2015.

1.4.3 Safety Permits and Equipment

Acquire safety permits (specified by the facility safety authorities) and necessary safety equipment.

1.4.4 Regulatory Requirements

a. Obtain permits required to comply with local, State, and Federal regulations.

b. Hazardous wastes, such as water, sediment, and sludge, shall be packaged, labeled, stored, transported, treated and disposed of in accordance with 40 CFR 260 through 40 CFR 266 and State and local regulations. Transporters, sorters, treaters and disposers must be certified and have EPA ID numbers. Payment for disposal of hazardous waste will not be made until a completed hazardous waste manifest from the treatment or disposal facility is returned, and a copy furnished to the Government. Deliver hazardous waste to the Government for disposal as directed by the Contracting Officer.

1.4.5 CIH Responsibilities

a. Certify training.

b. Review and approve safety plans and work plan for conformance to the applicable referenced standards.

c. Inspect tank cleaning work for conformance with the approved safety and work plans.

d. Direct monitoring.

e. Ensure work is performed in strict accordance with specifications at all times.

f. Ensure hazardous exposure to personnel and to the environment are adequately controlled at all times.

1.4.6 Training

Train each employee performing tank cleaning, waste disposal, and air sampling operations prior to the time of initial job assignment, in accordance with API Std 2015, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.1200. The training shall also include counseling of each employee on reproductive hazards involved in the work.
1.4.7 Pre-Construction Conference

Along with the CIH, marine chemist, or gas-free engineer, meet with the Contracting Officer to discuss in detail the tank cleaning work plan, including work procedures and precautions for the work plan.

1.4.8 Certificates

1.4.8.1 Qualifications of Marine Chemist

Submit name, address, and telephone number of the marine chemist selected to perform the required duties. Submit documentation that the marine chemist is certified by the National Fire Protection Association, including the certificate number and date of certification or recertification. The NFPA certification will be acceptable for non-ship work on this contract.

1.4.8.2 Qualifications of Certified Industrial Hygienist (CIH)

Submit name, address, and telephone number of the CIH selected to perform responsibilities in paragraph entitled "CIH Responsibilities." Provide previous experience of the CIH. Submit proper documentation that the Industrial Hygienist is certified by the American Board of Industrial Hygiene in comprehensive practice, including certification number and date of certification/recertification. The CIH shall be familiar with the hazards involved in fuel systems work.

1.4.8.3 Testing Laboratory

Submit the name, address, and telephone number of the testing laboratory selected to perform the monitoring, testing, and reporting of airborne concentrations of lead and other contaminants. Provide proper documentation that persons performing the analysis have been judged proficient by successful participation within the last year in the National Institute for Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program. The laboratory shall be accredited by the American Industrial Hygiene Association (AIHA). Provide AIHA documentation along with date of accreditation/reeaccreditation.

1.4.8.4 Safety Plan

Submit a safety plan within 45 calendar days after contract award and 30 days prior to commencing work. The safety plan shall meet OSHA requirements and address the following:

a. Identification and evaluation of the hazards and risks associated with each site being studied, including reproductive hazards and precautionary measures to be followed by workers for all hazards.

b. Names and qualifications of each Contractor's representative in charge of the work and present at the job site when tank cleaning and repair work will be performed.

c. Identification of supervisory personnel and alternates responsible for site safety/response operations.

d. Determination of levels of personal protection to be worn for various site operations.
e. List of equipment with adequate nomenclature by item, that will be used at the job site and the date and location where this equipment can be inspected by the Contracting Officer.

f. Establishment of work zones (exclusion area, contamination area, and support area).

g. Establishment of a tank entry and work permit program in accordance with 29 CFR 1910.146 and EM 385-1-1.

h. Establishment of decontamination methods and procedures.

i. Determination of the number of people required to enter the contamination zones during the initial entries and subsequent operations.

j. Establishment of emergency procedures, such as: Escape routes, fire protection, signals for withdrawing work parties from site, emergency communications, wind indicators, including Navy notification.

k. Identification and arrangements with nearest medical facility for emergency medical care for both routine-type injuries and toxicological problems. Submit name, location, and telephone number of this medical facility.

l. Establishment of continual air and personnel monitoring procedures.

m. Establishment of procedures for obtaining and handling potentially contaminated samples.

n. Identification of medical monitoring program, including respirator medical qualification examination for each individual at the work site.

o. Identification of training plan to be instituted, including contents of 29 CFR 1910.1200 and 29 CFR 1910.134; its training contents; and instructor with appropriate training certification. Training plan shall also include counseling to each employee on reproductive hazards.


1.4.8.5 Work Plan

The shut down or interruption to normal operations or traffic shall be listed on the progress schedule and submitted to the Contracting Officer.

1.4.8.6 Tank Certification of Safety

Submit certification, from an NFPA certified "Marine Chemist" or CIH stating that tank is safe for hot work and that special precautionary measures have been taken for workers to enter the tank to perform the work.

1.4.8.7 Training Certification

Submit certifications signed and dated by the CIH specified in the testing plan and by each employee stating that the employee has received training on work practices and received counseling on and fully understands the
reproductive hazards involved with toluene exposure and the work.

1.4.8.8 Non-Hazardous Waste Permits

Submit local permits for disposal site for non-hazardous residues and wastes.

1.4.9 Test Results

1.4.9.1 Air Monitoring

Submit monitoring results to the Contracting Officer within 2 working days after the samples are taken, signed by the testing laboratory employee performing the air monitoring, the employee that analyzed the sample, and the CIH.

1.5 DELIVERY AND STORAGE

Deliver equipment and materials to the site in an undamaged condition bearing the manufacturer's name and brand designation. Store equipment and materials off the ground to provide proper ventilation, drainage, and protection against dampness. Replace defective and damaged equipment and materials.

1.6 JOB CONDITIONS

1.6.1 Ventilation

Maintain a vapor-free condition throughout the course of the work inside the tank. The air movers shall be non-sparking, explosion-proof, electrically operated or air-driven exhaust type. A rate of one air change per hour shall be the lowest acceptable rate, for tanks under 30,000 BBL. Air movers shall be kept in operation whenever workers are in the tanks; except the air movers shall be shut down 15 minutes before taking tests.

1.7 SCHEDULING AND SEQUENCING

1.7.1 Sequence of Primary Phases of the Cleaning Procedure

   a. Planning the operations;
   b. Preparation for cleaning;
   c. Vapor-freeing of the tank;
   d. Cleaning the tank;
   e. Clean-up, residue disposal, inspection, and acceptance.

1.7.2 General Scheduling

Complete the work specified in this section before any other work in the tank is started. The work includes the complete interior cleaning of the storage tanks.
2.1 DESIGN CONDITIONS

Components shall be suitable for use with AFLP-3747 Jet A (F-24) turbine fuel with a specific gravity of 0.775 to 0.84, a viscosity 1.5 cSt at 100 degrees F, and a Reid Vapor Pressure 0.05 psia. Components shall be ASME Class 150 (275 psi at 100 degrees F) unless otherwise noted. Components to be suitable for outdoor, unsheltered location, and to function normally in ambient temperatures between 0 and 100 degrees F.

2.2 MATERIALS

2.2.1 Cleaning Agents


b. Solvent: MIL-PRF-680, Type II, minimum flashpoint of 60 degrees C.

c. Approved commercial cleaning agent.

2.3 EQUIPMENT

Furnish necessary clothing and equipment for the work and protection of people entering the tank. Electrical equipment and wiring shall be in accordance with NFPA 70, Class 1, Group D, Division 1. Provide any item or items for the protection of these people including but not limited to the following:

a. Gasoline-Oil-Resisting Rubber Gloves and Boots: Gauntlet type and conductive type respectively (acid-proof rubber is an acceptable material); furnished for each person entering or working inside the tank or handling sludge materials on the exterior of the tank, plus one extra pair each for emergency use.

b. Cotton Coveralls and Hard Hat: Light colored; one change per person per day, and an adequate supply of chemical-resistant disposable coveralls to be worn over cotton coveralls.

c. Respiratory Protection: Provide one of the following types of NIOSH-approved respiratory protective equipment for each person working inside the tank, plus one extra for emergency use. NIOSH 99-109 listing constitutes NIOSH approval.

(1) Self-contained breathing apparatus with a full facepiece operated in a positive pressure mode.

(2) A combination respirator which includes a Type C supplied-air respirator which a full facepiece operated in a positive pressure mode and an auxiliary positive pressure self-contained breathing apparatus.

(3) The CIH may specify airline (Type C) respirator in place of those specified above; however, the decision shall be based on the results of personal monitoring.

(4) CIH shall specify respiratory protection if required for personnel handling sludge material outside of the tank.
d. Safety Harness: For each person working inside tank, plus one extra for outside the tank.

e. One half Inch Diameter Life Rope of Required Length: For each person working inside the tank.


g. Combustible Gas Indicator, Hydrogen-Sulfide (H2S) Indicator, Benzene Indicator and Oxygen Meter. Recommend a portable gas chromatograph or other more accurate instrument for the benzene indicator.

h. Shovels, Buckets, Brooms, Wrenches, Scrapers, Squeegees, Wire Brushes, Scrub-Brushes, Ladders, Staging, and Other Tools: Do not use brooms or brushes that have plastic or synthetic bristles.

i. Lighting: UL 844, explosion-proof, minimum 50 footcandle, floodlight type, or Mining Enforcement and Safety Administration (MESA) approved, explosion-proof, portable battery-powered light.


l. Soap for Personnel Washing: Non-phosphate type.

m. A.B.C. Fire Extinguishers: UL listed 2A: 40B: C, 2A: 20B: C, or 4A: 30B: C; minimum 15 pound capacity.

n. First Aid Kit: One 16-unit kit for each 25 persons.

PART 3 EXECUTION

3.1 PROJECT CONDITIONS

3.1.1 Permission Conditions for Each Entry Into a Tank

Obtain written permission from the Contracting Officer prior to each entry into a tank. Permission will be granted only under the following conditions:

a. The Contractor's qualified supervisor is present.

b. The Contractor's personnel have been briefed by the supervisor on the procedure and role of each employee in the event of an emergency.

c. Required equipment is approved and properly located.

d. Personnel are properly equipped with properly fitted protective equipment and have received adequate training from a qualified instructor.

e. The entire area adjacent to the tank is secured.

f. A minimum of two persons outside and two or more persons inside of each
tank are provided at all times during cleaning operations.

g. Tank air is monitored and corrective action is taken to ensure that the vapor concentration is less than 10 percent of the lower flammable limit (LFL), hydrogen sulfide is less than 10 ppm permissible exposure level (PEL), benzene is less than one ppm PEL and oxygen content is a minimum of 19.5 percent.

h. An NFPA certified "Marine Chemist" or CIH has certified that the tank is safe for hot work, and that the required special precautionary measures have been taken due to the potential health hazard to the worker that still exists, even when the vapor concentration is well below the LFL. The Contractor shall be responsible for reviewing the record drawing(s) of the tank to be cleaned.

i. People entering the area leave smoking materials such as cigarettes and flame-producing devices at a previously determined location.

j. When work involves handling and disposal of hazardous waste, the Contractor has a copy of 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266 in his possession.

k. Permit only personnel authorized in the safety plan within 100 feet of the tank perimeter.

3.1.2 Traffic Control

Direct traffic minimum 200 feet away from the tank cleaning area. Set up road blocks and warning signs. Do not operate vehicles in hazardous areas.

3.1.3 Arrange for lavatory and toilet facilities.

3.1.4 Miscellaneous

Ensure that the manufacturers have labeled containers holding products involving hazards in use or storage, in accordance with 29 CFR 1910.1200. Remove small objects of ferrous metal within the working areas to prevent the accidental striking of a spark. Place equipment upwind of tank openings at highest elevation possible; do not place in a spot lower than the surrounding terrain. Review drawings of the tank to be cleaned and brief workers on the location of pits, sumps, piping, or other tank appurtenances which could be hazardous to personnel. Provide floodlights to illuminate the work area without the need for battery operated handlights. Provide scaffolding, platforms, and ladders for secure, safe accessibility to tank surfaces. Install electrical equipment in accordance with API RP 500. Provide floodlights to illuminate the work area without the need for battery operated handlights. Do not use artificial lights inside tank until the tank is vapor-free.

3.1.4.1 Grounding and Bonding for Equipment

Provide grounding and bonding for equipment which may generate static electricity. Do not pass the air hose through an area where flammable vapors may exist.
3.1.4.2 Fire Extinguishers

Furnish two carbon-dioxide fire extinguishers of minimum 15 pounds capacity each, in the immediate vicinity of the work. Provide a continuous fire watch. CAUTION: Do not discharge high pressure carbon dioxide extinguishers where explosive vapors exist since the discharge can cause a spark which will ignite the vapors.

3.1.4.3 Disconnection Pipelines

Disconnect pipelines connected to the tank. Insert a solid-plate blind flange between two flanges near the tank, or remove a valve or piece of pipe and install a blind flange to prevent flammable material from entering the tank. Blind flanges shall be of sufficient strength to withstand pressure which might be exerted by the material being blanked off, and shall be gasketed on both sides if blind flange is inserted between two flanges. CAUTION: Do not disconnect piping or valves until it is certain the line has been emptied of fuel.

3.1.4.4 Removal of Ignition Sources

Remove sources of ignition from the cleaning area. Do not permit ignition producing devices, including matches, lighters or cigarettes, within 100 feet upwind and 200 feet downwind of a tank, or inside the tank farm, or within the tank firewall, whichever is farther.

3.1.4.5 Survey of Hazardous Areas

Carefully survey the entire area around the tank to be cleaned to ensure that there are no vapors present in the pit, low places, or hazardous areas and that all unauthorized personnel are cleared from the area. Ensure that there is no possibility of anyone smoking in the immediate vicinity. Hazardous areas are defined as follows:

a. Interior of tanks.

b. Areas within 100 feet from points having flammable vapor emissions which, for example, are from the exhaust manholes of tanks under repair, open vents or pressure vacuum vents (breather valves) of active tanks in the vicinity of tanks under repairs or cleaning. CAUTION: Allowance shall be made for 4 or more miles per hour winds by increasing the size of the hazardous area to a minimum of 200 feet on the downwind side.

c. For aboveground tanks, all areas within a common impoundment dike up to the height of the dike walls and within 10 feet in all directions of the exterior surfaces of tank shell and roof.

3.1.4.6 Exit from a Tank During Emergencies

To permit quick, free exit from a tank during emergencies, keep the area around the tank openings and emergency routes clear of obstructions.
3.2 INSPECTION

3.2.1 Inspection of Equipment

3.2.1.1 Respirators

Respirator users shall inspect their respirators in strict accordance with the instructions provided by the manufacturer.

3.2.1.2 Air Hose from Breathing-Air Supply

If air line respirators are used, ensure that:

a. There are no breaks in outside covering;
b. Condition of gaskets is good;
c. Connections are tight; and
d. There are no restrictions in the hose.

3.2.1.3 Safety Harness and Life Line

Ensure that:

a. There is no frayed or weak material; and
b. Condition of harness is good.

3.2.1.4 Breathing-Air Supply Source

Ensure:

a. Good working condition; and
b. Location in vapor-free area.
d. Backup air supply source.

3.2.1.5 Monitoring Equipment

Calibrate each day before use:

a. Combustible gas indicator.
b. Oxygen meter.
c. H2S Indicator.

3.2.1.6 Other Equipment

Ensure:

a. Proper grounding and bonding;
b. Explosion-proof motors; and
c. Explosion-proof lighting.

3.2.2 Personnel Inspection

3.2.2.1 Clothing

Personnel for Proper Attire Commensurate with Hazards Involved: Check for:

a. Clean clothing in good condition (wear freshly laundered clothing at the beginning of the job and at the start of each workday thereafter).

b. Boots and gloves of approved type and in good condition.

3.2.2.2 Breathing-Air Supply

If air line respirators are used, ensure that air is supplied to the facepiece at a rate of 4 to 15 cfm. If self-contained breathing apparatus are use, ensure sufficient number of full replacement cylinders are available to last the duration of the job.

3.2.2.3 Harness and Lifeline

Harness and lifeline shall be in good condition and properly attached.

3.2.2.4 Gum or Tobacco Chewing

Ensure that gum or tobacco chewing is prohibited.

3.2.2.5 Physical Defects or Injuries

Ensure that people have no physical defects or injuries which may prevent their wearing respirators or which may cause rescue to be difficult. No beards, sideburns, or large mustaches shall be allowed on people who must wear respirators.

3.2.2.6 Alcoholic Beverages and Drugs

Ensure that people entering the tank are not under influence of alcoholic beverages and drugs.

3.2.2.7 Counseling on Reproductive Hazards

Ensure that all employees have been counseled on and fully understand the reproductive hazards related to work in contaminated areas or in leaded gasoline or chemically contaminated tanks since they may be seriously affected by organic lead compounds or other chemical contaminants.

3.2.2.8 Hazardous Areas

Check hazardous areas as defined in paragraph entitled "Survey of Hazardous Areas."
3.3 TABLE OF TANK HISTORY

<table>
<thead>
<tr>
<th>Tank Number</th>
<th>Tank Capacity</th>
<th>Date Constructed</th>
<th>Type of Lining (If Applicable)</th>
<th>Type of Fuel</th>
<th>Remarks from the Last Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>TK-1</td>
<td>2,500</td>
<td>1984</td>
<td>Unknown coating</td>
<td>F-24</td>
<td>Previously cleaned 2011</td>
</tr>
<tr>
<td>TK-2</td>
<td>2,500</td>
<td>1984</td>
<td>Unknown coating</td>
<td>F-24</td>
<td>Previously cleaned 2011</td>
</tr>
</tbody>
</table>

3.4 FUEL REMOVAL

All possible fuel will be pumped or otherwise removed from the tank by the Government. Consider remaining fuel contaminated or waste fuel. Dispose of remaining fuel emulsions in accordance with applicable local, State, and Federal regulations. Drums or tanks used for containerizing waste fuel will be furnished by the Contractor. Oil/water separator for fuel separation will be furnished by the Government.

3.5 TANK CLEANING

For the interior of the tanks, the shell, bottom, columns, roof, roof beams, and interior accessory equipment such as pumps, piping, and ladders, shall be cleaned not to bare metal but only to the sound surface of the lining or coating, free of rust, dirt, scale, loose materials, fuel, oil, grease, sludge, and other deleterious materials. Do not damage sound existing lining material. Remove unsound or loose lining or coating and clean the surfaces exposed thereby to bare metal or concrete as applicable. Immediately notify the Contracting Officer if the lining or coating is deteriorated or loose.

3.5.1 Monitoring

Monitoring of airborne concentrations of benzene in accordance with 29 CFR 1910.1028, and as specified herein. Air monitoring, testing, and reporting shall be performed by a CIH or an Industrial Hygiene (IH) Technician who is under the direction of the CIH.

a. The CIH or the IH Technician under the direction of the CIH shall be on the jobsite directing the monitoring, and inspecting the work to ensure that the requirements of the Contract have been satisfied during the entire operation.

b. Take personal air monitoring samples on employees who are anticipated to have the greatest risk of exposure as determined by the CIH. In addition, take air monitoring samples on at least 25 percent of the work crew or a minimum of two employees, whichever is greater, during each work shift.

c. Submit results of air monitoring samples, signed by the CIH, within 2 working days after the air samples are taken. Notify the Contracting Officer immediately of exposure to benzene at or in excess of 0.5 ppm.
3.5.1.1 Monitoring During Tank Cleaning Work

Perform personal and area monitoring during the entire tank cleaning operation. Sufficient area monitoring shall be conducted at the physical boundary to ensure unprotected personnel are not exposed above 0.5 ppm for benzene at all times. If the benzene levels are at or exceed 0.5 ppm, work shall be stopped and the CIH shall immediately correct the condition(s) causing the increased levels and notify the Contracting Officer immediately. The CIH shall review the sampling data collected on that day to determine if condition(s) requires any further change in work methods. Tank cleaning work shall resume when approval is given by the CIH. The Contractor shall control the benzene levels to less than 0.5 ppm at all times. As a minimum, conduct area monitoring daily on each shift in which tank cleaning operations are performed in areas immediately adjacent to the control area. For outdoor operations, at least one sample on each shift shall be taken on the downwind side of the control area. If adjacent areas are contaminated, clean and visually inspect contaminated areas. The CIH shall certify that the area has been cleaned of contamination.

3.5.2 Water, Sediment, and Sludge Analysis

The Contractor shall be responsible for independently testing the water, sediment, and sludge in accordance with 40 CFR 261 to verify the above. Submit laboratory reports to the Contracting Officer describing sampling and testing procedures used, test results, and findings. If the results differ such that the Contractor must handle the waste differently from the method specified, notify the Contracting Officer, and the Contractor will be subject to an equitable adjustment to the Contract under the Changes clause of the Contract Clauses. If the Contractor's tests determine that the water, sediment, and sludge are hazardous, then the hazardous wastes shall be packaged, labeled, stored, transported, treated and disposed of in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266. Transporters, storers, treaters and disposers must be certified and have EPA ID numbers. Payment for disposal of hazardous waste will not be made until a completed hazardous waste manifest from the treatment or disposal facility is returned, and a copy furnished to the Government. Deliver hazardous waste to the Government for disposal. Nonhazardous or hazardous wastes shall be handled and disposed of as described below.

3.5.3 Water Removal and Disposal

Pump or otherwise remove water from the tank. Ensure that the sludge and sediment are not pumped out or mixed with the water. There are assumed 45 gallons per the Contracting Officer of nonhazardous water that can be disposed of. Deliver hazardous waste to the Government for disposal.

3.5.4 Sludge and Sediment Removal and Disposal

Squeegee or brush any sludge, sediment, or other loose material into piles, shovel into buckets or other suitable containers, and remove from the tank.

3.5.4.1 Sludge Disposal Using Landfill

There is approximately 1 barrel of hazardous sediment and sludge in the tank that shall be disposed of by the Contractor. Package, label, store, transport, treat, and dispose of hazardous sludge and sediment in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, 40 CFR 265, and 40 CFR 266.
3.5.5 Washing

After water, fuel, and sludge have been removed, thoroughly wash the tank interior. Minimize the use of water; substitute brush blasting when practical. Start washing at the top of the walls and columns and work down to the floor. Wash the floor last starting from the sides and working towards the sump. Wash to remove oil, sludge, wax, tar, and other fuel residue adhering to the surface. Wash by any one or a combination of the following methods:

a. Use only fresh water under pressure.

b. Apply a detergent cleaning solution by spray or brush and allow to soak approximately 30 minutes. The cleaning solution shall be either a one-to-one ratio of detergent conforming to FS O-D-1276 and solvent conforming to MIL-PRF-680 or an equivalent commercial cleaning agent as approved by the Contracting Officer.

c. Hand-scrub the surfaces vigorously with long-handled stiff-bristle brushes. Wet the brushes intermittently with fresh cleaning agent during scrubbing process. For heavily oil-soaked areas which still appear to retain some residue after first scrubbing, scrub until clean.

d. Rinse the surfaces thoroughly with fresh water.

e. Brush-off blast clean.

3.5.6 Wash Water, Detergent Solution, and Sediment Removal

During the washing process, operate a portable pump continuously with suction hose extended to the tank bottom to remove water, detergent, dirt, oil, or other loose materials washed off. Following the final rinse, pump, squeegee, and mop the tank dry.

a. Prior to discharge or disposal, test the wash water, sediment, and sludge in accordance with paragraph entitled "Water, Sediment, and Sludge Analysis." The Contractor shall furnish temporary tanks to hold water and detergent solution until testing is completed.

b. The wash water shall be handled in accordance with paragraph entitled "Water, Sediment, and Sludge Analysis."

c. For bidding purposes, assume that the sediment is nonhazardous and can be disposed of in a sanitary landfill.

3.5.7 Special Precautions

Special Precautions for Tanks Pontoons:

a. Pontoons are a potential source of explosive vapors even after the tank is cleaned. The tank may be determined to be vapor free below 4 percent of lower explosive limit; but after one or two hours, explosive readings must again be obtained from this source. The Contractor shall take readings at least every half hour when working in tanks after they have been cleaned and each floating roof or pan pontoon shall be checked individually with a combustible gas indicator.

b. If the repair work is to be performed on floating roof tanks, the
interior of each pontoon on the roof shall be thoroughly cleaned of fuel, rust, water, and debris.

3.6 FINAL CLEAN-UP

After the Contracting Officer has inspected and accepted the tank cleaning and before final inspection, accomplish the following work:

3.6.1 Stenciling Tank

Stencil on the tank in 3/4 inch letters adjacent to the manhole openings the following data:

Date Cleaned -
Contractor Name -
Address -

3.6.2 Restoration of Site to Original Condition

Do not reconnect pipelines until repair application of interior and exterior coatings specified in other sections of this specification, have been completed. Replace valves, piping, manhole covers, and similar items which were removed at the start of the job with new gasket material resistant to fuel. Pressure check valves and piping. Remove, from the site, debris and equipment and materials used for the cleaning operations. Restore the site to its original condition.

-- End of Section --
PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)


AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318M (2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary


AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 (2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)


ASTM INTERNATIONAL (ASTM)


<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C478</td>
<td>(2015a) Standard Specification for Precast Reinforced Concrete Manhole Sections</td>
</tr>
</tbody>
</table>

**INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 404</td>
<td>(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V</td>
</tr>
<tr>
<td>IEEE 48</td>
<td>(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV</td>
</tr>
</tbody>
</table>

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)


NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)


NEMA RN 1 (2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit


NEMA TC 7 (2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit


NEMA WC 74 (2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)


TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758 (2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions. Seismic details must conform to UFC 3-310-04 "Seismic Design for Buildings" and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

a. Fungus Control: No.
b. Altitude: 750 feet.
c. Ambient Temperature: 85 degrees F.
d. Frequency: 60.
e. Ventilation: Yes.
f. Seismic Parameters:
   (1) SS = 1.50.
(2) SI = 0.60.
(3) TL = 12 seconds.
(4) Occupancy Category IV.
(5) Site Classification = Class C.
(6) Seismic Design Category D.
(7) Seismic Importance Factor, 1E = 1.50.

g. Humidity Control: No.
h. Corrosive Areas: Yes.

1.3 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this Section, with the additions and modifications specified herein.

1.4 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this Section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast underground structures; G

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Precast concrete structures; G

Sealing Material

Pulling-In Irons
Manhole frames and covers; G
Handhole frames and covers; G
Frames and Covers for Airfield Facilities; G
Composite/fiberglass handholes; G
Cable supports (racks, arms and insulators); G
Protective Devices and Coordination Study; G

The study must be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed must be based on recommendations of this study. The Government must not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered or procured prior to approval of the study.

SD-06 Test Reports

Medium voltage cable qualification and production tests; G
Field Acceptance Checks and Tests; G
Arc-proofing test for cable fireproofing tape; G

SD-07 Certificates

Cable splicer/terminator; G
Cable Installer Qualifications; G
Directional Boring Certificate of Conformance; G

1.6 QUALITY ASSURANCE

1.6.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy).
b. Manufacturer's printed assembly and installation instructions.
c. Design calculations.
d. Reinforcing shop drawings in accordance with ACI SP-66.
e. Plans and elevations showing opening and pulling-in iron locations and details.
1.6.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.6.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.6.4 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.6.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this Section.
1.6.6.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.6.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3,500 psi.

2.1.2 Plastic Duct for Concrete Encasement

Provide Type EB-20 per UL 651, ASTM F512, and NEMA TC 6 & 8 or Type EPC-40 per UL 651 and NEMA TC 2.

2.1.3 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

2.1.4 Innerduct

Provide corrugated polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, with pullwire. Size as indicated.

2.1.5 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.6 Fittings

2.1.6.1 Metal Fittings

UL 514B.
2.1.6.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.6.3 PVC Duct Fittings

NEMA TC 9.

2.1.6.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74 and UL 1072. Provide cables manufactured for use in duct or direct burial applications as
indicated. Cable must be rated 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B compact round conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71 and AEIC CS8.

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals

Neutral conductors must be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable. Concentric neutrals conductors must be copper, having a combined ampacity equal to the phase conductor ampacity rating.

2.5.6 Jackets

Provide cables with a PVC jacket. Direct buried cables must be rated for direct burial.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: Skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Termination must be designed for installation in low or highly contaminated indoor and outdoor locations and must resist ultraviolet rays and oxidative decomposition.
2.6.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination must be designed for installation in low or highly contaminated indoor or outdoor locations.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice must be packaged three splices per kit, including complete installation instructions.

2.8 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.9 TAPE

2.9.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.9.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.9.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than 0.030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.
2.10 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.11.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.12 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.13 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.13.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Concrete block must conform to ASTM C139 and Section 04 20 00 MASONRY.

2.13.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture
of precast concrete products, including precast manholes.

2.13.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.13.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (\(\phi\)) = 30 degrees.

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf.

c. Coefficient of Lateral Earth Pressure (\(K_a\)) = 0.33.

d. Ground Water Level = 3 feet below ground elevation.

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H2O highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.13.2.3 Construction

Structure top, bottom, and wall must be of a uniform thickness of not less than 6 inches. Thin-walled knock-out panels for designed or future duct
bank entrances are not permitted. Provide quantity, size, and location of
duct bank entrance windows as directed, and cast completely open by the
precaster. Size of windows must exceed the nominal duct bank envelope
dimensions by at least 12 inches vertically and horizontally to preclude
in-field window modifications made necessary by duct bank misalignment.
However, the sides of precast windows must be a minimum of 6 inches from
the inside surface of adjacent walls, floors, or ceilings. Form the
perimeter of precast window openings to have a keyed or inward flared
surface to provide a positive interlock with the mating duct bank
envelope. Provide welded wire fabric reinforcing through window openings
for in-field cutting and flaring into duct bank envelopes. Provide
additional reinforcing steel comprised of at least two No. 4 bars around
window openings. Provide drain sumps a minimum of 12 inches in diameter and
4 inches deep for precast structures.

2.13.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components.
Shiplap joints are not allowed. Design joints to firmly interlock
adjoining components and to provide waterproof junctions and adequate shear
transfer. Seal joints watertight using preformed plastic strip conforming
to ASTM C990. Install sealing material in strict accordance with the
sealant manufacturer's printed instructions. Provide waterproofing at
conduit/duct entrances into structures, and where access frame meets the
top slab, provide continuous grout seal.

2.13.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005.
Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power
and telecommunications manhole covers, respectively.

2.13.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in
accordance with standard commercial practice. Steel covers must be
rolled-steel floor plate having an approved antislip surface. Hinges must
be of stainless steel with bronze hinge pin, 5 by 5 inches by approximately
3/16 inch thick, without screw holes, and must be for full surface
application by fillet welding. Hinges must have nonremovable pins and five
knuckles. The surfaces of plates under hinges must be true after the
removal of raised antislip surface, by grinding or other approved method.

2.13.5 Frames and Covers for Airfield Facilities

Fabricate frames and covers for airfield use of standard commercial grade
steel welded by qualified welders in accordance with AWS D1.1. Covers must
be of rolled steel floor plate having an approved anti-slip surface. Steel
frames and covers must be hot dipped galvanized after fabrication.

2.13.6 Ductile Iron Frames and Covers for Airfield Facilities

At the contractor's option, ductile iron covers and frames designed for a
minimum proof load of 100,000 pounds may be provided in lieu of the steel
frames and covers indicated. Covers must be of the same material as the
frames (i.e., ductile iron frame with ductile iron cover, galvanized steel
frame with galvanized steel cover). Perform proof loading in accordance
with CID A-A-60005 and ASTM A48. Proof loads must be physically stamped
into the cover. Provide the Contracting Officer copies of previous proof
load test results performed on the same frames and covers as proposed for this contract. Modify the top of the structure to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure must be level and non-rocking, with the top flush with the surrounding pavement.

2.13.7 Brick for Manhole Collar

Provide sewer and manhole brick conforming to ASTM C32, Grade MS.

2.13.8 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface and this rating must not exceed the design load of the box.

2.14 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be zinc-coated after fabrication.

2.14.1 Cable Rack Stanchions

The wall bracket or stanchion must be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms must be spaced at 8 inch intervals.

2.14.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.14.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.15 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.15.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F.
Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.16 MEDIUM VOLTAGE ABOVE GROUND CABLE TERMINATING CABINETS

Provide cabinets with 200 A loadbreak junctions and elbow-type separable loadbreak connectors. Provide cable terminating equipment in conformance with IEEE 386.

2.17 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.18 SOURCE QUALITY CONTROL

2.18.1 Arc-Proothing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2-1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.18.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.
3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Prepare a checklist of significant requirements and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Steel and iron must be formed to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.5.1 Cast-In-Place Concrete Structures

Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Provide concrete block conforming to ASTM C139 and Section 04 20 00 MASONRY.
3.5.2 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons must be a minimum of 6 inches from the edge of the sump, and in the walls the irons must be located within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Irons must be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16-1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks must be as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" channel insert must be cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.
c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

Cast-iron frames and covers not buried in concrete or masonry must be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor above medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grounding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 4 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Provide ducts with end bells whenever duct lines terminate in structures.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections: 30 degrees.

3.6.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.
3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers.

3.6.5 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.6 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.7 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type, and depth of warning tape as specified in Section 31 00 00 EARTHWORK.
3.6.7.1 Encasement Under Roads and Structures

Under roads and paved areas, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads. Depths to top of the concrete envelope shall be as indicated on drawings.

3.6.7.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 36 inches in pavement- or non-pavement-covered areas.

3.6.8 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope shall be as indicated on drawings. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and must provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide steel reinforcing in the concrete envelope as indicated. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.8.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.8.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.8.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.
3.6.8.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. Abandon in place those no longer used ducts and cables which do not interfere with the work.

3.6.8.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one foot apart. Restrain reinforcing assembly from moving during concrete pouring.

3.6.9 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.7 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.
3.8.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.10 LOW VOLTAGE CABLE SPlicing AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be as specified elsewhere in this Section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.13 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.14 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.
3.14.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.15 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.15.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 30 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

If the specified ground resistance is not met, an additional ground rod must be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.15.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by compression connector.

a. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.15.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.15.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.15.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields,
3.15.6 Fence Grounding

Provide grounding for fences with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section must be bonded to its gatepost by a 1/8 by 1 inch flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

3.16 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.16.1 Reconditioning of Surfaces

3.16.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching. Provide work in accordance with Section 32 92 19 SEEDING.

3.16.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces. Make repairs as specified in Section 32 13 13.06 PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES.

3.17 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.17.1 Concrete Slabs (Pads) for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.
3.17.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.18 FIELD QUALITY CONTROL

3.18.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.18.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection:

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests:

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:
### CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Test Voltage (rms (peak))</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 kV</td>
<td>10 kV</td>
</tr>
<tr>
<td>8 kV</td>
<td>13 kV</td>
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<tr>
<td>15 kV</td>
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<td>25 kV</td>
<td>31 kV</td>
</tr>
<tr>
<td>35 kV</td>
<td>44 kV</td>
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</tbody>
</table>

### CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Test Voltage (rms (peak))</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 kV</td>
<td>7 kV</td>
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<tr>
<td>8 kV</td>
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<tr>
<td>15 kV</td>
<td>16 kV</td>
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<tr>
<td>25 kV</td>
<td>23 kV</td>
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<tr>
<td>35 kV</td>
<td>33 kV</td>
</tr>
</tbody>
</table>

3.18.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection:

1. Inspect exposed cable sections for physical damage.

2. Verify that cable is supplied and connected in accordance with contract plans and specifications.


4. Inspect compression-applied connectors for correct cable match and indentation.

5. Visually inspect jacket and insulation condition.

6. Inspect for proper phase identification and arrangement.

b. Electrical Tests:

1. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

2. Perform continuity tests to insure correct cable connection.
3.18.1.3 Grounding System

a. Visual and mechanical inspection:

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests:

(1) Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.18.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --
PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)


INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)


ICEA S-98-688 (2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements

ICEA S-99-689 (2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)


NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017) National Electrical Code
SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6 (2007) Commercial Blast Cleaning

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-107 (1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set

TIA-455-21 (1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices


TIA-472D000 (2007b) Fiber Optic Communications Cable for Outside Plant Use

TIA-492AAAA (2009b) 62.5-um Core Diameter/125-um Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers


TIA-526-14 (2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant

TIA-526-7 (2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

TIA-568-C.1 (2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard

TIA-568-C.2 (2009; Errata 2010) Balanced Twisted-Pair Telecommunications Cabling and Components Standards

TIA-568-C.3 (2008; Add 1 2011) Optical Fiber Cabling Components Standard

TIA-569 (2015d) Commercial Building Standard for Telecommunications Pathways and Spaces

TIA-590 (1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606 (2012b; Add 1 2015) Administration Standard for the Telecommunications Infrastructure

TIA-607 (2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

TIA-758 (2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

TIA/EIA-455 (1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components


TIA/EIA-598 (2014d) Optical Fiber Cable Color Coding

TIA/EIA-604-10 (2002a) FOCUS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755 Telecommunications Standards and Specifications for Materials, Equipment and Construction

RUS Bull 1751F-630 (1996) Design of Aerial Plant


RUS Bull 1751F-815 (1979) Electrical Protection of Outside Plant

RUS Bull 1753F-201 (1997) Acceptance Tests of Telecommunications Plant (PC-4)

RUS Bull 1753F-401 (1995) Splicing Copper and Fiber Optic Cables (PC-2)

RUS Bull 345-65 (1985) Shield Bonding Connectors (PE-65)

RUS Bull 345-72 (1985) Filled Splice Closures (PE-74)

RUS Bull 345-83 (1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

UNDERWRITERS LABORATORIES (UL)

UL 497 (2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits

UL 510 (2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
1.2 RELATED REQUIREMENTS

Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION apply to this Section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this Specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc., required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.
Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G
Telecommunications Entrance Facility Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and cable; G
Cable splices, and connectors; G
Closures; G
Building protector assemblies; G
Protector modules; G
Patch Panels; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests; G
Acceptance tests; G
Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G
Key Personnel Qualifications; G
Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation; G
Cable tensions; G
Fiber Optic Splices; G

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications outside plant (OSP), Data Package 5; G

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in
specification and drawings. Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA-606. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with TIA-606 that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, cabinet, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved Telecommunications Contractor and key personnel. Qualifications shall be provided for: The Telecommunications System Contractor, the Telecommunications System Installer, the Supervisor (if different from the Installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the Telecommunications Contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The Telecommunications Contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The Telecommunications Contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the Telecommunications Contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper
techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the Telecommunications Contractor, or have a commitment to the Telecommunications Contractor to work on this Project. All key persons shall be employed by the Telecommunications Contractor at the date of issuance of this solicitation, or if not, have a commitment to the Telecommunications Contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this Contract, as they functioned in the offered successful experience. Any substitutions for the Telecommunications Contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with
procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568-C.1 and RUS Bull 1753P-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this Section.

1.6.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 500 feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum
bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this Project.

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.
2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained screw type unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 25 pairs of outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation.

2.2.2 Protector Modules

Provide in accordance with UL 497 two-electrode gas tube or solid state type 5 pin rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide in accordance with TIA-455-21. Type of connector as necessary. Connector maximum attenuation shall be 0.3 dB at 1310 nm with less than a 0.2 dB change after 500 mating cycles.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Underground Cable Closures

a. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.1.2 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.
2.4 CABLE SPLICES AND CONNECTORS

2.4.1 Copper Cable Splices

Provide single pair in-line splices of a moisture resistant, two-wire connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.4.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 0.065 inch. Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

2.4.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 40.0 dB max for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.4.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer shall allow for a minimum of 3 feet of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.4.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.5 CONDUIT

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 PLASTIC INSULATING TAPE

UL 510.
2.7 WIRE AND CABLE

2.7.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.7.1.1 Underground

Provide filled cable meeting the requirements of ICEA S-99-689.

2.7.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAA, multimode 62.5/125-um, 0.275 aperture fiber optic cable in accordance with TIA-492AAAA, TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide quantity of optical fibers as indicated. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598.

2.7.2.1 Strength Members

Provide central strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.7.2.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.7.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.8 PATCH PANELS

Patch panels shall be minimum 16 gauge steel, sized as necessary for housing equipment indicated, and backboard mounted. Provide fiber and copper patch cords, as complete assemblies, with matching connectors as necessary. Patch cords shall meet minimum performance requirements.
specified in TIA-568-C.1, TIA-568-C.2 for cables, cable length, and
hardware specified.

2.8.1 Copper Patch Panel

Provide in accordance with TIA-568-C.1 and TIA-568-C.2. Patch panels shall
terminate the building cabling on Type 110 IDCs. Type 110 connector blocks
shall be suitable for Category systems. Provide 25 percent spare 110 blocks. Provide cable strain-relief and routing guides. Panel shall have
each port factory numbered and be equipped with laminated plastic
nameplates above each port.

2.8.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber
cables. Panel shall provide 12 single-mode adapters as duplex LC in
accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves.
Provide dust covers for unused adapters. Provide cable strain-relief and
routing guides. Panel shall have each adapter factory numbered and be
equipped with laminated plastic nameplates above each adapter.

2.9 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes,
handholes, and vaults. Cable tags shall be polyethylene and labeled in
accordance with TIA-606 and base standards. Handwritten labeling is
unacceptable.

2.9.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3,250
pounds per square inch; and that are 0.08 inch thick (minimum),
non-corrosive non-conductive; resistive to acids, alkalis, organic
solvents, and salt water; and distortion resistant to 170 degrees F.
Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a
one-piece nylon, self-locking tie at each end of the cable tag. Ties shall
have a minimum loop tensile strength of 175 pounds. The cable tags shall
have black block letters, numbers, and symbols 1 inch high on a yellow
background. Letters, numbers, and symbols shall not fall off or change
positions regardless of the cable tags' orientation.

2.10 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590.
Provide color, type and depth of tape as specified in paragraph BURIED
WARNING AND IDENTIFICATION TAPE in Section 31 00 00 EARTHWORK.

2.11 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections
for dependable shield bonding in accordance with RUS 1755.200. Braid shall
be made from flat tin-plated copper.

2.12 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's
name, address, model number, and serial number securely affixed in a
conspicuous place; the nameplate of the distributing agent will not be
acceptable.
2.13 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the Drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 1 by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.14 TESTS, INSPECTIONS, AND VERIFICATIONS

2.14.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of IEC 60769. Enhanced performance air core OSP copper cables shall meet the requirements of IEC 60796. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the Project Site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this Project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Galvanized conduits which penetrate concrete (slabs, pavement, and walls)
shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 6 inches per 12 inches burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased 4 inches PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.3.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the Job Site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.4 Underground Duct

Provide underground duct and connections to existing manholes, handholes, and existing ducts as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.5 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.6 Penetrations

Caulk and seal cable access penetrations in walls, ceilings, and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.7 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling
shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.7.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.7.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.7.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.8 Cable Splicing

3.1.8.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.8.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices.

3.1.9 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.10 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.
3.1.10.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.10.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.10.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly in the telecommunications cabinet. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

3.1.11 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the Telecommunications Contractor.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using laser printer.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag only new wire and cable provided by this Contract. Tag new wire and cable provided under this Contract and existing wire and cable which are indicated to have splices and terminations provided by this Contract. The labeling of telecommunications cable tag identifiers shall be in accordance with TIA-606.

Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks, and protection modules using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Provide ferrous metallic enclosure finishes as specified in Section 09 90 00 PAINTS AND COATINGS.
3.3.1 Cleaning

Clean surfaces in accordance with SSPC SP 6.

3.3.2 Priming

Prime with a two component polyamide epoxy primer which has a bisphenol-A base, a minimum of 60 percent solids by volume, and an ability to build up a minimum dry film thickness on a vertical surface of 5.0 mils. Apply in two coats to a total dry film thickness of 5 to 8 mils.

3.3.3 Finish Coat

Finish with a two component urethane consisting of saturated polyester polyl resin mixed with aliphatic isocyanate which has a minimum of 50 percent solids by volume. Apply to a minimum dry film thickness of 2 to 3 mils. Color shall be the manufacturer's standard.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.5.1 Pre-Installation Tests

Perform the following tests on cable at the Job Site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.5.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.5.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the Job Site.
3.5.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this Section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.5.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758:

a. Wire map (pin to pin continuity).
b. Continuity to remote end.
c. Crossed pairs.
d. Reversed pairs.
e. Split pairs.
f. Shorts between two or more conductors.

3.5.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this Section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 66 feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements shall be made on
all fibers, in both directions, using a 1310 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-455-46A for multimode and TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.5.3 Soil Density Tests

a. Determine soil-density relationships as specified for soil tests in Section 31 00 00 EARTHWORK.

-- End of Section --
PART 1    GENERAL

1.1    RELATED DOCUMENTS

Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2    SUMMARY

This Section includes the design, fabrication, erection, and certification for a complete Jet Blast Deflector (hereafter referred to as JBD).

The JBD manufacturer shall furnish the complete final design, material, labor, and equipment to fabricate and erect the JBD.

All civil work, including paving and foundations, is specified in other Sections.

Electrical work, including any required grounding, lightning protection or lighting, is specified in other Sections.

1.3    GENERAL REQUIREMENTS

1.3.1    Assembly and Fabrication Drawings

Provide assembly drawings and installation drawings detailing location and overall dimensional information, materials and finish details of the JBD. Drawings shall include details of the structural frame members and major assembly/subassembly details for the JBD structure, erection of the JBD, including plans, elevations, and Sections. Show anchorage and accessory items. Drawings shall be sealed by a qualified Professional Engineer registered in the State of North Carolina.

1.3.2    Design Analysis

Structural design calculations for the JBD structures, anchors, and deflecting surfaces prepared and stamped by a qualified professional engineer licensed in the United States or certified by the Structural Engineering Certification Board. Calculations shall be submitted for each major frame system and shall comply with IBC current standards.

1.3.3    Foundation Requirements

JBD manufacturer shall furnish the following:

a. Foundation design criteria: Anchor loads, reactions and locations, including miscellaneous requirements for foundation design.

b. Foundation design analysis and drawings: Design analysis and Drawings showing the minimum recommended foundation to adequately support the design loads above.
1.4 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)


ASTM A653  (2015; E 2016) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process


INDUSTRIAL FASTENERS INSTITUTE (IFI)

IFI 100/107  (2002) Prevailing Torque-Type Steel Hex and Hex Flange Nuts Regular and Light Hex Series

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD P-21035  Paint, High Zinc Dust Content, Galvanizing Repair

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)


SOCIETY FOR PROTECTIVE COATINGS (SSPC)


1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Assembly and fabrication drawings; G
SD-05 Design Data
Manufacturer's design analysis; G
Foundation design criteria; G
SD-07 Certificates
Mill certificates for all steel used in the manufacturing of the JBD
Professional Engineer Qualifications
SD-11 Closeout Submittals
Maintenance and Operation Manual; G
Manufacturer's warranty; G
As-built drawings

1.6 QUALITY ASSURANCE

1.6.1 As-built Drawings

At Project Closeout, submit As-Built Drawings of completed work in accordance with requirements of the Specification as indicated in DIVISION 1.

1.6.2 Manufacturer's Warranty

At Project Closeout, provide a written copy of the manufacturer's warranty certifying the workmanship, materials, installation and performance of the JBD system for a period of two (2) years. See the Section 3.3 ERECTION for JBD manufacturer supervision requirements.

1.6.3 Single Source Responsibility

The JBD structural members, deflecting surfaces, anchorage and fasteners shall be procured from a single source responsible for design, manufacture, supply, and issuing a performance guarantee/warranty.

1.6.4 Professional Engineer Qualifications

Drawings and calculations shall be sealed by a professional engineer with experience of at least five (5) past jet blast deflector projects rated for takeoff operations. Documentation of past experience shall be provided with the submittal package.

1.6.5 Alternate Manufacturers

To be approved as an alternate manufacturer, the following information shall be submitted to and approved by the Contracting Officer prior to submitting a bid. Approved manufacturer(s) shall include this information with the submittal package as outlined in Section 1.4 SUBMITTALS.
a. Results of full scale field proof tests in which the proposed JBD was subjected to the specified aircraft operating at takeoff power settings. Computer simulations are not an acceptable alternate to full scale field tests.

b. Results of full scale smoke dispersion demonstrating that smoke and gases are deflected in an upward direction, with no evidence of smoke dispersal behind the deflector. Video footage and test report shall be provided.

c. Evidence of satisfactory operation of at least five (5) installations of the proposed model, each with at least five (5) years of actual field service of continued use with similar aircraft, application, and engines.

d. Detailed structural design analysis of the proposed JBD, showing loads and stresses in structural members, deflecting surfaces and any bolted joints, using the worst case aircraft velocity profiles as the calculated pressure for load calculations. Structural calculations shall comply with current IBC standards.

e. Design Drawings of the proposed JBD demonstrating that the deflector meets all design and material specifications listed in Parts 1 and 2.

f. Evidence that the JBD designer/manufacturer has current ISO 9001 certification.

g. Evidence that the JBD designer/manufacturer has a combined commercial general liability and excess coverage of $10 million (minimum) with products/completed operations coverage. The JBD designer/manufacturer shall also provide evidence of professional liability coverage of $1 million (minimum).

1.7 DESIGN CRITERIA

1.7.1 Aircraft

This JBD shall be designed specifically for C-130 (all variants) and C-17 aircraft operating at takeoff power settings. The JBD shall be designed to allow operation with the tail of specified aircraft no closer than 35 feet from the JBD leading edge and the nozzle of any engine no closer than 60 feet from the JBD leading edge.

1.7.2 JBD Description

The JBD deflecting surface shall be a curved, corrugated non-perforated type. Deflecting surfaces may not use concrete, perforated metal or expanded metal. Corrugated surfaces shall run in the horizontal direction. Deflecting surfaces shall be rigidly supported by bolted structural steel frame assemblies spaced at 3 feet (maximum) centers. Blast panels shall be supported by single-piece curved steel members with a continuous radius. Field welds at joints subjected to tension or vibration shall not be used. End walls with a minimum height of 9 feet shall be used to contain span-wise flow. The JBD shall be a LYNNCO Type G14M-3 or an approved equal.

a. Blast deflectors with flat metal deflecting surfaces of lower section modulus than specified shall not be used due to 'oil-canning' of flat metal surfaces that can lead to early fatigue failure.
b. Vertical, or nearly vertical, blast fences shall not be used due to poor aerodynamic deflection characteristics.

1.7.3 JBD Performance

The JBD shall reduce jet blast velocities at ground level behind the JBD to a maximum of 25 mph. The jet blast envelope shall be deflected upward at a minimum angle of 60 degrees under no wind conditions.

1.7.4 Layout

Provide JBD and foundation layout as shown on Reference Drawing R-001.

1.7.5 Height

Minimum nominal height shall be 14 feet.

1.7.6 Foundation

The foundation shall be a reinforced slab/grade beam designed to withstand the anchor loads and clearances provided by the JBD manufacturer. The foundation elevations shall be constructed as a single plane surface with no breaks in grade. Provide a minimum safety factor of 1.50 against overturning and sliding. JBD manufacturer shall provide the recommended minimum foundation design to meet the requirements.

1.7.7 Connections

All field connections shall be bolted with locking fasteners.

1.7.8 Foreign Object Damage (FOD)

Fastenlers used for assembly of the JBD shall provide adequate locking properties to prevent them from working loose during continued normal operation of the facility.

1.7.9 Loading

The JBD shall be designed to withstand takeoff velocities from all aircraft specified. This velocity shall be converted to pressure at standard day conditions and applied normally to all deflecting surfaces.

PART 2 PRODUCTS

2.1 APPROVED JBD MANUFACTURER

JBD information from Blast Deflectors, Inc., was used as the basis for the preliminary layout shown on the Contract Drawings.

a. JBD manufacturer shall be one of the following:

(1) Blast Deflectors, Inc.
8620 Technology Way
Reno, NV 89521
(775) 856-1928
www.blastdeflectors.com

b. Government approved equal.
2.2  STRUCTURE

2.2.1  Frames

Fabricated from ASTM A36 structural steel shapes which shall be cut, rolled and punched, as required. All field connections shall be bolted. After fabrication, all individual structural steel members shall be hot-dip galvanized to a minimum coating of 2 oz/sq ft per ASTM A123.

2.2.2  JBD Face Sheets

Face sheets shall be galvanized corrugated steel formed from minimum 16-gauge ASTM A924 sheet steel with 2 oz/sq ft hot-dip galvanized coating per ASTM A653. They shall have a minimum section modulus of 0.1961 cu In/ft. Sheets shall be attached to frames with 3/8 inch diameter bolts using half oval washers.

2.2.3  Fasteners

Fasteners shall have adequate locking properties to withstand direct blast, and shall be as follows:

a. Bolts: ASTM A449 (or equivalent strength).

b. Flat Washers: 316 Stainless Steel.

c. Nuts: IFI 100/107 (all metal self locking type).

d. Finish: All hardware shall be zinc plated or hot-dip galvanized to resist corrosion.

e. Half washers: Half oval washers shall be A36 steel hot-dip galvanized per ASTM A123 to 2 oz/q ft after fabrication. Minimum bearing area on corrugated sheets 1.58 sq in.

f. Anchor Bolts: Zinc-plated type AB34-M bolts supplied by the JBD manufacturer.

g. Galvanizing Repair Paint: High zinc dust content paint for re-galvanizing damaged areas in galvanized steel, with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD P-21035 or SSPC Paint 20.

2.3  FABRICATION, GENERAL

a. Form metal fabrications from materials of size, thickness, and shapes as required. Work to dimensions indicated on approved shop drawings, using proven details of fabrication and support. Use type of materials indicated or specified for various components of each metal fabrication.

b. Form exposed work with accurate angles and surfaces and straight sharp edges.

c. Shear and punch metals clearly and accurately. Remove burrs.

d. Remove sharp or rough areas on exposed surfaces.
2.4 PRODUCT MARKING

JBD manufacturer shall provide a sign indicating manufacturer name, model number, project information, power rating and usage restrictions. Sign shall be bolted to the back of the completed structure.

PART 3 EXECUTION

3.1 SITE CONDITION

The JBD manufacturer shall inspect the Site prior to beginning work and notify the Owner of any defects, which must be corrected before installation of the JBD can be completed. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 MATERIAL STORAGE AND HANDLING

Store all JBD materials in approved areas. Protect all components from damage. Keep blast panels and steel members off ground by using pallets, platforms or other supports. Store all fasteners in a protected area. Do not store materials in a manner that might cause distortion, deterioration, or damage. Do not expose material to water or moisture. Repair or replace damaged materials. See Section 2.2.3 for details of the galvanizing repair paint.

3.3 ERECTION

a. The JBD manufacturer shall observe and supervise the JBD erection. Upon completion of the erection, the JBD manufacturer shall issue the warranty.

b. Set steel frames accurately in locations indicated on approved shop drawings in accordance with AISC Specifications.

c. Provide temporary guys and braces as required to temporarily support structures during erection.

d. Do not use thermal cutting or welding during erection.

e. Install concrete anchors in accordance with manufacturer's written instructions. Use steel templates during setting of anchors to ensure accurate positions.

f. Tighten all fasteners to torques specified by the JBD manufacturer.

g. Touch up any damaged galvanized surfaces with galvanizing repair paint. Follow paint manufacturer's instructions for application.

3.4 PERMITS

The General Contractor shall be responsible to obtain JBD structure and foundation design approval and any required building permits.

3.5 INSPECTION

The JBD manufacturer or designated representative and a representative from the Contracting Officer shall visually inspect the completed facility to assure that all work has been completed in an acceptable manner. Special care should be given to inspecting for loose components or missing
fasteners throughout the structure. At successful completion of the inspection, an acceptance letter shall be signed by the Contracting Officer, or designated representative. This inspection must be performed to validate the warranty of the JBD structure.

3.6 CLEAN UP

a. Following completion of construction and inspections and prior to any aircraft operations, the JBD Contractor shall remove all construction materials, equipment, and debris.

b. Prior to aircraft operation, the Owner shall thoroughly sweep the surrounding areas and inspect for FOD.

-- End of Section --