

T-ARC (X) NAVY CABLE SHIP

System Specification Attachment J-1

**Version 1.0
11 June 2020**

Solicitation No. N00024-20-R-2211

DISTRIBUTION STATEMENT D: Distribution authorized to the Department of Defense and DOD Contractors only (Critical Technology, 11 Jun 2020). Other requests for this document shall be referred to PEO Ships (PMS325).

T-ARC(X) NAVY CABLE SHIP SYSTEM SPECIFICATION

TECHNICAL AUTHORITY APPROVAL:

Date: 12 June 2020

J. CAREY FILLING
Chief Systems Engineer (Ships)
SEA 05D

PROGRAMMATIC AUTHORITY APPROVAL:

Date: _____

Mr. Michael P. Kosar
Program Manager
Support Ships, Boats and Craft
PMS325

T-ARC(X) SYSTEM SPECIFICATION

TABLE OF CONTENTS

1 SCOPE	16
1.1 INTRODUCTION	16
2 APPLICABLE DOCUMENTS	16
2.1 GENERAL	16
2.2 GOVERNMENT DOCUMENTS	16
2.2.1 SPECIFICATIONS, STANDARDS, AND HANDBOOKS	16
2.2.2 OTHER GOVERNMENT DOCUMENTS	17
2.3 NON-GOVERNMENT DOCUMENTS	21
2.4 ORDER OF PRECEDENCE	27
3 REQUIREMENTS	28
3.070 GENERAL REQUIREMENTS FOR DESIGN AND CONSTRUCTION	28
3.070.1 SERVICE LIFE	28
3.070.2 CLASSIFICATION, CERTIFICATION, AND REGULATORY REQUIREMENTS	28
3.070.3 SHIP CHARACTERISTICS	31
3.070.4 OPERATING PROFILE AND CONCEPT OF OPERATIONS	32
3.070.5 ENVIRONMENTAL CONDITIONS	33
3.070.5.1 TEMPERATURES AND HUMIDITY	33
3.070.5.2 WIND, SNOW, ICE, AND GREENWATER LOADS	33
3.070.6 MANEUVERABILITY	34
3.070.7 MASS PROPERTIES AND STABILITY LIMITS	34
3.070.8 LOADS AND ENDURANCE STORES	35
3.070.9 LOADING CONDITIONS AND LIMITS	36
3.070.10 SPACE AND WEIGHT RESERVATIONS	37
3.070.11 CYBERSECURITY	37
3.070.12 ICE STRENGTHENING	38
3.070.13 SHORE CONNECTIONS	38
3.070.14 MISSION VANS AND INTERFACES	39
3.071 ACCESS	39
3.071.1 GENERAL	39
3.071.2 VESTIBULES	40
3.071.3 SPARES AND STORES HANDLING	40
3.071.4 EQUIPMENT AND MACHINERY	40
3.071.5 HATCHES AND SCUTTLES	41
3.073 NOISE AND VIBRATION	41
3.073.1 AIRBORNE NOISE	41

3.073.2 SONAR SELF-NOISE	42
3.073.3 BUBBLE SWEEPDOWN	43
3.073.4 VIBRATION.....	44
3.076 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY	45
3.077 ENVIRONMENT, SAFETY, AND OCCUPATIONAL HEALTH	45
3.078 MATERIALS.....	46
3.079 GENERAL SEAKEEPING	46
3.080 LOGISTICS AND READINESS	47
3.080.1 LOGISTICS SUPPORT REQUIREMENT	47
3.080.2 SUPPLY SUPPORT	48
3.080.3 MAINTENANCE	48
3.080.4 OUTFITTING/FITTING OUT	48
3.080.5 STANDARDIZATION.....	48
3.080.6 COMPUTER RESOURCES.....	48
3.080.7 FACILITIES	49
3.088 HUMAN FACTORS ENGINEERING	49
3.100 REQUIREMENTS FOR HULL STRUCTURE.....	49
3.100.1 LOADS NOT ADDRESSED BY ABS	49
3.100.2 HULL STRUCTURE.....	49
3.100.3 STRESS RISERS.....	50
3.100.4 CORROSION	50
3.100.5 TANKS	51
3.100.6 DOCKING PLUGS	51
3.100.7 COAMINGS	51
3.130 HULL DECKS.....	51
3.170 MASTS	52
3.180 FOUNDATIONS	53
3.184 NAVIGATION SYSTEM AND MISSION ELECTRONIC SYSTEM (MES) ALIGNMENT	53
3.184.1 DEFINITION AND REALIZATION OF REFERENCE FRAME.....	53
3.184.2 MASTER REFERENCE BLOCK AND REFERENCE FRAME.....	54
3.184.3 INSTALLATION ALIGNMENT.....	55
3.184.4 MEASUREMENT OF COMPONENT POSITION AND ROTATION.....	56
3.200 GENERAL REQUIREMENTS FOR MACHINERY PLANT	56
3.202 CONTROL AND MONITORING SYSTEMS	57
3.202.1 MACHINERY CENTRALIZED CONTROL SYSTEM	57
3.202.2 POWER MANAGEMENT SYSTEM (PMS)	59
3.202.3 SHORE POWER MONITORING CAPABILITY	60
3.233 DIESEL ENGINES.....	60

3.235 ELECTRIC PROPULSION.....	62
3.236 MAIN PROPULSION THRUSTERS AND PODDED PROPULSOR SYSTEMS	63
3.241 REDUCTION GEARS	64
3.243 PROPULSION SHAFTING	64
3.245 PROPELLERS	66
3.256 SEAWATER COOLING SYSTEM.....	66
3.258 COMBUSTION AIR AND EXHAUST SYSTEMS.....	67
3.258.1 GENERAL.....	67
3.258.2 COMBUSTION AIR SYSTEMS	68
3.258.3 COMBUSTION EXHAUST SYSTEMS	70
3.260 LUBE OIL	71
3.260.1 GENERAL.....	71
3.260.2 TANKS	71
3.260.3 LUBE OIL FILL AND TRANSFER SYSTEM	72
3.260.4 LUBE OIL PURIFICATION SYSTEM.....	72
3.260.5 LUBE OIL SERVICE SYSTEM.....	73
3.300 GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS.....	73
3.300.1 GENERAL.....	73
3.300.2 ELECTRIC POWER	74
3.300.2.1 CLEAN POWER	75
3.300.3 ELECTRICAL SYSTEMS	76
3.300.4 SHORE POWER	76
3.302 MOTORS AND ASSOCIATED EQUIPMENT	77
3.302.1 MOTORS.....	77
3.302.2 CONTROLLERS.....	78
3.302.3 GROUP CONTROL CENTERS	78
3.303 PROTECTIVE DEVICES	79
3.304 CABLE	79
3.304.1 GENERAL.....	79
3.304.2 CABLE ROUTING AND PENETRATION	79
3.304.3 CABLE SEPARATION.....	80
3.304.4 CABLE CONDUIT	80
3.310 ELECTRIC POWER GENERATION.....	80
3.313 SHIP’S BATTERIES AND CHARGING EQUIPMENT	82
3.314 CONVERSION DEVICES	82
3.320 POWER DISTRIBUTION SYSTEMS.....	83
3.320.1 RECEPTACLES	83
3.320.2 EQUIPMENT LOCATED IN THE WEATHER	85
3.320.3 EMERGENCY POWER DISTRIBUTION.....	85

3.324 SWITCHBOARDS AND PANELS	86
3.330 LIGHTING SYSTEMS	87
3.330.1 GENERAL.....	87
3.330.2 INTERIOR LIGHTING.....	87
3.330.3 EXTERIOR LIGHTING.....	88
3.330.4 WATERLINE/HULL SECURITY LIGHTING.....	89
3.330.5 EMERGENCY LIGHTING.....	89
3.400 GENERAL REQUIREMENTS FOR COMMAND AND SURVEILLANCE SYSTEMS	90
3.402 SECURITY REQUIREMENTS	90
3.405 ANTENNA SYSTEMS	91
3.405.1 SHIP ANTENNA SYSTEMS.....	91
3.405.2 NAVAL COMMUNICATIONS ANTENNA SYSTEMS	92
3.406 BONDING AND GROUNDING	92
3.407 ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3).....	92
3.420 DYNAMIC POSITIONING SYSTEM AND INDEPENDENT AUTOPILOT	93
3.420.1 DYNAMIC POSITIONING SYSTEM	93
3.420.2 DPS AUTOMATIC CONTROL MODE	95
3.420.3 INDEPENDENT AUTOPILOT	96
3.421 NON-ELECTRICAL NAVIGATION AIDS	96
3.421.1 MAGNETIC COMPASS.....	96
3.421.2 PELORUS STANDS	96
3.421.3 BAROMETER.....	96
3.421.4 BINOCULARS	97
3.422 ELECTRICAL NAVIGATION AIDS & NAVIGATION LIGHTS.....	97
3.426 NAVIGATION SYSTEMS	97
3.426.1 GENERAL.....	97
3.426.2 ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM.....	98
3.426.3 SURFACE SEARCH RADAR.....	98
3.426.4 AUTOMATIC IDENTIFICATION SYSTEM.....	99
3.426.5 SPEED LOG	99
3.426.6 GYROCOMPASSES.....	99
3.426.7 DEPTH SOUNDER.....	99
3.431 INTERIOR COMMUNICATIONS SYSTEMS.....	100
3.431.1 WIRELESS COMMUNICATIONS SYSTEMS.....	100
3.431.2 SOUND POWERED TELEPHONE SYSTEM	100
3.431.3 MISSION COMMUNICATIONS SYSTEM	101
3.431.4 PBX TELEPHONE SYSTEM.....	102
3.431.5 ANNOUNCING SYSTEMS	104

3.431.5.1 GENERAL ANNOUNCING CIRCUIT.....	104
3.431.5.2 INTERSHIP ANNOUNCING (LOUD HAILER CIRCUIT) (6MC).....	105
3.431.5.3 BRIDGE ANNOUNCING CIRCUIT (18MC).....	105
3.432 SHIPWIDE LOCAL AREA NETWORKS	105
3.434 ENTERTAINMENT AND TRAINING SYSTEM	106
3.436 ALARMS AND INDICATORS	106
3.436.1 GENERAL.....	107
3.436.2 CHEMICAL, BIOLOGICAL, RADIOLOGICAL (CBR) DETECTION.....	107
3.436.3 FIRE AND SMOKE DETECTION SYSTEMS.....	107
3.436.4 FLOODING ALARMS	108
3.436.5 WATERTIGHT DOOR INDICATOR SYSTEM	108
3.436.6 EXTERNAL INTRUSION DETECTION SECURITY SYSTEM	109
3.436.7 INTERNAL INTRUSION DETECTION SECURITY SYSTEM	109
3.436.8 GENERAL EMERGENCY ALARM SYSTEM.....	109
3.436.9 MEDICAL FACILITY ALARMS	110
3.436.10 REGRIGERATED SPACE LOCKED-IN ALARM	110
3.436.11 STEERING CASUALTY ALARM	110
3.436.12 TANK LEVEL INDICATORS (TLIs)	111
3.436.13 PROPULSION SHAFT REVOLUTION COUNTERS	111
3.439 CCTV SYSTEM.....	111
3.440 EXTERIOR COMMUNICATIONS SYSTEMS.....	114
3.440.1 GENERAL.....	114
3.440.2 SHIP COMMUNICATIONS EQUIPMENT.....	115
3.440.3 NAVAL COMMUNICATIONS EQUIPMENT	115
3.443 SHIP'S WHISTLE.....	115
3.455 IDENTIFICATION SYSTEMS.....	115
3.461 MISSION SONAR SYSTEMS (MSS).....	115
3.461.1 MSS REMOTE DISPLAY CONSOLE.....	116
3.461.2 SONAR SYNCHRONIZATION UNIT	116
3.461.3 MULTIBEAM SURVEY SYSTEM – DEEP WATER	117
3.461.4 SUB BOTTOM PROFILER	117
3.461.5 ACOUSTIC NAVIGATION AND TRACKING SYSTEM	117
3.461.6 SINGLEBEAM SURVEY SYSTEM	117
3.461.7 ACOUSTIC DOPPLER CURRENT PROFILER	118
3.461.8 SURFACE SOUND VELOCIMETER SYSTEM.....	118
3.461.9 EXPENDABLE SOUND VELOCITY PROFILER (XSVP).....	118
3.461.10 ACOUSTIC MONITORING SYSTEM.....	118
3.461.11 ATTITUDE, HEADING & REFERENCE SYSTEM/INERTIAL REFERENCE SYSTEM	119
3.500 GENERAL REQUIREMENTS FOR AUXILIARY SYSTEMS.....	119

3.503 PUMPS	119
3.504 INSTRUMENTS AND INSTRUMENT BOARDS.....	121
3.504.1 GENERAL.....	121
3.504.2 PRESSURE GAUGES.....	121
3.504.3 THERMOMETERS.....	122
3.504.4 CLOCKS.....	122
3.505 REQUIREMENTS FOR PIPING SYSTEMS	122
3.505.1 GENERAL.....	122
3.505.2 MATERIALS.....	125
3.505.3 FLOW VELOCITY	125
3.505.4 SEACHESTs	125
3.506 OVERFLOWS, AIR ESCAPES, AND SOUNDING ARRANGEMENTS.....	126
3.507 MACHINERY AND PIPING DESIGNATION AND MARKING.....	126
3.508 THERMAL INSULATION FOR MACHINERY, EQUIPMENT, AND PIPING	126
3.509 THERMAL INSULATION AND ACOUSTIC ABSORPTIVE TREATMENT FOR DUCTING AND TRUNKS	126
3.512 HEATING, VENTILATION, AND AIR CONDITIONING	127
3.512.1 GENERAL.....	127
3.512.2 AIR CONDITIONING (A/C) SYSTEMS	129
3.512.3 MACHINERY SPACE VENTILATION	129
3.514 AIR CONDITIONING MACHINERY	129
3.516 REFRIGERATION.....	130
3.516.1 GENERAL.....	130
3.516.2 SHIPS SERVICE REFRIGERATION SYSTEM DESIGN.....	131
3.516.3 REFRIGERATED STORAGE COMPARTMENTS	132
3.521 FIREMAIN SYSTEM	132
3.523 COUNTERMEASURES WASHDOWN	134
3.528 MAIN AND SECONDARY DRAINAGE SYSTEMS.....	134
3.528.1 GENERAL.....	134
3.528.2 DECK DRAINS.....	134
3.528.3 PLUMBING DRAINS.....	135
3.528.4 CLEANOUTS.....	136
3.528.5 PLUMBING VENTS.....	136
3.529 BILGE AND BALLAST SYSTEM	136
3.529.1 GENERAL.....	136
3.529.2 DEWATERING BILGE SYSTEM	136
3.529.3 BALLASTING/DEBALLASTING	137
3.531 FRESHWATER PRODUCTION AND SERVICE.....	137
3.532 FRESH WATER SERVICE SYSTEMS	138

3.532.1 CHILLED WATER SYSTEM	138
3.532.2 FRESHWATER COOLING SYSTEMS.....	139
3.532.2.1 LOW TEMPERATURE FRESHWATER COOLING SYSTEM(S).....	139
3.532.2.2 HIGH TEMPERATURE FRESHWATER COOLING SYSTEM(S).....	139
3.532.3 COOLANT WATER DRAINS	140
3.533 POTABLE WATER SYSTEMS	140
3.533.1 GENERAL.....	140
3.533.2 BROMINATION SYSTEM	140
3.533.3 SHIP’S POTABLE WATER.....	140
3.541 SHIP’S FUEL SYSTEMS	141
3.541.1 GENERAL.....	142
3.541.2 TANKS	142
3.541.3 FUEL FILL AND TRANSFER SYSTEM	143
3.541.4 FUEL PURIFICATION SYSTEMS.....	144
3.541.5 FUEL SERVICE SYSTEMS.....	145
3.541.6 WORKBOAT AND RESCUE BOAT REFUELING STATIONS.....	146
3.541.7 TANK VENTING AND OVERPRESSURIZATION PROTECTION.....	146
3.541.8 FUEL STRIPPING SYSTEM	146
3.551 COMPRESSED AIR SYSTEMS	146
3.551.1 GENERAL.....	146
3.551.2 STARTING AIR.....	147
3.551.3 LOW PRESSURE AIR.....	147
3.551.4 BREATHING AIR COMPRESSOR SYSTEM	149
3.555 FIREFIGHTING SYSTEMS	150
3.555.1 FIXED FLOODING SYSTEMS	150
3.555.2 MACHINERY SPACE FIREFIGHTING	150
3.555.3 GALLEY FIRE SUPPRESSION.....	151
3.555.4 FIRE EXTINGUISHERS	151
3.555.5 SMALL ARMS MAGAZINE SPRINKLING SYSTEM.....	152
3.555.6 LITHIUM BATTERY ROOM SPRINKLING	152
3.556 HYDRAULIC SYSTEMS	153
3.562 STEERING SYSTEMS	153
3.565 ROLL STABILIZATION.....	154
3.568 AUXILIARY THRUSTER(S).....	154
3.573 HANDLING GEAR.....	155
3.573.1 GENERAL.....	155
3.573.2 CRANES.....	155
3.573.3 MAIN CRANE(S)	156
3.573.4 STORES CRANE(S)	157
3.573.5 OVERHEAD LIFTING DEVICES	157

3.573.5.1 MISSION OVERHEAD LIFTING DEVICES.....	157
3.581 ANCHORING SYSTEMS.....	164
3.582 MOORING AND TOWING SYSTEMS.....	165
3.582.1 FENDERS.....	167
3.583 FAST RESCUE BOAT, LIFEBOATS, AND WORKBOAT	167
3.588 AIRCRAFT INTERFACE.....	168
3.589 ELEVATORS AND DUMBWAITERS.....	168
3.593 ENVIRONMENTAL POLLUTION CONTROL SYSTEMS.....	168
3.593.1 SEWAGE AND GRAY WATER SYSTEMS.....	168
3.593.2 OIL POLLUTION SYSTEMS	170
3.593.3 SOLID WASTE HANDLING SYSTEMS.....	172
3.593.4 FOOD WASTE.....	173
3.593.5 MEDICAL WASTE.....	174
3.595 CABLE MISSION SYSTEMS.....	174
3.595.1 CABLE HIGHWAY.....	174
3.595.2 CABLE TANKS LAYOUT & DESIGN.....	177
3.595.3 REPEATER STORAGE AND HANDLING	179
3.595.4 MISSION SPACES AND ROOMS	180
3.595.5 CABLE HANDLING EQUIPMENT	188
3.595.6 SEA PLOW.....	193
3.595.7 REMOTELY OPERATED VEHICLE.....	194
3.595.8 CABLE GEAR.....	195
3.595.9 MOONPOOL.....	198
3.600 GENERAL REQUIREMENTS FOR OUTFIT AND FURNISHINGS.....	201
3.602 DESIGNATING AND MARKING.....	202
3.602.1 LABELS, MARKINGS, AND PLACARDS.....	202
3.604 LOCKS AND KEYS	203
3.604.1 DOOR LOCKS	203
3.604.2 KEYS.....	204
3.612 RAILS, STANCHIONS, LIFELINES, AND SAFETY NETS	204
3.613 FLAG HOISTS	205
3.621 JOINER WORK.....	205
3.621.1 GENERAL.....	205
3.621.2 JOINER BULKHEADS.....	206
3.621.3 JOINER LINERS.....	206
3.621.4 JOINER CEILINGS.....	206
3.623 LADDERS AND STAIRS.....	207
3.623.1 GENERAL.....	207
3.623.2 ACCOMMODATION LADDERS.....	207

3.624 ACCESS CLOSURES	208
3.624.1 INTERIOR DOORS	208
3.624.2 EXTERIOR DOORS	210
3.624.3 HATCHES AND SCUTTLES.....	211
3.625 WINDOWS AND PORTLIGHTS.....	212
3.631 CORROSION PREVENTION AND CONTROL.....	213
3.631.1 LIMITATIONS.....	213
3.631.2 SURFACE PREPARATION	214
3.631.3 STRIPE COATING	215
3.631.4 ENGINE EXHAUST TREATMENT SYSTEM REDUCING AGENT SERVICE AND STORAGE TANKS	216
3.633 CATHODIC PROTECTION	216
3.634 DECK COVERING.....	218
3.635 COMPARTMENT TREATMENTS	218
3.635.1 GENERAL.....	219
3.635.2 INSULATION, THERMAL	219
3.635.3 INSULATION, ACOUSTIC	220
3.635.4 VAPOR BARRIERS	220
3.637 SHEATHING.....	220
3.640 LIVING SPACES	220
3.641 STATEROOMS.....	221
3.641.1 LOCATION AND SIZE.....	221
3.641.2 ARRANGEMENTS AND CLEARANCES.....	222
3.641.3 FURNISHINGS AND MATERIALS	222
3.644 SANITARY SPACES AND FIXTURES.....	222
3.644.1 STATEROOM SANITARY SPACES	222
3.644.2 DECK HEADS	223
3.644.3 CLEANING GEAR LOCKERS	223
3.644.4 EMERGENCY WASH FACILITIES.....	223
3.644.5 ENGINEER’S CHANGE ROOM	224
3.645 LEISURE SPACES	224
3.651 FOOD SERVICE SPACES	224
3.651.1 EQUIPMENT AND INSTALLATION.....	225
3.651.2 GALLEY.....	227
3.651.3 SCULLERY.....	227
3.651.4 MESSROOMS.....	228
3.652 MEDICAL FACILITIES	228
3.652.1 DISTRIBUTED MEDICAL SUPPORT EQUIPMENT	228
3.654 SHIP STORE	229

3.655 LAUNDRY SPACES	229
3.661 ADMINISTRATIVE SPACES.....	230
3.661.1 LOCATIONS.....	230
3.661.3 FURNISHINGS AND MATERIALS	230
3.662 CONTROL SPACES	230
3.662.1 PILOT HOUSE.....	231
3.662.1.1 GENERAL.....	231
3.662.1.2 CONSOLES, CONTROL, AND DISPLAYS	231
3.662.1.3 PILOT HOUSE FURNISHINGS	232
3.662.2 ENGINEER’S OPERATING STATION	232
3.662.3 QUARTERDECK STATIONS	232
3.663 NAVAL COMMUNICATIONS CENTER.....	233
3.664 DAMAGE CONTROL SPACES	233
3.664.1 DAMAGE CONTROL CENTRAL.....	234
3.664.2 DAMAGE CONTROL LOCKERS AND SECONDARY DAMAGE CONTROL CENTRAL.....	234
3.664.3 BREATHING AIR COMPRESSOR ROOM	235
3.665 WORKSHOPS, LABORATORIES, AND MAINTENANCE AREAS	235
3.665.1 MACHINE SHOP.....	236
3.665.2 DIESEL REPAIR SHOP	236
3.665.3 ELECTRICAL WORKSHOP.....	236
3.665.4 MACHINERY SPACE FUEL OIL, LUBE OIL, AND WATER SAMPLING TEST LABORATORY	236
3.665.5 ELECTRONICS TEST SHOP.....	236
3.665.6 AUXILIARY MACHINERY ROOM WORKSHOP.....	237
3.665.7 BOSUN WORKSHOP	237
3.670 STOWAGE SPACES	237
3.671 LOCKERS AND SPECIAL STOWAGE.....	238
3.671.1 WATERLINE SECURITY LIGHTING SYSTEM STOWAGE	238
3.671.2 POTABLE WATER TREATMENT STORAGE LOCKER.....	238
3.671.3 POTABLE WATER HOSE STOWAGE	238
3.671.4 GAS FREE PORTABLE SENSOR STOWAGE	239
3.671.5 MOORING LINE STOWAGE.....	239
3.671.6 SEWAGE TREATMENT CHEMICAL STOWAGE	239
3.671.7 SEWAGE SPILL RESPONSE LOCKER	239
3.671.8 GUARDLINE STOWAGE.....	239
3.671.9 PYROTECHNIC LOCKER.....	239
3.671.10 FLAG STOWAGE.....	239
3.671.11 SHORING STOWAGE	239
3.671.12 COMPRESSED GAS CYLINDER STOWAGE.....	240

3.671.13 ACCOMMODATION LADDER EQUIPMENT LOCKER.....	240
3.672 STOREROOMS.....	240
3.672.1 GENERAL STORES STOREROOM	240
3.672.2 SHIP SPARE PARTS STOREROOM	240
3.672.3 ENGINEER STOREROOM(S).....	241
3.672.4 ELECTRICAL STOREROOM	241
3.672.5 SHORE POWER CABLE STOREROOM.....	241
3.672.6 BOSUN STOREROOM	241
3.672.7 BOAT GEAR LOCKER.....	242
3.672.8 FOUL WEATHER GEAR LOCKERS	242
3.672.9 PAINT LOCKER.....	242
3.672.10 BAGGAGE STOREROOM	242
3.672.11 MORALE, WELFARE, AND RECREATION STOREROOM	242
3.672.12 FOOD SERVICE PROVISION STOREROOM.....	243
3.672.13 MEDICAL STORES LOCKER	243
3.672.14 SHIP’S STORE STOREROOM	243
3.672.15 LINEN LOCKERS	243
3.672.16 CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL DEFENSE EQUIPMENT STOREROOM	243
3.672.17 FLAMMABLE LIQUIDS STOREROOM.....	243
3.672.18 NON-FLAMMABLE HAZARDOUS MATERIALS STOREROOM	244
3.672.19 USED HAZARDOUS MATERIALS STOREROOM.....	244
3.700 GENERAL REQUIREMENTS FOR ARMAMENT SYSTEMS.....	244
3.711 ANTITERRORISM/FORCE PROTECTION (AT/FP) WEAPONS MOUNTS AND READY SERVICE LOCKERS	245
3.763 AT/FP SMALL ARMS MAGAZINE	245
3.764 SHIP’S ARMORY.....	245
4 VERIFICATION.....	246

LIST OF TABLES

Table 1: [3.070.3-1] Number of Personnel	32
Table 2: [3.070.4-1] Notional Annual Operating Profile.....	32
Table 3: [3.070.5.1-1] Environmental Conditions – Temperatures and Humidity	33
Table 4: [3.070.8-1] Non-Payload Variable Loads.....	35
Table 5: [3.070.8-2] Provisions/Store Endurance.....	36
Table 6: [3.070.8-3] Tank Loads	36
Table 7: [3.070.9-1] Loading Conditions	37
Table 8: [3.073.2-1] Sonar Self Noise Level Requirements	42
Table 9: [3.079-1] Seakeeping Criteria.....	46
Table 10: [3.070-2] Sea State Properties Table	47
Table 11: [3.184.2-1] Survey Specifications	55

Table 12: [3.258-1] Exhaust Reagent Operating Profile	70
Table 13: [3.300.2.1-1] 480 VAC Clean Power System Requirements	75
Table 14: [3.300.2.1-2] 208 VAC/120 VAC Clean Power System Requirements.....	75
Table 15: [3.505-1] Valve types by use and size	124
Table 16: [3.516-1] Refrigeration system design conditions.....	132
Table 17: [3.593.3-1] Solid Waste Generation Rates	172
Table 18: [3.631.2-1] Surface Preparation Standards (per SSPC).....	214
Table 19: [3.633-1]: Requirements for Impressed Current Cathodic Protection Anodes.....	216
Table 20: [3.641-1] Number and Size of Staterooms	221

LIST OF FIGURES

Figure 1: [3.595.9.1-1] Concept Sketch of Moonpool Door Openings	199
--	-----

LIST OF APPENDICES

APPENDIX A	ACRONYM LIST.....	A-1
APPENDIX B	MOBILITY PERFORMANCE CALCULATIONS.....	B-1
APPENDIX C	CONCEPT OF OPERATIONS	C-1
APPENDIX D	DAMAGE STABILITY CRITERIA.....	D-1
APPENDIX E	MILITARY SEALIFT COMMAND MAINTENANCE PHILOSOPHY	E-1
APPENDIX F	DIESEL ENGINE APPROVAL TEST	F-1
APPENDIX G	PIPING SYSTEM REQUIREMENTS.....	G-1
APPENDIX H	MSC PAINT APPROVAL PROCEDURES AND PRESERVATION INSTRUCTIONS.....	H-1
APPENDIX I	DECK COVERINGS.....	I-1

1 SCOPE

1.1 INTRODUCTION

This System Specification provides the initial draft requirements for concept baseline definition for T-ARC(X) also referred to as “the ship.” System Specification updates will be developed and issued as revisions to support further design maturation during the execution of the industry studies contracts based in part on participating contractor recommendations. The System Specification will be updated and incorporated in the Detail Design and Construction (DD&C) Request for Proposals (RFP).

2 APPLICABLE DOCUMENTS

2.1 GENERAL

The documents listed in this section are referenced in this specification, including the appendices. While every effort has been made to ensure the completeness of this list, document users are cautioned that they shall meet all specified requirements documents cited in this specification, whether or not they are listed in this section. Documents, drawings, and publications form a part of this document to the extent specified herein. Where the referenced documents use terms similar to “recommendation”, “guideline”, or “guidance” in its title or text, features indicated by the use of such terms shall be mandatory.

2.2 GOVERNMENT DOCUMENTS

Effective issue: The issue or revision of the documents, drawings and publications specified herein shall apply.

2.2.1 SPECIFICATIONS, STANDARDS, AND HANDBOOKS

2.2.1.1 DEPARTMENT OF DEFENSE (DoD)

Specifications

MIL-DTL-16884	Fuel, Naval Distillate
MIL-S-901	Shock Tests. H.I. (High-Impact) Shipboard Machinery, Equipment, And Systems, Requirements For

Standards

DoD-STD-1399 (Navy)	Interface Standard for Shipboard Systems, Ship Motion and Attitude
MIL-STD-461	Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

MIL-STD-882 Standard Practice, System Safety

MIL-STD-1310 (Navy) Standard Practice, Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility, Electromagnetic Pulse (EMP) Mitigation, and Safety

Handbooks

DoD-HDBK-289 (SH) Lighting On Naval Ships

2.2.2 OTHER GOVERNMENT DOCUMENTS

2.2.2.1 DEPARTMENT OF DEFENSE

Instructions and Directives

DoD Instruction 8100.04 DoD Unified Capabilities (UC)
DoD Instruction 8500.1 Information Assurance (IA)
DoD Instruction 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT)
UFC 4-150-02 Dockside Utilities for Ship Service, with Change 5

National Security Telecommunications and Information Systems Security Advisory Memorandum (NSTISSAM)

TEMPEST/2-95 Red/Black Installation Guidance

2.2.2.2 DEPARTMENT OF THE NAVY

Information Assurance (IA) Publications

Module 5239-22 Information Assurance Protected Distribution System (PDS) Publication
Module 5239-31 Information Assurance Shipboard Red/Black Installation Publication

Military Sealift Command (MSC)

COMSCINST 3541.2 Shipboard Damage Control Policy for MSC Ships
COMSCINST 5530.3 Military Sealift Command (MSC) Shipboard Antiterrorism (AT) Program
MSC Drawing No. 664-8393510 Damage Control Locker Standard Arrangements
MSC Drawing No. 664-8393515 Breathing Air Compressor Room Standard Arrangements
MSC Drawing No. 802-4844759 Standard Plan for Decontamination Station
MSC QMS N0720-006.00-AQ Identifying Markings

[None]	Guidance for Implementing and Validating MSC ECDIS with DNC® and TOD0 Capabilities
MSC QMS N0720-110.00-P	Habitability Standards for New Construction Large Ships
MSC QMS N0720-111.00-P	Steward Department and Food Service Standards for New Construction Large Ships
MSC QMS N0720-112.00-P	Engine Department and Shop Standards for New Construction Large Ships
MSC QMS N0720-113.00-P	Deck Department and Pilot House Standards for New Construction Large Ships
MSC QMS N0720-114.00-P	Medical Space Standards for New Construction Large Ships
MSC QMS N0732-221.00-AQ	Emergency Escape Breathing Devices
MSC QMS N0732-227.00-AQ	Damage Control Markings

Naval Sea Systems Command (NAVSEA)

Drawings

BUSHIPS Drawing No. 803-1400075	N.T. Door Medium Steel 26 X 66
BUSHIPS Drawing No. S3209-866181	Hull Type Drawing Log Desk Drop Leaf Aluminum
NAVSEA Drawing No. 803-921865	Cathodic Protection Hull Zinc Anodes
NAVSEA Drawing No. 803-5184287	Rack, Stowage, Multi-Purpose Gas Cylinder
NAVSEA Drawing No. 803-6397261	Doors Watertight, Individually Dogged Arrangement
NAVSEA Drawing No. 804-1360106	Locker Details
NAVSEA Drawing No. 804-4444649	Locker, Pistol
NAVSEA Drawing No. 804-4444650	Connections Surface Ship Sewage Discharge
NAVSHIPS Drawing No. 804-860159	Storerooms, Details
NAVSHIPS Drawing No. 804-2255403	Accommodation Ladder Boat Fender, Shl Bumper, Lwr Platform Assy & Det For All Ships Except Those Operating w/Amph Craft
NAVSHIPS Drawing No. 804-4444648	Locker, Small Arms, Arrangement & Details
NAVSHIPS Drawing No. 804-4563098	Bins, Storeroom Stowage Aids
NAVSHIPS Drawing No. 804-4563099	Storeroom Stowage Aids J & K Racks E & L Counters

Instructions

NAVSEAINST 5000.8	Naval SYSCOM Risk Management Policy
NAVSEAINST 5100.12	System Safety Engineering Policy
NAVSEAINST 9096.6B	Weight and KG Margin Policy
NAVSEAINST 9405.1A	Numbering Identification System for Surface Ship Antennas

Manuals

NAVSEA S9086-KC-STM-010/CH-300	Electric Plant - General
NAVSEA S9522-AA-HBK-010	Description, Operation and Maintenance Handbook for Magazine Sprinkler Systems

Other NAVSEA documents

NAVSEA OP 4	Ammunition and Explosive Safety Afloat
NAVSEA OP 3565	Electromagnetic Radiation Hazards (Hazards to Personnel, Fuel and Other Flammable Material)
[None]	Metric Guide for Naval Ship Systems Design and Acquisition
[None]	NAVSEA Prohibited and Controlled Chemicals List (PCCL)
[None]	NAVSEA Qualified Products List (QPL)

Office of the Chief of Naval Operations (OPNAV)

NTTP 4-01.4	Underway Replenishment
OPNAVINST 5090.1	Environmental Readiness Program
OPNAVINST 5100.19	Navy Safety and Occupational Health (SOH) Program Manual for Forces Afloat
OPNAVINST 5530.13	Department of the Navy Physical Security Instruction for Conventional Arms, Ammunition, and Explosives (AA&E)

Other Navy publications

CNSS Policy No. 11	Acquisition of Information Assurance (IA) and IA- Enabled Information Technology (IT) Products
GSA Commercial Item Description A-A-59470	Cabinets, Modular Drawer Storage (Naval Shipboard)
NTRP 1-03.5	Defense Readiness Reporting System - Navy Reporting Manual
SECNAV M-5510.36	Department of the Navy Information Security Program
[None]	NOSSA Explosives Safety Design Validation
[None]	Damage Control Allowance Equipage Lists
[None]	DD&C Accepted Weight Estimate

2.2.2.3 OTHER GOVERNMENT AGENCIES

Centers for Disease Control and Prevention (CDC)

Vessel Sanitation Program 2018 Operations Manual

Defense Information Systems Agency (DISA)

DISA Approved Products List

Federal Communications Commission (FCC)

Regulations on Global Maritime Distress and Safety System

National Counterintelligence and Security Center (NCSC)

Technical Specifications for Construction and Management of Sensitive
Compartmented and Information Facilities

United States Coast Guard (USCG)

Navigation and Vessel Inspection Circulators (NVIC) 9-81	Guidance Regarding Shipboard Helicopters
Navigation and Vessel Inspection Circulars (NVIC) 1-89	Underwater Survey Guidance
Navigation and Vessel Inspection Circulars (NVIC) 02-95 Change 3	U.S. Coast Guard's Alternate Compliance Program

United States Environmental Protection Agency (EPA)

Vessel General Permit

United States Food and Drug Administration (FDA)

Certificate of Sanitary Construction

United States Government

33 CFR	Navigation and Navigable Waters
46 CFR	Shipping
47 CFR	Telecommunication
[None]	Clean Air Act, 42 U.S.C.
[None]	Federal Information Processing Standards

United States Public Health Service (USPHS)

Publication No. 68	Handbook of Sanitation of Vessels in Operation: Sanitation Features and Facilities on Vessels in Operation
--------------------	---

2.3 NON-GOVERNMENT DOCUMENTS

Effective issue: The issue or revision of documents, drawings, and publications in effect at Detail Design and Construction Request for Proposal due date shall apply unless otherwise specified herein.

American Bureau of Shipping (ABS) (versions as required by ABS)

Classification Certificate
Guidance Notes on Ship Vibration
Guide for Bridge Design and Navigational
Equipment/Systems
Guide for Certification of Lifting Appliances
Guide for Crew Habitability on Ships
Guide for Dynamic Positioning Systems for DPS-2 Vessels
Guide for 'SafeHull-Dynamic Loading Approach' for
Vessels
Guide for Spectral-Based Fatigue Analysis for Vessels
Rules for Building and Classing Marine Vessels
(Also referred to as "Marine Vessel Rules (MVR)")

American National Standards Institutes (ANSI)

ANSI C63.12	Electromagnetic Compatibility Limits, Recommended Practice
ANSI/AGMA 2015-1-A01	Accuracy Classification System - Tangential Measurements for Cylindrical Gears
ANSI/ASA S2.25	Measurement, Reporting, and Evaluation of Hull and Superstructure Vibration in Ships
ANSI/ASA S2.26	Vibration Testing Requirements and Acceptance Criteria for Shipboard Equipment
ANSI/ASA S2.27	Guidelines for the Measurement and Evaluation of Vibration of Ship Propulsion Machinery
ANSI/ASA S2.28	Guide for the Measurement and Evaluation of Broadband Vibration of Surface Ship Auxiliary Rotating Machinery
ANSI/BHMA A156.2	Bored and Preassembled Locks and Latches
ANSI/BHMA A156.5	Cylinders and Input Devices for Locks
ANSI/ISEA Z358.1	American National Standard for Emergency Eyewash and Shower Equipment
ANSI/NEMA Z535.2	Environmental and Facility Safety Signs

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

[None] ASHRAE Handbook - HVAC Systems and Equipment
Standard 34 Designation and Safety Classification of Refrigerants

American Society of Mechanical Engineers (ASME)

ASME A17.1/CSA B44 Handbook on Safety Code for Elevators and Escalators
ASME A112.19.2/CSA B45.1 Ceramic Plumbing Fixtures
ASME B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
ASME B40.100 Pressure Gauges and Gauge Attachments
ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)
ASME BPVC Boiler and Pressure Vessel Code

American Society of Plumbing Engineers (ASPE)

Domestic Water Heating Design Manual

American Society for Testing and Materials (ASTM)

ASTM A480/A480M Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM B418 Standard Specification for Cast and Wrought Galvanic Zinc Anodes
ASTM D975 Standard Specification for Diesel Fuel Oils
ASTM F683 Standard Practice for Selection and Application of Thermal Insulation for Piping and Machinery
ASTM F707/F707M Standard Specification for Modular Gage Boards
ASTM F718 Standard Specification for Shipbuilders and Marine Paints and Coatings Product/Procedure Data Sheet
ASTM F721 Standard Specification for Gage Piping Assemblies
ASTM F765 Standard Specification for Wildcats, Ship Anchor Chain
ASTM F821/F821M Standard Specification for Domestic Use Doors and Frames, Steel, Interior, Marine
ASTM F841 Standard Specification for Thrusters, Tunnel, Permanently Installed in Marine Vessels
ASTM F998 Standard Specification for Centrifugal Pump, Shipboard Use
ASTM F1005 Standard Practice for HVAC Duct Shapes; Identification and Description of Design Configuration
ASTM F1106 Standard Specification for Warping Heads, Rope Handling (Gypsy Head, Capstan Head)

ASTM F1134	Standard Specification for Insulation Resistance Monitor for Shipboard Electrical Motors and Generators
ASTM F1155	Standard Specification for Selection and Application of Piping System Materials
ASTM F1166	Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities
ASTM F1182	Standard Specification for Anodes, Sacrificial Zinc Alloy
ASTM F1323	Standard Specification for Shipboard Incinerators
ASTM F1347	Standard Specification for Manually Operated Fueling Hose Reels
ASTM F1510	Standard Specification for Rotary Positive Displacement Pumps, Ships Use
ASTM F1511	Standard Specification for Mechanical Seals for Shipboard Pump Applications
ASTM F1718	Standard Specification for Rotary Positive Displacement Distillate Fuel Pumps
ASTM F2070	Standard Specification for Transducers, Pressure and Differential, Pressure, Electrical and Fiber-Optic
ASTM F2283	Standard Specification for Shipboard Oil Pollution Abatement System
ASTM F2362	Standard Specification for Temperature Monitoring Equipment

International Code Council (ICC)

[None]	International Plumbing Code
--------	-----------------------------

International Electrotechnical Commission (IEC)

IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 60533	Electrical and Electronic Installations in Ships - Electromagnetic Compatibility
IEC 60947-2	Low Voltage Switchgear and Control Gear - Part 2: Circuit Breakers
IEC 61162-1	Maritime Navigation and Radiocommunication Equipment and Systems - Digital Interfaces - Part 1: Single Talker and Multiple Listeners
IEC 61162-2	Maritime Navigation and Radiocommunication Equipment and Systems - Digital Interfaces - Part 2: Single Talker and Multiple Listeners, High-Speed Transmission
IEC Publication 61000-4	Electromagnetic Compatibility Standard for Industrial Process Measurements and Control Equipment

Institute of Electrical and Electronics Engineers (IEEE)

IEEE Std. 45.1	Recommended Practice for Electrical Installations on Shipboard-Design
----------------	---

IEEE Std. 45.2	Recommended Practice for Electrical Installations on Shipboard-Controls
IEEE Std. 45.3	Recommended Practice for Electrical Installations on Shipboard-Systems Engineering
IEEE Std. 45.4	Recommended Practice for Electrical Installations on Shipboard-Marine Sectors and Mission Systems
IEEE Std. 45.5	Recommended Practice for Electrical Installations on Shipboard-Safety Considerations
IEEE Std. 45.6	Recommended Practice for Electrical Installations on Shipboard-Electrical Testing
IEEE Std. 45.7	Recommended Practice for Electrical Installations on Shipboard-AC Switchboards
IEEE Std. 45.8	Recommended Practice for Electrical Installations on Shipboard-Cable Systems
IEEE Std. 518-1982	IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources
IEEE Std. 1580	IEEE Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities
IEEE Std. 1709	IEEE Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships
IEEE Std. C37.13	IEEE Standard for Low-Voltage AC Circuit Power Breakers Used in Enclosures
IEEE Std. C95.1	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

International Chamber of Shipping

[None] Guide to Helicopter/Ship Operations

International Maritime Organization (IMO)

IMO-110E	International Convention for the Safety of Life at Sea (SOLAS)
IMO-155E	International Code for Fire Safety Systems
IMO-200E	International Maritime Dangerous Goods Code (IMDG Code)
IMO-210E	IMDG Code Supplement
IMO-520E	International Convention for the Prevention of Pollution from Ships (MARPOL convention)
IMO-847E	Code on Intact Stability
IMO-877M	Prevention of Corrosion on Board Ships
IMO-904E	Convention on the International Regulations for Preventing Collisions at Sea (COLREG 1972)

IMO FAL.2/Circ.131- MEPC.1/Circ.873- MSC.1/Circ.1586- LEG.2/Circ.3	List Of Certificates And Documents Required To Be Carried On Board Ships, 2017
IMO MSC/Circ. 913	Guidelines For The Approval Of Fixed Water-Based Local Application Fire-Fighting Systems For Use In Category A Machinery Spaces
IMO Resolution MEPC.107(49)	Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships
IMO Resolution MEPC.157(55)	Recommendations on Standards for the Rate of Discharge of Untreated Sewage from Ships
IMO Resolution MEPC.209(63)	Guidelines on Design and Construction to Facilitate Sediment Control on Ships (G12)
IMO Resolution MEPC.227(64)	2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants
IMO Resolution MSC.215(82)	Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in All Types of Ships and Double-Side Skin Spaces of Bulk Carriers
IMO Resolution MSC.337(91)	Code on Noise Level On Board Ships

International Organization for Standardization (ISO)

ISO 484-1	Shipbuilding - Ship Screw Propellers - Manufacturing Tolerances - Part 1: Propellers of Diameter Greater than 2.50 M
ISO 668	Series 1 Freight Containers - Classification, Dimensions And Ratings
ISO 3730	Shipbuilding and Marine Structures - Mooring Winches
ISO 4568	Shipbuilding - Sea-Going Vessels - Windlasses and Anchor Capstans
ISO 6482	Shipbuilding - Deck Machinery - Warping End Profiles
ISO 8217	Petroleum Products - Fuels (Class F) - Specifications of Marine Fuels
ISO 8468	Ships and Marine Technology - Ship's Bridge Layout and Associated Equipment - Requirements and Guidelines
ISO 13795	Ships and Marine Technology - Ship's Mooring and Towing Fittings - Welded Steel Bollards for Sea-Going Vessels

International Telecommunications Union (ITU)

ITU-R M.1371	Technical Characteristics for an Automatic Identification System Using Time-Division Multiple Access in the VHF Maritime Mobile Frequency Band
--------------	--

National Association of Corrosion Engineers (NACE)

SP0178 Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to be Lined for Immersion Service

National Electrical Manufacturers Association (NEMA)

NEMA MG 1 Motors and Generators

National Fire Protection Association (NFPA)

NFPA 30 Flammable and Combustible Liquids Code
NFPA 70E Standard for Electrical Safety in the Workplace
NFPA 72 National Fire Alarm and Signaling Code
NFPA 86 Standard for Ovens and Furnaces
NFPA 400 Hazardous Materials Code
NFPA 1901 Standard for Automotive Fire Apparatus
NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems

North Atlantic Treaty Organization (NATO)

STANAG 4194 Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions

Panama Canal Authority (ACP)

Op Notice to Shipping Vessel Requirements
No. N-1-2015

Society of Allied Weight Engineers (SAWE)

Recommended Practice Weight Control Technical Requirements
M-1 for Naval Surface Ships

Society of Naval Architects and Marine Engineers (SNAME)

SNAME T&R Bulletin No. 3-15 Guide to the Design and Testing of Anchors
Windlasses for Merchant Ships
SNAME T&R Bulletin No. 3-39 Guide for Shop and Installation Tests
SNAME T&R Bulletin No. 3-47 Guide for Sea Trials
SNAME T&R Bulletin No. 4-7 Thermal Insulation Report
SNAME T&R Bulletin No. 4-16 Recommended Practices for Merchant Ship
Heating, Ventilation and Air Conditioning
Design

Society for Protective Coatings (SSPC)

SSPC-SP 1 Solvent Cleaning
SSPC-SP 2 Hand Tool Cleaning
SSPC-SP 3 Power Tool Cleaning
SSPC-SP 7/NACE No. 4 Brush-Off Blast Cleaning

SSPC-SP 10/NACE No. 2
SSPC-SP 11

Near-White Metal Blast Cleaning
Power Tool Cleaning to Bare Metal

Suez Canal Authority (SCA)

[None]

Rules of Navigation

Underwriters Laboratories (UL)

UL 489

Molded-Case Circuit Breakers, Molded-Case Switches
and Circuit-Breaker Enclosures

2.4 ORDER OF PRECEDENCE

Any referenced document directly cited for use or application by an identifying number or name in this specification is a primary reference for each particular use or application for which it is so cited. Any document cited in a primary reference, or in a document referenced therein, is a sub-tier reference. A document that is a sub-tier reference in one application may be a primary reference in another application when it is cited directly. Where the referenced documents use terms similar to “recommendation”, “guideline”, or “guidance” in its title or text, features indicated by the use of such terms shall be mandatory.

In case of conflict between this System Specification and referenced documents, the following order of precedence shall apply:

- The text in this System Specification
- Primary references including ABS Marine Vessel Rules (MVR), except non-mandatory features of Type drawings
- Sub-tier references

The order of precedence of requirements of sections within this System Specification is dependent on the relative broadness of coverage of the various specification sections:

- Requirements within a section applicable to the entire ship (for example, General Requirements for Design and Construction) have the broadest application and apply to all systems and equipment unless otherwise specified in the more detailed sections.
- Requirements within a lead section (for example, a section that includes the general or common requirements for a number of similar systems, such as General Requirements for Piping Systems) have the next broadest application and shall apply to all systems and equipment in its grouping unless specifically modified in detailed system sections.
- Requirements within a detailed system section (for example, a section that includes the details of a particular ship system such as freshwater service systems) are the most specific requirements and apply only for the system covered in the detailed section.

Silence of one document with respect to details shown in another document or in another section of the same document shall not be considered an inconsistency. In cases where additional requirements in references cited herein constitute additional details or features, which do not violate the specified performance, then it shall not be considered a conflict. In these cases, the more stringent requirement shall be met.

In case of conflict between this System Specification and regulatory body, classification, and international regulations and requirements, the more stringent requirement shall take precedence. If any item specified in this System Specification, or in its mandatory references, exceeds the regulatory body requirements, the more stringent requirement shall be met.

3 REQUIREMENTS

The following are the Government's systems requirements for the T-ARC class vessels hereafter referred to as "the ship". The requirements provided herein are supplementary to those required by the classification society, regulatory bodies, and international regulations. Included are requirements for systems and equipment that may or may not be included in the Contractor's design. For example, if an auxiliary steam system is provided, then the requirements herein applicable to auxiliary steam systems shall be met. However, if the Contractor's design meets the performance requirements herein without any auxiliary steam services, then the auxiliary steam system requirements, such as shore connections for shore steam, shore condensate, and reserve feed, are not applicable.

The metric system of measurement (International System of Units (SI)) shall be used for all elements of the ship requiring new design except where necessary to interface with existing English unit equipment or systems. NAVSEA publication "Metric Guide for Naval Ship Systems Design and Acquisition" may be used for guidance. Values cited in both SI units and U.S. Customary units typically are not exact equivalents. In these cases, either value may be used.

The effective date for references not specifically dated and/or indicated by revision number shall be those in effect at DD&C contract award. With NAVSEA approval, later effective dates of standards may be used for ease of procurement and cost reduction.

3.070 GENERAL REQUIREMENTS FOR DESIGN AND CONSTRUCTION

3.070.1 SERVICE LIFE

The ship shall be designed and constructed to provide a 40-year service life.

3.070.2 CLASSIFICATION, CERTIFICATION, AND REGULATORY REQUIREMENTS

The ship shall be designed and constructed to commercial ship standards, complying with Maritime Laws and Regulations of the United States Government including USCG Regulations as applied in Navigation & Vessel Inspection Circular (NVIC) 2-95 Change-3 and ABS Rules for Building and Classing Marine Vessels (Marine Vessel Rules). The ship shall comply with the laws and Federal regulations of the United States and certification and classification requirements included, but not limited to, those specified herein.

The ship shall be certified in accordance with U.S. Coast Guard Regulations for Certification as a Cargo and Miscellaneous Vessel.

3.070.2.1 REGULATORY REQUIREMENTS

The ship, as delivered, shall comply with the applicable regulatory and classification requirements in effect at the time of award of DD&C, including those regulatory and classification requirements formally approved and scheduled for implementation prior to delivery of the ship. Requirements applicable to T-ARC(X) follow.

- Code of Federal Regulations (CFR) - Title 33 - Volume 2 - Chapter I - Subchapter O (Pollution)
- CFR – Title 46 – Subchapter I (Cargo and Miscellaneous Vessels)
- CFR - Title 47 - Volume 5 (Telecommunication)
- Safety of Life at Sea (SOLAS), including applicable amendments
- Federal Communication Commission Regulations on Global Maritime Distress and Safety System (GMDSS)
- Suez Canal Regulations, for routine transit
- Panama Canal Regulations, for routine transit
- FDA Certificate of Sanitary Construction requirements
- CDC Vessel Sanitation Program 2018 Operations Manual
- Annex I of the International Convention for the Prevention of Marine Pollution from Ships (MARPOL), 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)
- EPA Regulations
- Annex III of MARPOL 73/74, Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV of MARPOL 74/74, Regulations for the Prevention of Pollution by Sewage from Ships
- Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships
- Annex VI of MARPOL 73/78, Regulations for the Prevention of Air Pollution from Ships

3.070.2.2 CLASSIFICATION

The ship shall be ABS classed to the ABS Rules for Building and Classifying Marine Vessels (Marine Vessel Rules – MVR) for unrestricted service with the following ABS Notations:

- A1 (Hull and Equipment)
- Circle E (Anchor and Chain Cable Equipment)
- AMS (Machinery and Systems)
- Automated Centralized Control Unmanned (ACCU)
- NIBS (Navigational Bridge Layout and Equipment/Systems) per ABS Guide for Bridge Design and Navigational Equipment Systems
- Baltic Ice Class I C
- DPS-2 per ABS Guide for Dynamic Positioning Systems
- SH-DLA per ABS Guide for ‘SafeHull-Dynamic Loading Approach’ for Vessels
- SFA (40) per ABS Guide for Spectral-Based Fatigue Analysis for Vessels
- UWILD (Underwater Inspection in Lieu of Drydocking)
- NVIC 2-95 Change 3 ACP
- Crane Register Certificate (CRC) as applicable (SC, SElev, OC, OC-Subsea, OC-PL) per ABS Guide for Certification of Lifting Appliances

3.070.2.3 CERTIFICATION

The Contractor shall obtain all required regulatory body and Government approvals and certifications to show vessel compliance with requirements identified herein. In addition to those certificates and documents required by IMO FAL.2/Circ.131-MEPC.1/Circ.873- MSC.1/Circ.1586-LEG.2/Circ.3 and the USCG, the following Certifications are required with vessel delivery:

- ABS Classification Certificates (Interim at delivery)
- U.S. Coast Guard Certificate of Inspection
- USCG Underwater Inspection in Lieu of Drydocking (UWILD) in accordance with NVIC 1-89
- Panama Canal Tonnage Certificate
- Suez Canal Tonnage Certificate
- Food and Drug Administration Certificate of Sanitary Construction (The FDA will issue a Certificate of Sanitary Construction using the requirements in the CDC Vessel Sanitation Program 2018 Operations Manual)
- ABS Lifting Appliance Certification
- Naval Ordnance Safety and Security Activity (NOSSA) Explosives Safety Design

Validation (ESDV)

- Gangway Winch Wire Certificate(s) as applicable
- Dumbwaiter Certificate(s) as applicable
- Passenger Elevator Certificate(s) as applicable
- Cargo Ship Safety Construction Certificate (SLC)
- Cargo Ship Safety Equipment Certificate (SLE), including Record of Equipment
- Cargo Ship Safety Radio Certificate (SLR), including Record of Equipment
- International Regulations for Avoiding Collisions at Sea (COLREGS)
- USCG UWILD in accordance with NVIC 1-89
- Statements of Voluntary Compliance (SOVC) Certificates from ABS in lieu of the following:
 - Voyage Data Recorder Certificate of Compliance
 - International Sewage Pollution Prevention Certificate (ISPP)
 - International Garbage Pollution Prevention Certificate (IGPP)
 - International Air Pollution Prevention Certificate (IAPP)
 - International Energy Efficiency Certificate
 - International Anti-fouling System Certificate
 - International Ballast Water Management Certificate
 - International Oil Pollution Prevention Certificate (IOPP)
- Statements of Fact (SOF) Certificates from ABS are acceptable in lieu of the following:
 - International Maritime Dangerous Goods Code (IMDG)

3.070.3 SHIP CHARACTERISTICS

Navigation draft at full load in seawater shall not exceed 8.07 m (26.5 ft).

The ship shall be capable of transiting the new Panama and Suez canals.

Sustained speed shall be 15 knots. Sustained speed shall be measured at Full Load Departure condition in calm water (no current, wind, or waves), clean bottom and propeller(s) using a maximum of 85% of the propulsors rated power.

Unrefueled range shall be a minimum of 14,500 nm at 15 knots in calm seas. Unrefueled range shall be in accordance with Appendix B.

Bollard pull shall be at least 120 MT in calm water at zero speed. The ship shall be capable of producing thrust of at least 80 MT at speeds up to 1 knot through sea state 5.

The ship, the Sea Plow, and the Sea Plow LARS shall be capable of accommodating Plow tow wire tensions of up to the maximum bollard pull of 120 MT, and capable of continuous Plow tow wire tension of up to 80 MT.

An emergency medical evacuation capability via helicopter is required.

The ship shall be operated and crewed by the MSC under the administrative command of the Special Mission Programs, PM2. MSC habitability standards shall be used for MSC crew, mission personnel and the Embarked Security Team (EST) per Military Sealift Command QMS N0720-110.00-P Habitability Standards for New Construction Large Ships and QMS N0720-111.00-P Steward Department and Food Service Standards for New Construction Large Ships. Table 3.070.3-1 summarizes projected accommodation number requirements. Berthing areas shall be sized to permit a wide range of male to female ratios.

Table 1: [3.070.3-1] Number of Personnel

Ship	Grade (MSC)	
		Master & Chief Engineer
	Other Licensed	17
	Chief Petty Officer (CPO)	14
	Unlicensed	42
	Total	75
Mission Personnel	Licensed	27
	Total	27
EST	Officer (MSC licensed equivalent)	1
	Chief Petty Officer /Senior Non-Commissioned Officer (MSC licensed equivalent)	1
	Enlisted (MSC unlicensed equivalent)	10
	Total	12
	Grand Total	114

3.070.4 OPERATING PROFILE AND CONCEPT OF OPERATIONS

The notional annual operating profile is shown in Table 3.070.4-1.

Table 2: [3.070.4-1] Notional Annual Operating Profile

Operating Condition	Days per Year	Speed ³ (knots)	Dynamic Positioning
In-port (hot) ¹	14	-	-
In-port (cold) ²	42	-	-
Maintenance (hot) ¹	55	-	-
Maintenance (cold) ²	55	-	-
Transit	44	15	No
Cable Installation with Sea Plow	52	1	Yes

Cable Installation without Sea Plow	38	3.5	Yes
Cable Repair with ROV and UUV and Package Ops	57	0.50	Yes
Bathymetric Survey and Projector Tow	8	10	Yes
Total	365	-	-

Notes:

1. Hot Condition: On ship’s power
2. Cold Condition: On shore power
3. Average speed in operating condition

The Concept of Operations (CONOPS) is provided in Appendix C.

3.070.5 ENVIRONMENTAL CONDITIONS

3.070.5.1 TEMPERATURES AND HUMIDITY

The ship and all its systems shall be capable of getting underway and operating in the environmental conditions shown in Table 3.070.5.1-1:

Table 3: [3.070.5.1-1] Environmental Conditions – Temperatures and Humidity

	Maximum	Minimum
Outside Dry Bulb Temperature, °C	40	-18
Relative Humidity, Percent	95	0
Seawater Temperature, °C	35	-2

Equipment and machinery exposed to weather shall be capable of operating at an ambient temperature between -30 °C (-22 F) and 49 °C (120 F) and humidity of 0% to 100%. Equipment and machinery internal to the ship shall be rated at no less than the compartment design temperature in which installed.

The machinery necessary to operate the ship’s machinery plant shall be capable of starting and operating continuously over the ambient temperature range of -30 °C (-22 F) to 49 °C (120 F) with a relative humidity of 0% to 100%.

3.070.5.2 WIND, SNOW, ICE, AND GREENWATER LOADS

Ship structure, systems, and equipment exposed to the weather shall withstand a horizontal wind loading of 1.5 kN/m² (31.3 lb/ft²) of projected area. Ship structure shall withstand a snow and ice weight of 0.4 kN/m² (8.35 lb/ft²) on exposed surfaces. Exposed systems and equipment shall

start and operate properly when initially covered with an ice weight of 0.22 kN/m² (4.59 lb/ft²) on exposed surfaces.

Foundations and the structures that support them shall withstand a horizontal wave slap loading of 24 kN/m² (500 lb/ft²) acting on the projected area of that portion of equipment and machinery mounted in the weather that is located beneath the height corresponding to the head required by ABS for weather deck design.

3.070.6 MANEUVERABILITY

The ship shall be directionally stable at all speeds in all loading conditions. The ship shall be capable of achieving a steady turning diameter of no more than four ship lengths in either direction at sustained speed, at full load condition and in calm water, without use of the bow thruster. The average yaw overshoot angle from the second overshoot on shall be no more than 10° for a 10-10 zig-zag maneuver at all speeds at full load. The track reach in a crash stop from transit speed shall be no more than 15 ship lengths.

The maneuverability requirements shall apply to the ship operating in deep, calm water without wind or current. Maneuverability requirements shall be met without the assistance of transverse thrusters, even if thrusters are provided.

3.070.7 MASS PROPERTIES AND STABILITY LIMITS

Weight estimates shall include Contractor-specified acquisition margins and Government-controlled margins for contract modifications and Government Furnished Material (GFM). Weight and KG acquisition margins shall be in accordance with the guidance provided in Naval Sea Systems Command Instruction (NAVSEAINST) 9096.6B. DD&C contract modification margins shall be 0.40% of the light ship displacement and 0.30% growth of the light ship vertical center of gravity (VCG).

The displacement service life allowance shall be a weight equal to 5% of the Full Load Departure condition displacement, with vertical, longitudinal, and transverse moments corresponding to locating the weight at the center of gravity (CG) of Full Load Departure condition. The KG service life allowance shall be the vertical moment required to raise the KG of the Full Load Departure condition with the displacement service life allowance added, a total of 0.5 ft.

Fixed ballast, other than that specified in the DD&C Accepted Weight Estimate (AWE), shall not be used as a corrective measure to deliver the ship within KG, list, and trim values. Fixed ballast, where provided, shall be capable of being removed using high pressure water agitation and pumping systems. The ballast shall be non-corrosive, non-flammable, temperature-stable, and micro-organism resistant.

The ship shall meet the regulatory body requirements for stability applicable to the provided ship capabilities including the IMO Code on Intact Stability. Intact stability requirements shall include ice accretion loading based on 46 CFR 28.550(c).

As a minimum, the stability calculations shall address the loading conditions in Table 3.070.9-1. In addition, the Full Load Departure, Mid-Voyage, Cable Laying, and Cable Repair loading conditions shall follow guidelines from ABS MVR Part 5D, Chapter 3 Anchor Handling and Towing, Appendix 3.3.1 Intact Stability Criteria addressing the bollard pull requirement herein.

The ship shall meet the damage stability requirements in Appendix D in all loading conditions in Table 3.070.9-1, with and without the service life allowance for displacement and KG.

3.070.8 LOADS AND ENDURANCE STORES

Payload loads are defined in Section 3.595. Non-payload variable loads shall be as shown in Table 3.070.8-1.

Table 4: [3.070.8-1] Non-Payload Variable Loads

ITEM AND LOADS		
PERSONNEL AND EFFECTS:		
MILDET:		
Officers	182 kg/person	400 lbs/person
CPO	150 kg/person	330 lbs/person
Enlisted	104 kg/person	230 lbs/person
MSC:		
Master or Chief Engineer	227 kg/person	500 lbs/person
Officers (Licensed)	204 kg/person	450 lbs/person
CPO	172 kg/person	380 lbs/person
Unlicensed	150 kg/person	330 lbs/person
Mission Personnel	159 kg/person	350 lbs/person
Transient	125 kg/person	275 lbs/person
PROVISIONS AND STORES:¹		
Dry	1.45 kg/person/day	3.20 lbs/person/day
Freeze	1.04 kg/person/day	2.30 lbs/person/day
Chill	1.36 kg/person/day	3.00 lbs/person/day
Canned Soda	0.30 kg/person/day	0.66 lbs/person/day
Ship Store Stock	0.45 kg/person/day	1.00 lbs/person/day
General Stores	1.81 kg/person/day	4.00 lbs/person/day
Medical Stores	0.67 kg/person/day	1.48 lbs/person/day
FUEL: 95% Capacity		
LUBE OIL: 95% Capacity		
POTABLE WATER: 100% Capacity		
RESIDUAL BALLAST WATER:		

ITEM AND LOADS		
All seawater ballast tanks filled to bottom of suction inlets, as a minimum.		
OPERATING MISCELLANEOUS LIQUIDS: 95% Capacity		
OTHER MISCELLANEOUS TANKS: 10% Capacity		
MISSION VANS: 10 MT per van; weight located at centroid of each van		
SMALL ARMS LOCKER: Empty		

Note: The weight of each provisions/stores category shall be based on the total number of accommodations and the days of endurance shown in Table 3-070.8-2 below.

Table 5: [3.070.8-2] Provisions/Store Endurance

Type	Days Endurance
Dry Provisions	60
Chilled Provisions	45
Frozen Provisions	60
Repair Parts/Equipment-Related Consumables	90
Non-Equipment-Related Consumables	90
Medical Stores	90

Tank loads shall be based on Table 3.070.8-3 below using molded tank volumes adjusted to account for structure, piping, etc. and the filled percentages specified in Table 3.070.8-1 above.

Table 6: [3.070.8-3] Tank Loads

Tank Type	Density (kg/m³)	Density (lb/ft³)
Diesel Fuel, Marine (DFM)	834 kg/m ³	52.1 lb/ft ³
Lube oil and waste oil	921 kg/m ³	57.5 lb/ft ³
Fresh water	998 kg/m ³	62.2 lb/ft ³
Seawater	1025 kg/m ³	64.0 lb/ft ³
Sewage and gray water	1025 kg/m ³	64.0 lb/ft ³
Oily waste	1025 kg/m ³	64.0 lb/ft ³

3.070.9 LOADING CONDITIONS AND LIMITS

The ship shall operate over the full range of loading conditions shown in Table 3.070.9-1.

Table 7: [3.070.9-1] Loading Conditions

T-ARC(X) Loading Table						
Item	Full Load Departure	Ballast Departure	Mid-Voyage	Cable Repair	Full Load Arrival	Ballast Arrival
Cable Tanks	100% capacity	0% capacity	50% capacity	25% capacity	100% capacity	0% capacity
Cable Gear Stowage	100% capacity	0% capacity	90% capacity	90% capacity	100% capacity	0% capacity
Ship's Consumables	100% capacity	100% capacity	50% capacity	50% capacity	10% capacity	10% capacity
Ship's Fuel	95% capacity	95% capacity	50% capacity	50% capacity	10% capacity	10% capacity
Potable Water	95% capacity	95% capacity	50% capacity	50% capacity	10% capacity	10% capacity
Seawater Ballast	As required	As required	As required	As required	As required	As required

Notes:

- All loading conditions shall include non-payload variable loads as shown in Table 3.070.9-1.
- Overflow tanks shall be empty in all loading conditions. Overflow tanks shall not be used to satisfy capacity and endurance requirements.
- Ballasting of fuel tanks is not acceptable.

The ship's trim shall not exceed 0.15 m by the bow and 1.0 m by the stern in the Full Load condition. In all other loading conditions, the trim shall not exceed the required to adequately submerge the propeller. The ship's list shall not exceed 0.50° in all loading conditions.

3.070.10 SPACE AND WEIGHT RESERVATIONS

“Space and weight” as referenced herein, is defined as the volume that shall be reserved for the future provision of a function, and the weight of the items that would have to be installed to provide the function. Applicable drawings and weight reports shall identify and include space and weight reservations. No other equipment or distributive systems shall be located within the volume designated.

3.070.11 CYBERSECURITY

Cybersecurity shall be in accordance with Department of Defense Instruction (DoDI) 8500.1 and 8510.01. The T-ARC(X) Program will follow the DoD Risk Management Framework (RMF)

process proceeding in six steps using supporting National Institute of Standards and Technology Special Publications (NIST SPs), Federal Information Processing Standards (FIPS), Committee on National Security Systems (CNSS) Instructions, and Information Assurance Technical Authority (IATA) Standards:

- Step 1 - Categorize Information Systems
- Step 2 - Select Security Controls
- Step 3 - Implement Security Controls
- Step 4 - Assess Security Controls
- Step 5 - Authorize Information Systems
- Step 6 - Monitor Security Controls

T-ARC(X) will need to operate in a cyber-contested environment against the span of anticipated adversaries and threats that range from amateurs and unorganized cyber criminals to advanced nation states. The capability shall include sufficient resiliency to complete the mission. The capability's survivability shall include mitigations for confidentiality, integrity, and availability (C, I, & A) compromises of internal and external information flows. Supply chain risk and anti-counterfeiting measures will need to be implemented.

Cybersecurity measures shall apply to all Information Technology (IT) associated with Contractor-furnished control systems. Commercial IA and IA-enabled IT products shall be certified, to the maximum extent possible, to meet common criteria security standards in accordance with CNSS Policy No. 11. In cases where certain requirements cannot be met (1) due to the limitations of Commercial control system capabilities, or (2) to preserve existing accreditations or certifications associated with classification, certification, and regulatory requirements, or (3) to prevent timing, performance, or availability failures of control systems, the Contractor shall notify the Government in accordance with the contract.

If supported by the system, commercially available Host Intrusion Prevention (HIPS) mechanisms shall be implemented and selected from the DISA Approved Products List (<https://aplits.disa.mil/processAPList.action>), on servers and workstations.

If supported by the information system, commercially available malicious code protection mechanisms (i.e. antivirus or similar) on all servers and workstations shall be implemented. A DISA Approved Anti-Virus/Anti-Spyware product (<https://www.disa.mil/Cybersecurity/Network-Defense/Antivirus>), shall be provided.

3.070.12 ICE STRENGTHENING

ABS Baltic 1C ice strengthening shall be provided.

3.070.13 SHORE CONNECTIONS

Shore connections shall be located port and starboard for freshwater, sewage, oily waste, waste oil, fuel, lube oil, and other shore connections. Shore connections for information technology/communications and electrical power shall be accessible port and starboard. The selected location for these connections and operations involving their use shall not interfere with cable highway operations, equipment loading or unloading from the pier, cable loading and unloading, and tank-to-tank cable transfers.

A powered means shall be provided for lifting and positioning shore connection hoses and cables. An anti-chafing guard or flanged roller shall be provided at the deck edge at each station to prevent chafing of cables and hoses. Anti-chafing guards shall be Type 316L stainless-steel. If an anti-chafing guard is provided, rollers shall be provided at the deck edge to facilitate inhaul of shore power cables prior to moving the cables to the anti-chafing guard. Weathertight closures shall be provided on piping shore connections.

3.070.14 MISSION VANS AND INTERFACES

Stowage locations shall be provided for four 20 ft ISO containers on exterior decks, excluding the aft working deck. If stacked, access platforms are required.

Service connections for the container locations shall include electrical power, controls, compressed air, cold potable water, fire detection, ship alarm, telephone, and network.

3.071 ACCESS

3.071.1 GENERAL

Interior spaces, except inaccessible voids, shall be provided with practical and convenient access. Clear headroom in living spaces, working spaces, and passageways from finished deck to overhead sheathing shall be a minimum of 2.1 m. Passageways shall have a minimum clear width of 1.1 m. Passageways where lines will form shall have a minimum clear width of 1.7 m. Interior passageways shall be provided with handrails. Railings shall be installed on stairs and ladders. Handrails shall not be considered a deduction to the clear passageway width.

Passageways shall be provided from the medical facility to transport sick or injured personnel to the accommodation ladders, and lifeboat embarkation areas. Passageway width along these routes shall permit passage of the Stokes litter without tilting or otherwise adjusting the attitude of the stretcher or gurney.

Access trunks, stairtowers, and inclined ladders, regardless of height, shall be fitted with a lifting padeye at the top for handling a Stokes litter.

Centrally located, enclosed, continuous stairtowers shall be provided within the living spaces for routine access and emergency egress. Elevators shall not be considered as a means of escape. Individual stairtowers and flights may be provided for vertical access in other locations.

Inclined ladders shall be provided for access to and within machinery spaces, workshops, storerooms, working areas, and other non-living spaces requiring vertical access. Inclined ladders shall be provided for access between exterior decks and walkways.

Exterior inclined ladders shall be fitted in pairs, port and starboard. Exterior inclined ladders shall provide an escape route(s) to the lifeboat embarkation deck.

Vertical ladders greater than 3,048 mm (120 in) shall have a ladder climbing system installed. Climbing harnesses shall be provided for use with the ladder climbing system(s). Vertical ladders shall be provided where limited space is available for access or escape via inclined ladder. Vertical ladders shall be provided for access to crane operator positions, to masts, to kingposts, in trunks, in vertical ducts with personnel access, and in uptake trunks.

Manholes and ladders or rungs shall be provided for access to tanks and voids. Egress routes and escape scuttles shall prevent unauthorized access from unsecure to secure spaces.

3.071.2 VESTIBULES

Vestibules shall be provided on the weather ends of passageways to protect air-conditioned boundaries. Vestibules shall be a minimum clear width and length of 1.1 m.

3.071.3 SPARES AND STORES HANDLING

Passageways utilized for the movement of equipment, spares, and stores shall have a minimum clear width of 1.8 m. Handling routes between the pallet jack accessible space(s) and the location at which the pallet jack and pallets are landed on the deck shall have a minimum clear width of 1.8 m. Portable ramps shall be supplied at doors with sills or coamings that are part of the stores handling path(s).

3.071.4 EQUIPMENT AND MACHINERY

Equipment and machinery shall be accessible for routine maintenance and condition monitoring without the use of portable ladders or scaffolding. Pipes, ducts, wireways, lighting fixtures, and other permanent fittings shall be accessible for maintenance. Access for maintenance shall not be from within a stateroom or sanitary space contiguous with a stateroom unless the equipment is serving that space.

Clear envelopes for equipment operation, maintenance, adjustment, testing, and repair shall be provided for machinery and equipment. These envelopes shall not require removal of adjacent equipment, piping, or structure. Clear envelopes for maintenance shall incorporate removal envelopes, rigging, and personnel working areas. Removal envelopes around equipment shall be in accordance with or exceed manufacturer's recommendations for maintenance envelopes.

Removal routes shall be provided for equipment and machinery that is to be shipped or unshipped. Pipes, ducts, wireways, and other permanent fittings shall be kept clear of equipment removal routes. Original Equipment Manufacturer's (OEM) jacks, supports, and other lifting gear necessary for overhaul of machinery and piping systems shall be provided. Permanent lifting and removal fittings such as monorails and padeyes shall be provided to enable equipment removal via these routes. External fittings below the waterline for removing items such as the rudder, propeller, shafting, etc., shall be hydrodynamically shaped or provided with a fairing to cover the fitting when not in use.

Hatches, Bolted Equipment Removal Plates (BERPs), or Welded Equipment Removal Plates (WERPs) shall be provided for removal of selected equipment. BERPs or WERPs shall be provided for the largest diesel generator components and propulsion motor rotor removal. Removal of BERPs or WERPs shall not require the removal of other fixed ship structure. Ancillary systems shall be kept clear of BERP or WERP openings. Additional BERPs or WERPs shall be provided for large equipment removal from the ship as required. The selection of BERPs or WERPs shall be based on the regularity of need for equipment removal. Where equipment can be expected to require removal every 8 years or less, a BERP shall be used for removal. For longer periods, a WERP is acceptable.

Fans shall be removable for maintenance or arranged to allow in-place replacement of bearings, shafts, impellers, and motors. A BERP or WERP shall be provided for removal of ventilation fans from their plenums to the interior of the ship onto a fixed deck or platform.

3.071.5 HATCHES AND SCUTTLES

Flush watertight hatches and scuttles shall be provided in interior walking and working areas. Ramped low-profile hatches and scuttles shall be provided in weather walking and working areas. Quick-acting hatches or scuttles shall be provided for personnel access. Portable handrails and/or stanchions and safety chains shall be provided for hatches and scuttles when open.

3.073 NOISE AND VIBRATION

3.073.1 AIRBORNE NOISE

Airborne noise limits shall comply with IMO Resolution MSC.337(91); Code on Noise Levels On Board Ships.

Airborne noise requirements are applicable during normal ship operation at sustained speed at 85% of Maximum Continuous Rating, during cable handling operations, and during position keeping through sea state 5. Noise level requirements are applicable with all ventilation systems in proper balance and operating at proper flow rates at the high-speed setting. Hearing protection signs shall be affixed in compartments and deck areas where airborne noise levels exceed 85 dBA.

Normally occupied service spaces such as galleys and sculleries should not subject seafarers to noise levels above IMO MSC.337(91) 5.3.5 as measured during normal galley operations requiring use of installed food or waste processing equipment.

In addition to IMO Resolution MSC.337(91); Code on Noise Levels On Board Ships, the following noise levels shall apply:

The following spaces shall have a maximum noise level 75 dBA:

- Bridge Wings at full power
- Working Decks (Note 1)
- Cable Highway
- Moonpool Staging Bay
- Splice Shop
- Test and Transmission Room (TTR)

The following spaces shall have a maximum noise level 65 dBA:

- Mission Control Room (MCR)
- Plow and Remotely Operated Vehicle (ROV) Control Room
- Unmanned Underwater Vehicle (UUV) Control Room

Storerooms shall have a maximum noise level of 80 dBA.

Note 1: For airborne noise purposes, Working Decks includes the entire aft working deck, mission van locations, rescue boat operating station, anchor handling station, Sea Plow Launch and Recovery System (LARS) control station, ROV LARS control station, and crane control locations.

3.073.2 SONAR SELF-NOISE

The sonar self-noise at the transducer locations shall meet the requirements of the sonar manufacturers and the requirements herein. The sonar self-noise levels at the sonar transducer locations shall not exceed the values given in Table 3.073.2-1 for all mission sonar operating conditions through 10 knots.

Table 8: [3.073.2-1] Sonar Self Noise Level Requirements

Equipment	System Model	Frequency (kHz)	Spectrum Noise Level (dB re 1 μPa/Hz) (See note)
Multibeam Survey System (MBSS-DW)	EM124	12	49

Sub Bottom Profiler (SBP)	SBP 29	2 – 3	64
		3 - 9	60
Acoustic Navigation and Tracking System (ANTS)	High Precision Acoustic Positioning (HiPAP) 502 HiPAP 102	21 – 31	47
Singlebeam Survey System (SBSS)	EA 640	12	49
		38	40
		200	32
Acoustic Doppler Current Profiler (ADCP)	Pinnacle	45	38

Note: The spectrum noise level shall be achieved without the thruster(s) in operation.

Stern tube bearings (if used) shall be selected to ensure that no shaft squeal affects sonar self-noise at any speed.

3.073.3 BUBBLE SWEEPDOWN

The ship's hull and appendages shall prevent bubble sweepdown interference with the sonar transducers. Bubble sweepdown refers to the tendency of entrained air bubbles, originating at the free surface near the bow of the ship, to follow flow streamlines and be drawn under the hull into the area of the bottom mounted sonar transducers. Flow diverting fences, fins, scoops, and other devices installed solely as a means of bubble streamline diversion shall not be used. Conventional bulbous bows, defined as shapes containing underwater volume projecting forward of the forward perpendicular and designed to reduce wave resistance, shall not be used. The hull shape shall be selected such that flow streamlines originating at the ship's stem shall pass no closer than 6.6 ft (2 m), measured transversely, from the centerline of the MBSS-DW sonar transducer receive array area at sustained speed at the Full Load Departure condition without service life allowance and at the Mid-Voyage condition without service life allowance. Streamline initiation points shall include:

- The stem at the even-keel free surface
- The stem at a point below the free surface equivalent to an aft trim of 1.65 times the maximum Root Mean Squared (RMS) pitch in sea state 4

The Contractor shall incorporate the following design features, as a minimum:

- Sonar transducers shall be arranged to minimize interference associated with local flow noise and located at the flat of the bottom of the hull.
- All hull appendages including sonar transducers and their housings, closed moonpool doors, and bilge keel leading edges shall be cavitation free, aligned with water flow, and

fair within 0.125 in (3.2 mm) over any 24 in (610 mm) span. Surfaces within 10 ft (3 m) of sonar transducer locations shall be fair within 0.125 in (3.2 mm) over any 24 in (610 mm) span and have a 250 micro-inch finish when painted.

- Bilge keel leading edge construction details shall be Government Furnished Information (GFI).
- Within 20 ft (6.1 m) of sonar receive transducers, all piping and ducting, except in fuel tanks, shall be supported by resilient hangers and air flow in ducting shall not exceed 33 ft/s (10.1 m/s).
- Piping penetrations for fluid systems shall be located as far as practical from sonar receive transducers. Structural paths to the sonar from bulkhead penetrations shall be damped to prevent compromising sonar transducer performance.
- The bow thruster inlet and discharge openings shall be cavitation free and arranged to minimize turbulence at the sonar transducer locations. Accumulation of air in the thruster shall be prevented.
- Hull openings for main sea suctions and discharges shall be located at least 30 ft (9.1 m) from all sonar transducers. Except for the bow thruster openings and uncontaminated seawater system intakes, all sea connectors and underwater shell openings shall be aft of the sonar transducers.
- Orifices and other flow control devices for fluid systems shall be located a minimum of 20 ft (6.1 m) from sonar receive transducers.

3.073.4 VIBRATION

3.073.4.1 HULL VIBRATION

Ship vibration levels shall be in accordance with ANSI S2.25. The natural frequency of the hull structure shall be a minimum of 125% of the maximum propulsor and thruster blade rates, and less than 67% or greater than 125% of the engine-induced excitation frequencies, unless resolved by global forced vibration analyses. Structure resolved by global forced vibration analyses shall have responses within the limits specified in the ABS Guidance Notes on Ship Vibration.

3.073.4.2 MACHINERY AND EQUIPMENT VIBRATION

Reciprocating engine vibration levels shall be in accordance with the torsional vibration requirements of ANSI S2.27. Vibration levels of engine mounted platforms, walkways, and components shall not exceed the vibration levels specified in ANSI S.2.27 for cylinder heads. Ship propulsion machinery vibration levels shall be in accordance with ANSI S2.27, including the requirements for hard turns as described in Annex A. Barred speed ranges shall not be allowed. Generating set vibration levels shall be in accordance with ANSI S2.27.

Machinery not covered by ANSI S2.27 shall meet the vibration criteria of ANSI S2.28 unless otherwise approved. For machinery tested to ANSI S2.28 the measured vibration of machinery

shall be within Zone boundary A/B of Tables 2, 3 or 4 as applicable. Machinery not listed in Table 1 shall meet vibration limits for Group 3 of Table 1.

Shipboard equipment and machinery components supporting essential services as identified in ABS MVR shall meet the acceptance criteria of ANSI S2.26.

3.073.4.3 FOUNDATION VIBRATION

Foundations shall have a natural frequency less than 67% or greater than 125% of the rotational speed of the equipment supported by the foundation.

Foundations that support equipment greater than 1,000 kg shall have a natural frequency greater than 125% of the maximum propulsor and thruster blade rates, and less than 67% or greater than 125% of engine induced excitation frequencies. Forced vibration responses shall be within the limits specified in ABS Guidance Notes on Ship Vibration.

3.076 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

The ship shall achieve a minimum Materiel Availability (A_m) of 0.70 based on being Ready For Tasking (RFT) a minimum of 255 days per year. A_m is defined below with “Days RFT” representing the number of days that the ship is not classed in a C4 material readiness level per Navy Tactical Reference Publication (NTRP) 1-03.5 and is not in a scheduled maintenance period.

$$A_m = \frac{\text{Days RFT}}{365}$$

When the ship is RFT, it shall achieve a minimum Operational Availability based on Critical Failures (A_{ocf}) of 0.92 and a minimum Materiel Reliability (mean time between critical failures) (R_m) of 600 hours. A_{ocf} is defined as:

$$A_{ocf} = \frac{\text{Days RFT}}{\text{Days RFT} + \text{Days C4}}$$

R_m is defined as:

$$R_m = \frac{\text{Operating Hours}}{\text{No. of Critical Failures}}$$

A critical failure is defined as a failure that results in a C4 material readiness level.

3.077 ENVIRONMENT, SAFETY, AND OCCUPATIONAL HEALTH

The ship’s systems, equipment, and arrangements shall incorporate Environment, Safety, and Occupational Health (ESOH) requirements to ensure the safety of personnel, systems, equipment, and the environment during design, construction, operation, maintenance, and support evolutions.

The ship shall comply with Navy environmental policy in accordance with OPNAVINST 5090.1 and occupational safety and health requirements in OPNAVINST 5100.19. System safety shall be incorporated into the design and construction process in accordance with MIL-STD-882 and NAVSEAINST 5000.8.

Class I or II ozone depleting substances, as defined in the Clean Air Act, 42 U.S.C., shall not be permitted in the construction and operation of the ship. Lead paint shall not be used in the construction of the ship. Lead shall not be used for acoustic insulation.

The Prohibited chemicals in the NAVSEA Hazardous Material Avoidance Process (NHMAP) shall not be used in the construction and operation of the ship. Chemicals on the Restricted list of the NHMAP cannot be used unless there is a listed exception or their use is approved by the Government.

3.078 MATERIALS

Materials and equipment shall be new and of the best commercial marine quality. Only new equipment and systems with proven high reliability levels, based on wide marine usage, shall be employed. Direct contact of electrolytically dissimilar metals is prohibited unless electrolytic corrosion precautions are used. Lubricants and hydraulic fluids shall be selected from those recommended by the equipment manufacturer.

3.079 GENERAL SEAKEEPING

The wave-induced ship motions shall not exceed the seakeeping criteria specified in Table 3.079-1 for the specified sea state in Table 3.079-2, over the indicated range of modal periods, using a Bretschneider spectrum with long and short-crested seas with cosine-squared spreading function.

Table 9: [3.079-1] Seakeeping Criteria

Mission	Speeds	Sea State	Headings	Motion	Limit ¹	Location
Transit	15 knots	SS 5	All	Vertical Accel RMS	0.2 g	Bridge
				MII	1/min	Bridge
				Slams/hour	20	At bow ²
				Deck Wetness/hr	30	At bow and stern ²
				Propeller Emergence/hr	90	¼ propeller diameter
Cable Operations	0 knots 7 knots	SS 5	All	Vertical Accel RMS	0.2 g	Aft working deck
				MII	0.5/min	Aft working deck

				Deck Wetness/hr	0.5	Transom
				Roll RMS	2.2 deg	
				Pitch RMS	2.2 deg	
Plow/ROV Deploy/ Retrieve	2 knots	SS 5	All (Plow) Best (ROV)	Vertical Accel RMS	0.2 g	Plow and ROV LARS stations
				MII	0.5/min	Plow and ROV LARS stations
				Deck Wetness/hr	0.5	Transom
				Roll RMS (ROV)	2.2 deg	
				Pitch RMS	2.2 deg	
Moonpool Operations	2 knots	SS 3	Best	Roll RMS	2.2 deg	
				Pitch RMS	2.2 deg	
				Vertical Accel RMS	0.2 g	Moonpool Staging Bay
				MII	0.5/min	Moonpool Staging Bay
				Deck Wetness (Overtopping)/hr	0.1 ³	Moonpool Staging Bay
				Air pressure oscillation	± 2 millibar	Moonpool Staging Bay
Survival	Best	SS 8	Best	Survival of ship and crew. Ship shall maintain mobility, structural integrity and watertight integrity.		

Notes:

1. Displacement, velocity and acceleration limits are relative to an earth-fixed reference frame and are RMS values.
2. Bow is defined as 15% of the Length Between Perpendiculars (LBP) aft of Forward Perpendicular (FP). Stern is defined as at the transom.
3. With moonpool door open

Table 10: [3.070-2] Sea State Properties Table

Sea State Number	Significant Wave Height (meters)	Modal Wave Period (seconds)	Sustained Wind Speed (knots)
3	1.25	5.5-14.8	13.5
4	2.5	7.90 – 15.2	21
5	4.0	10.0 – 15.5	27
8	14.0	16.4	63

3.080 LOGISTICS AND READINESS

3.080.1 LOGISTICS SUPPORT REQUIREMENT

The primary own-ship logistics support requirement is to sustain operational requirements and availability during both peacetime and wartime scenarios throughout the service life. Life cycle logistics support planning and supportability analyses results shall be incorporated in the ship design in order to optimize tradeoffs between operational performance and life cycle support costs. The reliability, maintainability, and supportability characteristics of the ship and its critical systems shall enable the ship to complete its mission at the lowest total ownership cost.

3.080.2 SUPPLY SUPPORT

Materials Storeroom Items (SRI), Operating Space Items (OSI), shore-based spares, other items needed to support the systems and equipment, and other support and test equipment shall be provided. The ship's supply support requirements shall be based on the MSC maintenance and operational philosophy.

3.080.3 MAINTENANCE

The ship will employ a two-level (organizational (shipboard) and depot) maintenance philosophy in accordance with Appendix E. This philosophy incorporates standard commercial practices and complies with the Alternate Compliance Program (ACP) certification and ABS classification. Embedded diagnostics and prognostics data from the main propulsion, generator sets, major auxiliary, and ship control systems shall be exportable to the Shipboard Automated Maintenance Management (SAMM) system via the Machinery Centralized Control System (MCCS).

3.080.4 OUTFITTING/FITTING OUT

Stowage spaces and stowage aids shall be provided for outfitting materials in the approved allowance documentation.

3.080.5 STANDARDIZATION

Equipment commonality shall be provided among ships of the class. This commonality shall include the main propulsion, generator sets, cable machinery, major auxiliary, and ship control systems. Standardization shall be incorporated in design and equipment selection for each ship and across the ship class.

The number of different grades of lubricants and hydraulic fluids shall be minimized.

3.080.6 COMPUTER RESOURCES

The MSC-developed SAMM system will be utilized for documenting and scheduling shipboard maintenance actions and assessing ship energy performance. Space, power, and network connectivity shall be provided in the Pilot House and Engineer Operating Station (EOS) for bulkhead mounted SAMM Energy Dashboard Workstation display panels in a location that is

eye-level or higher, in accordance with the GFI to be provided in Phase 2. The display panel in the EOS shall be visible to an operator standing in front of the Main Control Console (MCC). Where systems are required to make data exportable to SAMM, the respective system shall interface to the unclassified Local Area Network (LAN) through a SAMM Data Acquisition Interface (DAI) unit. Space, power, and network connectivity shall be provided for all DAI units in accordance with the GFI, to be provided in Phase 2. The MSC Ship's Configuration and Logistics Information Program (ShipCLIP) will be utilized for supply and configuration support.

3.080.7 FACILITIES

Facilities shall be provided onboard for the ship's complement to perform the maintenance as specified herein, taking into consideration the equipment installed onboard the ship.

3.088 HUMAN FACTORS ENGINEERING

The ship shall be in accordance with ASTM F1166. Design of systems shall take into account the needs of operators, maintainers, and support personnel. The ship will be manned and operated by a mixed gender complement of civilian mariners from MSC, contractors and military personnel in accordance with Table 070.3-1. All ship systems shall be operable and accommodate personnel from the 5th percentile female to the 95th percentile male (North American). Systems including hardware and software shall minimize the requirement for special cognitive, physical, or sensory requirements of the operators, maintainers, or support personnel. The ship shall be automated wherever practical to reduce workload requirements. The ship shall be designed to prevent personnel overload in the performance of critical tasks by optimally allocating assignment of functions to personnel, hardware, and software.

3.100 REQUIREMENTS FOR HULL STRUCTURE

3.100.1 LOADS NOT ADDRESSED BY ABS

Loads not specifically addressed by ABS shall be determined. Design loads shall be combined to represent worse case loading conditions.

Tug push zones shall be provided to ensure that hull damage is prevented.

Fender-induced side shell design loads shall account for berthing at a pier in full-load condition.

3.100.2 HULL STRUCTURE

The ship's structure shall provide the elastic strength, reliability, and stiffness required to perform the missions specified and meet the service life of the ship. The ship's structure shall not fail from structural instability when subjected to design loads. The ship's structure shall be of welded construction.

Welding in tanks, bilges, coamings, and structures exposed to the weather shall be double continuous. Welding in wet areas shall be double continuous up to a minimum height of 300 mm above the deck.

Hull, deck, and bulkhead penetrations shall not compromise the structural integrity and tightness integrity of the penetrated structure.

The sheer strake shall not extend above the strength deck. Where a welded waterway bar is provided on the deck, it shall be a minimum of 150 mm inboard of the shell.

Ends of longitudinal structure shall not be left unsupported. Longitudinal structure shall terminate on frames or headers. Exposed outside corners of interior steel bulkheads in accommodation spaces shall be rounded to a minimum 75 mm radius.

Structure contributing to the longitudinal hull girder strength of the ship shall be continuous through transverse structure. Structure shall be aligned so that advantage can be taken of continuity in the design. Structural continuity of the hull girder shall be maintained. Structural discontinuities, especially at compartment boundaries, shall be avoided. Longitudinal framing, transitioning to transverse framing or vice versa, shall be avoided unless the design can be shown to avoid structural discontinuities and stress concentrations.

3.100.3 STRESS RISERS

Structural details subjected to seaway induced cyclic loads shall have a crack free fatigue life that equals or exceeds that required for the ship's service life and operational profile specified herein. Structural stress concentrations shall be minimized. Loads shall be effectively distributed. Knife-edge crossings shall be eliminated except that waterway bars shall not require knife-edge mitigation. Openings in any part of the ship's structure, including those parts that do not contribute to the longitudinal strength of the ship, shall have radiused corners. Corner radii of openings in the innerbottom tank top, shell plating, and decks that contribute to the longitudinal strength of the ship shall be at least 1/8 of the transverse, or girth dimension of the opening, with a minimum of 150 mm but need not exceed 610 mm. In structural bulkheads and deckhouse sides, the radius shall be at least 1/8 of the vertical dimension of the opening, but need not exceed 150 mm. Where specified radiused corners in openings are impractical, the detail shall have a fatigue life greater than or equal to the service life of the ship.

Changes in thickness of plating or scantlings of longitudinal stiffeners and highly stressed transverse members shall be gradual. Plate thickness changes greater than 6 mm shall be tapered at a minimum gradual slope of 1:4.

3.100.4 CORROSION

Reduction of scantlings through the use of special coatings for corrosion control is not permitted.

In addition to the material thickness required by ABS MVR, a corrosion allowance of 10% shall be provided in seawater ballast tanks, machinery space bilges, inaccessible areas, and areas which are infrequently dewatered (e.g. forepeaks, cofferdams, and voids). Bilges are the lowest 1 m of the space. For this purpose, the following are defined as machinery spaces: shaft alleys, shaft alley accesses, sewage treatment rooms, water equipment rooms, main machinery spaces, auxiliary machinery spaces, and spaces containing solid waste transfer and processing equipment.

3.100.5 TANKS

Structure used in tanks shall be of the open-section type. Where structural members pass through the boundary of a tank, oil and water stops shall be provided. Oil and water stops shall preclude migration of fluids along weld joints. The cumulative area and location of the limber holes shall prevent trapping air and liquid in pockets when filling and draining the tank at the maximum rate.

3.100.6 DOCKING PLUGS

Docking plugs shall be provided for tanks, voids, rudder cavities, and double plate bilge keels that have a boundary to the shell below the scantling draft waterline, unless otherwise specified herein. Within each space, docking plugs shall be located at each low point in the space when the ship is at zero trim and list. In those instances where an area of the space bottom qualifies as the lowest point in the space (i.e. due to a flat bottom), the aft-most location shall be considered the lowest point. In spaces with multiple low points, a maximum of three locations shall be selected for docking plugs, and they shall be those three that drain the greatest amount of retained fluid.

If placement of a docking plug within practical restrictions of detail arrangement results in the docking plug being placed more than 1 m above the level of the tank suction, then a docking plug is not required. Docking plugs shall be located where they do not interfere with docking blocks.

The docking plug insert plate shall be Grade DH-36 with a minimum thickness of 25 mm regardless of the grade and thickness of the shell material into which it is inserted.

3.100.7 COAMINGS

Open deck-edges, catwalks, open ramps, and deck cutouts shall be fitted with toeboards or coamings a minimum of 75 mm high, as measured from the walking surface. Coamings in way of ladders and stairs shall be cropped. Ship sides without a bulwark shall be provided with a 150 mm high waterway bar.

3.130 HULL DECKS

Decks exposed to the weather shall have straight camber starting no more than 500 mm off ship centerline with the following exceptions:

- Hatch covers are not required to be cambered or have sheer.
- The forward mooring area may have sheer instead of camber.
- Decks covered by a deck above are not required to be cambered in the center 50% of the covered portion.

Camber and sheer shall be approximately 20 mm per meter (2%).

Camber and sheer shall be prohibited within the deck house and other interior spaces.

The Aft Working Deck, crane landing areas, and UUV stowage and staging locations shall be designed for a live load of 49 kPa (5 tonnes/m², 1,025 lb/ft²).

Deck Bolt Sockets and Mission Van Fittings

The Aft Working Deck, crane landing areas, ROV LARS area, Moonpool Staging Bay, cable hauler locations, and the UUV and Package stowage locations shall be provided with a grid of 1-in 8NC (SAE National Coarse Thread) flush deck bolt sockets on 2 ft (610 mm) centers with a tolerance of $\pm 1/16$ in (2 mm) on center. The bolt down pattern on the deck shall be parallel and perpendicular to the centerline of the ship to facilitate design of equipment foundations. The sockets shall be installed and tied to the deck structure to provide maximum holding strength. Dedicated bolt sockets shall be provided for demountable deck equipment. Deck bolts and sockets shall be capable of being loaded to minimum of 5,000 lbs (2,268 kg) each.

All deck sockets shall be CRES 316. Deck sockets and welds shall be flush with the finished surface of the deck. Deck sockets shall have a minimum threaded length of two bolt diameters. Deck sockets shall not compromise the integrity of watertight decks. Removable bronze bolts with flush socket heads shall be provided, set in anti-seize compound to fill all deck bolt sockets. The ship shall be delivered with the bolts installed.

The Mission Van locations and the Package stowage and staging locations shall be designed to withstand loading imposed by stowage of ISO Standard 668, freight designation 1CC vans, each with a maximum gross weight as specified by ISO Standard 668.

Flush ISO deck fittings shall be provided for the Mission Van locations and the Package stowage and staging locations. Flush corrosion resistant plugs shall be provided for ISO deck fittings to prevent debris from collecting and protect against tripping.

3.170 MASTS

Masts, kingposts, and their platforms shall support the installed equipment, weight of maintenance personnel, and withstand the effects of ship motions and weather loads combined to produce worst case loading conditions. In tension, the sum of the bending and axial stresses resulting from the combined loads shall not exceed 40% of the yield strength of the material. In compression, the sum of the ratios of the bending stress to yield stress and axial stress to buckling capacity shall not exceed 0.40. The structure of the platforms shall meet the frequency requirements of the antennas.

Masts shall meet requirements for ship's structure.

Design shall include attachment points for climber safety gear.

3.180 FOUNDATIONS

Structure for major foundations shall be incorporated into hull, deck, and bulkhead framing where practical. Backup structure shall be aligned with the foundation and integrated into the base structure.

Foundations shall be free of pockets that could retain liquids. Foundations shall be rigid and aligned to avoid distortions of structure, equipment supported, and resilient mounts under conditions of static and dynamic loading.

Ship motion load factors in accordance with DoD-STD-1399 (Navy) Section 301 shall be applied to foundations and equipment. The load factors shall be calculated using the shortest ship heave, roll, and pitch periods computed for the ship in the loading conditions identified in Section 3.070.9. Foundations subject to cyclical loadings shall withstand these loadings over the ship life cycle without failure.

3.184 NAVIGATION SYSTEM AND MISSION ELECTRONIC SYSTEM (MES) ALIGNMENT

3.184.1 DEFINITION AND REALIZATION OF REFERENCE FRAME

The spatial reference frame for the ship shall be defined by a right-hand, orthogonal system with the general orientations: x-axis forward, y-axis to starboard, and z-axis down. The origin of this system shall be at the center of the heading and athwartships lines of the master reference block (MRB). The direction of the z-axis shall be defined as perpendicular to the design waterline plane. The direction of the x-axis shall be defined by the centerline of the keel. Positive rotations shall be defined as counterclockwise about the axis looking towards the origin, such that positive rotations are: in yaw (z-axis) to starboard, in pitch (y-axis) bow up, and in roll (x-axis) starboard down.

The spatial reference frame of the ship shall be realized in the following manner:

- The z-axis orientation by fitting, in a least squares sense, a plane through the draft marks closest to the design waterline (e.g. if the design waterline is 12.3 ft, a plane shall be fitted to the 12 ft draft marks). This is the waterline plane. The z-axis shall be perpendicular to this plane.
- The x-axis orientation by fitting, in a least squares sense, a plane perpendicular to the waterline plane through the external keel centerline benchmarks. This plane is the centerline plane. The x-axis orientation shall be embedded in this plane and perpendicular to the z-axis.
- The y-axis shall be perpendicular to both the x and z-axis.
- The origin of the reference frame shall be the center of the heading and athwartships lines of the MRB.

3.184.2 MASTER REFERENCE BLOCK AND REFERENCE FRAME

An MRB shall be provided, consisting of a granite reference block at least 18 in (450 mm) length by 12 in (300 mm) wide by 2 in (50 mm) height, permanently scribed with orthogonal heading and athwartships lines, and aligned to the ship's reference frame within 6 minutes of arc in the x, y, and z axes. The block shall be mounted on a sufficiently rigid foundation and supported in a steel box by swivel-leveling threaded bolts, which shall also be used to position and level the block. After installation and alignment of the reference block, the block shall be fixed in the box with poured epoxy, Chockfast Orange or equivalent.

The ship's spatial reference frame shall be additionally defined with permanent benchmarks throughout the ship. Benchmarks shall be CRES, unpainted plates 2 in (50 mm) square with permanently scribed center marks and unique, permanently inscribed numbers. The position of these benchmarks in the spatial reference frame of the ship shall be measured to the accuracy specified in Table 3.184.2-1. Benchmarks shall be located to maximize field of view and not be located behind equipment, cabinets, or other obstructions. Benchmarks shall not be located within the area required to be cut out for installation of transducers, seachests, and other equipment. Benchmarks shall be installed:

- not less than four benchmarks on the keel (forward and aft)
- not less than four benchmarks on the aft working deck area and on the deck forward (one forward near foremast on centerline, one on the aft working deck area on centerline, and one each port and one starboard on the aft working deck area perpendicular to centerline)
- one on the O1 level weather deck forward of amidships on centerline
- one on the base of the foremast
- one on the upper main mast antenna servicing platform

The aft working deck area benchmarks shall be located to provide alignment instruments with a clear line of sight to the main mast benchmark and adjacent benchmarks. Forward deck

benchmarks shall be located to provide a clear line of sight to the foremast, other forward deck benchmarks, and the main mast benchmark.

A minimum of four local permanent benchmarks, referenced to the MRB, shall be installed at each of the following locations in such a manner and quantity so as to permit accuracy in resurvey and positioning of equipment:

- in each space containing transducers
- in the space containing the inertial measurement unit (IMU)
- in each space containing gyrocompasses
- within line of sight at each Global Positioning System (GPS) antenna, scientific antenna, and navigational antenna

Draft marks shall be surveyed to the tolerances required for benchmarks.

Table 11: [3.184.2-1] Survey Specifications

System	MEASUREMENT TOLERANCES ALIGNMENT				
	Horizontal	Vertical	Heading	Pitch	Roll
Ship's MRB	(0, 0, 0) Coordinate reference		0 ± 0.0025° ref to centerline vertical keel	0 ± 0.0025° ref to gravity plane	0 ± 0.0025° ref to gravity plane
IMU	± 5 mm	± 5 mm	0 ± 0.1°	0 ± 0.025°	0 ± 0.025°
GPS, Differential Global Positioning System (DGPS) and Attitude Heading Reference System (AHRS) antennas	± 5 mm	± 5 mm	--	--	--
GPS antennas (referenced to each other)	± 5 mm scalar	--	--	--	--
Radar antennas and Gyrocompasses	± 50 mm	± 20 mm	0 ± 0.1°	--	--
Multi-Beam transducers	± 5 mm	± 5 mm	0 ± 0.1°	0 ± 0.025°	0 ± 0.025°
ADCP	± 50 mm	± 20 mm	0 ± 0.1°	0 ± 0.1°	0 ± 0.1°
Benchmarks	± 5 mm	± 5 mm	--	--	--
Single Beam transducers, directional finders, and navigational antennas	± 50 mm	± 20 mm	0 ± 0.1°	0 ± 0.1°	0 ± 0.1°

3.184.3 INSTALLATION ALIGNMENT

Unless otherwise specified, GPS antennas, DGPS antennas, AHRS antennas, the IMU, navigational antennas, directional finders, radar antennas, gyrocompasses, transducers, and mission system sensors shall comply with the manufacturer's system installation and alignment requirements, comply with recommended optimum sensor mounting locations, and support orthogonal survey requirements.

The following components shall be aligned with the ship's reference frame to within 1°:

- top surface of the multi-beam mounting frame flange or the underside of the “flange counterpart”
- IMU attitude sensor mounting plate
- MRB
- gyrocompass foundation plates

The IMU and gyrocompasses shall be mounted to these plates, physically aligned in heading within 6 minutes of arc, and fixed in place.

Multi-beam transmit and receive arrays shall be co-aligned within 1° and each shall be aligned to the ship frame within 1°, or manufacturer's recommendations, whichever is more precise.

Each transducer housing shall have a forward and aft lineup mark parallel to the ship's centerline and on the interior side of the hull. Each lineup mark shall consist of two triangles with a center punch mark, separated by 2 in (50 mm).

3.184.4 MEASUREMENT OF COMPONENT POSITION AND ROTATION

Unless otherwise specified, the position of all GPS antennas, DGPS antennas, AHRS antennas, IMU, navigational antennas, directional finders, radar antennas, gyrocompasses, transducers, and benchmarks shall be surveyed in the ship's reference frame in accordance with Table 3.184.2-1, or to manufacturer's recommendations in cases where the manufacturer's recommendations are more precise than the value stated in Table 3.184.2-1 for a particular piece of equipment.

3.200 GENERAL REQUIREMENTS FOR MACHINERY PLANT

The ship shall be propelled by mechanical, electrical, or combined mechanical and electrical transmission systems. Steam shall not be used as a means of providing propulsion, electric power, or auxiliary services.

All components of the propulsion system shall be designed to function continuously in all required modes of operation including the cyclical variations imposed by dynamic positioning. The machinery shall be capable of continuous operation using the fuels specified herein.

The machinery plant shall be in compliance with ABS Guide for Dynamic Positioning Systems for DPS-2 vessels.

The design margin for effective power shall be commensurate with the design development and the margins provided in Appendix B.

Rated shaft power shall be achieved at the Full Load Departure condition. Sustained speed shall be achieved at the Full Load Departure condition using a maximum of 85% propulsors rated power and no greater than the following:

- For mechanical drive plants and combined mechanical and electric drive plants at sustained speed, 85% of the installed propulsion engine rating.
- For electric drive plants, 85% of the installed propulsion motors rating and 85% of the sum of the propulsion generator set ratings.
- For integrated electric plants, 85% of the installed propulsion motors rating and 85% of the sum of the installed generator set ratings following deductions for at-sea ship service power requirements and electric power service life allowances.

The machinery plant shall be capable of the following:

- Continuous, steady state operation at low speed and low load without adverse impact to the prime movers, propulsion system components, or imposing operational restrictions.
- Operating in trail shaft without adverse impact to the prime movers or propulsion system components, or without imposing operational restrictions.

3.202 CONTROL AND MONITORING SYSTEMS

3.202.1 MACHINERY CENTRALIZED CONTROL SYSTEM

A distributed MCCS shall be provided to monitor the propulsion, electrical, auxiliary, damage control, mission systems and other systems and equipment. The MCCS shall be comprised of an MCC, a Ship Control Console (SCC), a Damage Control Central Console (DCCC), a Secondary Damage Control Central workstation, a Duty Engineer's workstation, and a Chief Engineer's workstation.

The MCCS consoles and workstations shall be provided with 600 mm minimum diagonal color flat panel monitor(s). Color laser printers with the capability to print from MCCS shall be provided in the following quantities and locations:

- One in the Pilot House
- One in EOS
- One in the Chief Engineer's Office

The MCC shall be located in the EOS. The MCC shall provide a sufficient number of displays to ensure that the operator can monitor and control the following functions simultaneously without the need to toggle between the display screens:

- Propulsion system
- Electrical generation and distribution systems
- Auxiliary systems
- Damage Control (DC) systems
- An additional screen for use at the operator's discretion

The MCCS shall provide the capability for a single operator to shift from each machinery plant operating mode to each other machinery plant operating mode from the MCC.

The SCC shall be installed in the Bridge. The Bridge Wing controls shall interface with the SCC. The SCC shall contain equipment required to initiate and sustain control of all ship control operating modes.

The DCCC shall be installed in Damage Control Central (DCC) and provide the capabilities specified herein. The secondary DCC workstation shall provide the capabilities specified herein.

The Duty Engineer's workstation shall be installed in a passageway in the vicinity of the licensed engineer staterooms. The Duty Engineer's workstation shall have full monitoring capabilities.

The Chief Engineer's workstation shall be installed in the Chief Engineer's Office. The Chief Engineer's workstation shall have full monitoring and control capabilities.

The MCCS shall provide primary propulsion control from the MCC and secondary control from the SCC and Bridge Wings. Propulsion control from the SCC, Bridge Wings, and MCC shall include independent and combined control of each propulsor's speed, pitch (if Controllable Pitch (CP)), and direction (if azimuthing).

Mimics shall dynamically display and allow the operator to control the system parameters and status of machinery, electric plant, circuit breakers, valves, tank levels, and controls on a schematic representation of the system. Monitored parameters shall include temperatures, system pressures, pump suction, discharge pressures, flows, levels, equipment starts and stops, operating hours, and propulsion shaft torque. Abnormal conditions shall actuate alarms and provide for automatic shutdown in the case of malfunctions which could lead to equipment damage or personnel hazard. Alarms shall be automatically displayed on MCCS mimics.

MCCS consoles shall be provided with NEMA Type 250, or IEC 60529 equivalent certified enclosures. MCCS shall provide distinct audio and visual notifications within console and workstation spaces. Indicator lights on control consoles and local panels shall be the Light Emitting Diode (LED) type. MCCS consoles shall contain lamp test and horn test capabilities.

SCC, DCCC, and shall have dimmer capability. Touch screen interfaces shall have backup keyboard and pointer input devices.

The MCCA shall be provided with a data acquisition system and a condition-based monitoring system. The condition-based monitoring system shall be provided that integrates the MSC SAMM system for log entries, machinery run hours, vibration monitoring and oil analysis. The data acquisition system shall have the capability to collect, store, and generate reports for parameters monitored by MCCA in a central ship database. The central ship database shall provide a direct source parameter reference for the SAMM system. It shall have a graphic module with online and historical trending capabilities that allow it to operate using a non-proprietary system. MCCA data, shall be exportable to SAMM. Embedded diagnostics and prognostics data or equivalent condition-based monitoring from the main propulsion, generator sets, cable handling, propulsion auxiliary, and ship control systems shall be exportable to the SAMM system.

The data acquisition system shall be comprised of Data Acquisition Units (DAUs) that receive and transmit data to the components monitored and controlled by the MCCA. An interface unit will be provided as part of the SAMM system for the exchange of data between the MCCA and the unclassified LAN. A minimum of one unassigned Ethernet port shall be provided to allow connection of the MCCA and the SAMM interface unit.

The central ship database shall be equipped with synchronizing protocols capable of parameter and database synching with the MCCA consoles.

Automatic MCCA data logging shall be provided. MCCA data logging shall be capable of producing a color printed record of selected monitored parameters and associated alarm status every 4 hours, whenever the station in control of propulsion changes, and on demand. The printed summary shall be in a form similar to an engineer's logbook. The data logger shall provide a permanent record of alarm parameters including date, time, and alarm set or reset (and maneuvering bell) on electronic storage media. An automatic digital backup record shall be provided. The data acquisition system shall have an electronic storage memory capable of retaining a minimum of 180 days of continuous data from the bell and MCCA data logs. The MCCA shall include provisions for 20% growth overall allowing appropriate spare capability at each DAU for future alarms and controls. The MCCA Central Processing Unit (CPU) average utilization shall not exceed 50%.

A means to prevent unauthorized modification of MCCA software data, bell logs, and set points shall be provided.

Two laptop computers with the capability to perform system maintenance, upgrade software, and diagnose problems shall be provided.

3.202.2 POWER MANAGEMENT SYSTEM (PMS)

The PMS shall be integrated into MCCS. The PMS shall display the power generation system and heavy consumers. The PMS shall provide the control capability to permit re-configuration of the electrical plant (i.e. generators, bus ties, and circuit breakers). The PMS shall include a blackout detection and recovery system.

The power management system shall provide the capability to configure set points allowing the operator to adjust the following:

- Percentage of connected generating capacity and time delay that initiates starting and loading a standby generator
- Percentage of connected generating capacity and time delay that initiates taking an online generator offline
- Percentage of connected generating capacity and time delay for initiating load shedding

The power management system shall allow the operator to select an operating mode that permits single generator operation during unattended operation and in-port operation.

3.202.3 SHORE POWER MONITORING CAPABILITY

MCCS shall have a shore power monitoring capability at the MCC. Voltage, current, power factor, and power monitoring shall be provided for the total shore power demand and individual shore power cable phases. Shore power monitoring shall include cumulative energy used, energy metrics and imbalances for each phase of each shore power cable (V, I, PF, kW, and kW demand), energy peaks, and quality of shore power provided to the ship. Summary information shall display V_{ac} , V_{bc} , V_{ca} , I_a , I_b , I_c , kW, 3phase, and current and voltage imbalance for each cable and cumulative kWh at the main control console mimic/control display. Daily and monthly data log files shall be automatically created in an MS Excel compatible format and all energy data and logs stored. The shore power monitoring device shall be capable of remote communication via Ethernet port.

3.233 DIESEL ENGINES

Diesel engines shall produce rated power at the maximum ambient temperature, the engine cooling water temperature based on the maximum conditions, and the intake depression and exhaust backpressure of the combustion air intake and exhaust systems listed in Appendix F.

Diesel engines shall comply with 40 CFR, EPA, and IMO emissions requirements applicable to marine engines intended for US Flag commercial vessels. Means shall be provided to maintain diesel exhaust temperature within the engine exhaust treatment system (if applicable) manufacturer's recommendations over the intended operating range of the engine and over the range of combustion air inlet temperatures from the minimum ambient temperature to the maximum inlet air temperature specified in Appendix F.

The engines shall be capable of running continuously at its rated power, rated speed, and rated ambient conditions between the manufacturer's recommended maintenance intervals.

All diesel engine cooling systems shall be freshwater.

Main propulsion engines shall be capable of continuous operation at low speed and low load without adverse emissions or negative effect on material condition. Main generator, propulsion generator, and ship service generator engines shall be capable of continuous operation at loads greater than or equal to 20% without adverse emissions or negative effect on material condition.

Diesel engines shall be fitted with heaters capable of raising operating liquids from the minimum ambient temperature to the temperature recommended by engine manufacturer for reliable starting in a time period not to exceed eight hours. Means shall be provided to maintain temperatures required to support immediate start-up and loading, when in stand-by.

The following shall be provided for each diesel engine:

- Duplex fuel suction strainer (in accordance with the manufacturer's recommendations)
- Pre-lubrication oil system (in accordance with the manufacturer's recommendations)
- Electronic governor with ball-head backup or fully redundant electronic control with a back-up power supply
- Turbocharger exhaust transition connections (in accordance with the manufacturer's recommendations)
- Exhaust silencer. shall be provided with a spark arrestor. Soot collector boxes shall be readily accessible for periodic cleaning.
- Reversible engine barring device
- Means for measuring individual cylinder pressure and temperature
- Oil mist detector (providing input to the MCCS)
- Crankcase ventilation system consisting of a blower filter element style oil mist eliminator independently discharging to weather. The oil mist eliminator shall remove a minimum of 99.97% of oil mist particles larger than 0.3µm. The system shall maintain crankcase pressure within the manufacturer's specified limits throughout the entire range of engine operations.
- Local control/instrument/alarm panel

Combustion air shall be filtered in accordance with the engine manufacturer's recommendations. Where diesel engine combustion air is taken from within the space, removable and cleanable engine-mounted air intake filter(s) with filter change indicators shall be provided. Where diesel engine combustion air is not taken from within the space, removable and cleanable type filters shall be provided on the diesel engine air intakes. Where diesel engines draw combustion air from the surrounding space, combustion air temperature shall be monitored and alarmed locally and remotely via MCCS. The alarm shall be set at the maximum ambient temperature listed in Appendix F.

Each main propulsion diesel engine and main generator diesel engine shall be served by a powered bridge crane. Ship service diesel engines and the emergency diesel generator shall be served by powered hoists running on monorails. The bridge cranes, generator monorails, and associated powered hoists shall have the capability of removing engine components as needed to perform the engine manufacturer's required maintenance and moving removed components to an adjacent laydown area and to the Diesel Repair Shop.

Local instruments, controls, and alarms - Instrumentation shall be provided on a panel, mounted adjacent to each engine. The instrument panel shall be isolated from engine vibration. The instrumentation shall indicate the following:

- Lube oil pressure
- Lube oil inlet temperature
- Fuel manifold pressure
- Jacket water temperature from the engine
- High Temperature Freshwater (HTFW) outlet temperature
- Low Temperature Freshwater (LTFW) outlet temperature
- Air manifold pressure for turbocharged engines
- Common exhaust duct temperature
- Crankcase pressure/vacuum
- Starting air pressure
- Engine rotations per minute (RPM) and hour meter (roll over at 100,000 hours)
- Turbo charger speed
- Turbo charger inlet and outlet temperatures
- Individual cylinder outlet temperatures

Local alarms and sensors shall be provided for the following:

- Engine overspeed
- Engine high jacket water temperature
- Engine low lube oil pressure
- Jacking gear engaged

3.235 ELECTRIC PROPULSION

Electric propulsion (if provided) shall comply with IEEE 45.

The windings of propulsion motors, and propulsion transformers (if provided) shall utilize a minimum of Class F insulation systems with a Class B temperature rise. The windings of propulsion generators (if provided) shall utilize a minimum of Class F insulation systems with a

Class B temperature rise. Where the propulsion motor requires excitation, it shall be provided by brushless exciters. The propulsion motors and propulsion transformers (if provided) shall have water leak detector alarms.

Propulsion motors (if provided) shall be provided with continuous shaft speed control from the minimum shaft speed required through rated shaft speed ahead and astern. Speed fluctuation shall be limited to $\pm 1\%$ of rated speed at steady state under constant load.

Propulsion motors shall be totally enclosed water-to-air cooled. Heat exchangers shall be of double tube construction. Independent electric motor driven fans shall circulate air through the propulsion motors and heat exchangers. Heat exchangers shall be provided with removable air filters.

3.236 MAIN PROPULSION THRUSTERS AND PODED PROPULSOR SYSTEMS

Main propulsion thrusters or podded propulsors (if provided) shall be capable of unlimited 360° azimuthing rotation. Main propulsion thrusters or podded propulsors shall be rated for continuous service. Each thruster or podded propulsors shall be rated for maximum rated power in all directions. Azimuthing thrusters or podded propulsors shall be capable of providing rated thrust at any static azimuthing position.

Thrusters or podded propulsors shall include a rope cutter and shaft grounding device. A mechanical shaft lock shall be provided. A vibration and oil condition monitoring system shall be provided for each thruster or podded propulsor.

Seals used to maintain watertight integrity shall remain effective throughout the full range of drafts for the ship. The shaft seal shall be replaceable while the ship is waterborne without damage or degradation to the bearings, electrical systems, or mechanical systems contained within the podded propulsor.

A freewheeling propeller shall not cause damage to the thruster or podded propulsor machinery.

Indicators shall be provided in the rooms containing the electrical conversion equipment serving the thruster or podded propulsor to indicate azimuth angle, RPM, and load percentage.

The thruster or podded propulsors shall have multiple low point suctions connected to the oily waste transfer system. Thrusters or podded propulsors shall be integrated into the cathodic protection system in accordance with the recommendations of the manufacturer. The external wetted structure of the thrusters or podded propulsors shall be grounded to the hull structure via a slipping grounding assembly.

Gear tooth case hardness depth after final machining shall be adequate for the design service. Factory acceptance testing shall be performed and include full load tooth contact measurements to verify that design parameters are met.

Main propulsion thruster and podded propulsor equipment loads and their auxiliary systems shall be freshwater cooled.

3.241 REDUCTION GEARS

Where propulsion reduction gear assemblies are provided, they shall continuously transmit torque to the main shaft, equivalent to torque, power, and speed limitations of the driving engines or motors, with all combinations of installed engines. The reduction gears shall meet the requirements of the prime mover manufacturer. Trail shaft operation shall not adversely affect the reduction gear. Reduction gears shall be in accordance with ANSI/American Gear Manufacturers Association (AGMA) 2015-1-A01. The total accumulated pitch error shall be equivalent to a maximum of 10 arc seconds.

Gear cases shall be provided with hinged or bolted inspection opening covers that permit access to gear meshes. Inspection opening covers shall be capable of being secured with retaining bolts when opened. The covers shall be secured to prevent unauthorized entry into the reduction gear case. Oil spray nozzles, pins, bolts, and nuts shall be secured in a manner to prevent them from falling into the gear case during inspection.

Reduction gears shall be provided with a jacking gear and disconnect clutch(es).

Propulsive thrust shall not be transferred to the gear housing.

Each reduction gear shall have a dedicated lubrication system. Reduction gear lubrication systems shall be independent from their prime mover's lubrication system.

A permanently installed dehumidifier shall be provided to prevent condensation in the reduction gear case. A vent fog precipitator shall be provided on the reduction gear case.

Gear bearings for main rotating elements shall be journal type. Cladding or plating of journal surfaces is not permitted. Bearing oil lubrication systems shall be provided with sight flow fittings. Bearings shall be provided with oil sight flow indicators. Bearings shall be provided with Resistance Temperature Detectors (RTDs) that directly monitor the temperature of the bearing metal. RTDs shall be replaceable without the need to remove the bearing or gear casing. Indication of bearing temperatures shall be provided locally and via MCCS.

3.243 PROPULSION SHAFTING

Where propulsion shafting is provided, it shall have an outside diameter 5 mm in excess of ABS requirements. Tail shaft liners shall be provided with a 25% margin above ABS required thickness. The propulsion shafts shall be capable of rotating in both directions without adverse effects to the propulsion system and include allowing for trail shaft operations.

Peak propeller induced unsteady axial, lateral, and torsional shaft forces at all speeds, for both straight course operation and maximum rudder conditions, shall not overload the shafting or shaft bearings.

Shafting design and coupling locations shall permit:

- Removal of outboard shafting without cutting shafting or structure, except for access to couplings and shafting through closure tubes. Cutting and welding shall not affect shaft alignment.
- Removal of inboard shafting without cutting shafting
- Temporarily displacing inboard shafting from the shaft line without cutting shafting or structure
- Checking bearing clearances
- Checking shaft wear down by means of a poker-type wear down gauge

Shaft bearings shall maintain lubrication during trail shaft operations. The rotation of the propulsion shaft(s) opposite the normal direction of rotation by the use of jacking gear, windmilling, or under abnormal circumstances shall not result in damage to the propulsion system.

Shaft seals shall be capable of being inspected and replaced without removing the shaft or propeller. Rope guards and shaft rope cutters shall be provided. Rope guards shall be removable to permit shaft seal inspection and shaft wear down measurement waterborne. Propulsion shafts shall be provided with motor operated jacking gears.

Propulsion shafts shall be provided with brakes as applicable. The shaft brake shall be capable of stopping the shaft from rotating and holding it to allow engagement of the shaft lock as follows:

- The shaft brake shall stop and hold the propulsion shaft(s) from rotating when the ship's shaft(s) speed corresponds to 3 knots.
- Where CP propellers are used, the brake shall engage and stop the propulsion shaft at up to the shaft speed corresponding to engine idle speed.
- Where fixed pitch propellers are used, the brake shall engage and stop the shaft at up to either 15% of rated shaft speed for electric drive propulsion or at the prime mover idle speed for mechanical propulsion.

Means shall be provided to prevent applying the shaft brake if the propulsion engine(s) or propulsion motor(s), as applicable, are engaged or if the shaft speed is in excess of the engaging speeds specified above.

A shaft lock with means to mechanically align and engage shall be provided in each shaft line or reduction gear as applicable. The lock shall be capable of holding the shaft and propeller (with

the propeller at full ahead pitch, where CP propellers are used) while the other shaft(s) and propeller(s) are driving at full power and in hard turns. Means shall be provided to prevent engaging the propulsion engine(s) or propulsion motor(s), as applicable, if the shaft is locked.

Passive shaft grounding devices shall be provided.

Stern tube bearings (if used) shall be selected to ensure that no shaft squeal affects sonar self-noise at any speed. Lubrication of stern tube and strut bearings shall be by means of a closed loop circulating system using either fresh water or lube oil. Separate stern tube and strut bearing circulating systems shall be provided for each shaft. Temperature, pressure, and head tank level shall be monitored and alarmed locally and via MCCS.

3.245 PROPELLERS

Propeller material shall be nickel aluminum bronze. Propellers shall be manufactured to Class I standard tolerances in accordance with ISO 484-1.

Propellers used for main propulsion shall not extend below the baseline of the ship.

The propellers shall:

- Operate free of pressure side cavitation through full power at all ship loading conditions
- Exhibit a maximum of 5% suction side cavitation through full power at all ship loading conditions
- Operate free of cavitation erosion tendencies through full power at all ship loading conditions
- Operate free of cavitation in the free route condition up to 10 knots at full load displacement

CP propellers, if used, shall be of the servo-in-hub type with built-in pitch change mechanism. A hydraulic oil system for controlling the flow of oil to and from each hub servo shall be provided. The system shall maintain a positive head on the hub and shaft seals.

Seals used to maintain watertight integrity shall be replaceable while the ship is waterborne without damage or degradation to the CP system. The propeller blades shall be capable of being removed and replaced waterborne without the loss of oil and loss of CP hub watertight integrity.

The CP system hydraulic pumps shall be capable of changing from maximum full ahead pitch to maximum full astern pitch, and vice versa, in a maximum of 60 seconds. The pitch setting system shall be capable of positioning and holding the propeller pitch within $\pm 2\%$ of the ordered pitch.

3.256 SEAWATER COOLING SYSTEM

Machinery circulating and cooling seawater systems shall be provided for cooling the central freshwater cooling system and as secondary cooling for other freshwater cooled equipment. Pumps shall be selected to provide required system performance and minimize power consumption across the ship's operating profile.

Main, auxiliary, and other machinery's circulating and cooling seawater systems shall utilize titanium plate heat exchangers with cleanout access ports with integral strainers. Isolation valves shall be provided for individual seawater heat exchangers to permit the heat exchanger to be isolated without securing other portions of the system or cooling loads. The seawater sides of heat exchangers shall be provided with valved freshwater flushing and drainage connections.

Systems serving titanium plate and frame heat exchangers shall be supplied with an electrolytic chlorine generator biofouling control system with feedback analyzer. Where ballast water treatment (BWT) is of the electrolytic chlorine type, it may be utilized for marine growth prevention in seawater cooling systems.

The seawater system(s) shall be provided with valved high point freshwater flushing connections and low point drains. Offline portions of the seawater system piping shall be capable of being flushed and drained while other portions of the system are online.

The seawater overboard discharge(s) shall be below the lightest load water line.

Harbor cooling pump(s) shall be provided for low load conditions.

The seawater cooling system shall serve the maximum load including all design margins and service life allowances of the systems cooled.

Seawater strainers shall be duplex.

3.258 COMBUSTION AIR AND EXHAUST SYSTEMS

3.258.1 GENERAL

The combustion air and exhaust systems shall withstand transfer of vibration to supporting structure and stresses induced by weight, thermal expansion, engine vibration, working of the ship, exhaust gas pressure pulsations, and pressure thrust caused by the exhaust gas and intake air. The fundamental frequencies for systems and their principal subsections shall be a minimum of 40% above the operating range of the propulsion system. Combustion air and exhaust systems shall accommodate dynamic forces that cause deflection of the systems' hangers, supports, and connections. Systems shall be arranged and supported to prevent stress loading of the flexible connections and expansion joints.

The design of the exhaust system shall ensure the exhaust plume clears the ship's boundary layer and prevents re-ingestion of exhaust gases into combustion air, ventilation, and replenishment intakes.

Intake and exhaust systems shall be provided with instrumentation and alarms recommended by the engine manufacturer. Intake and exhaust instrumentation and alarms shall be monitored via MCCS.

Turbulence, noise, and shipping of water and spray at weather openings for engine combustion air and exhaust systems shall be minimized.

Exhaust duct flanges, gaskets, and mechanical connecting hardware shall withstand thermal cycling without loss of seal.

Access openings shall be provided on both sides of any bends that use turning vanes. Ducts too small to permit entry of personnel shall be provided with cleanout openings with removable cover plates at the ends of horizontally installed sections. Cover plates for maintenance and access openings shall be bolted on. Cover plates shall be provided with means for handling during removal. Cover plates shall open outwards.

The combustion air and exhaust systems shall be provided with a minimum of 50 mm diameter drains at the low points. These drains shall be connected to the oily waste collection system.

Flexible metal hose or expansion joints shall be provided at the engine air inlet for engines drawing combustion air from weather. Expansion joints shall be provided at the engine exhaust outlets and elsewhere as required for flexibility. The method of connecting these flexible metal hose or expansion joints to the engine shall be in accordance with the expansion joint manufacturer's and the engine manufacturer's recommendations.

Strengthening members shall be on the external surface of the duct. The internal surface of ducting shall be smooth with no items attached to internal surfaces, with the following exceptions:

- Grab rods and ladder rungs shall be provided where ducts are large enough to permit entry of personnel for inspection and maintenance
- Retainer clips shall be welded to the duct structure to restrain perforated plate interior surfaces of the exhaust ducts

3.258.2 COMBUSTION AIR SYSTEMS

Ice, snow, and airborne particulate protection shall be provided for combustion air intakes. Combustion air inlets shall be located away from working and habitability areas.

Combustion air system materials shall be galvanized steel.

For combustion air systems ducted to the engine, a plenum shall be provided on the interior side of the weather inlet.

Portable screens shall be provided for combustion air weather inlets. The portable screens shall be installed on the interior side of the inlet. The portable screens shall consist of a frame and nominal 75 mm wire mesh screening front and back to allow installation of 25 mm thick disposable filter media between the wire mesh screening. The screening shall be Type 316 stainless-steel. Plenums shall be provided with access to allow for inspection and replacement of the screens and disposable media. The screens shall permit routine replacement of the filter media. A means to routinely attach and remove the screens from the combustion air weather inlets shall be provided.

Diesel engine combustion air may be taken from the diesel engine space or ducted from the weather directly to the engine. Combustion air weather intakes shall be of the self-draining air lift type. Where necessary to meet airborne noise criteria for the space(s) they are run through, combustion air intakes for diesel engines shall be drawn through silencers.

Diesel engine combustion air intakes shall be provided with a dry-type air filter(s) with a minimum 99% removal efficiency for particles 40 μm and larger, or the engine manufacturer's requirements, whichever provides the greater level of filtration.

Combustion air systems for diesel engines drawing combustion air from weather shall be designed to prevent the collapse of the ducting due to the maximum vacuum that can be produced by the engine or the vacuum produced due to blockage of the weather inlet with the engine operating at each point across its operating range, whichever is greater. The systems shall be provided with the following:

- A Foreign Object Damage (FOD) screen with 13 mm mesh located near the turbocharger inlet(s)
- An emergency air inlet and blow in doors or similar devices sized for full engine rating to permit continued uninterrupted operation in the event of blockage of the primary intakes. Where the emergency combustion air supply is taken from within the ship, the corresponding ventilation system shall prevent the pressure in the space from exceeding the limits for normal ventilation fan operation.

The combustion intake systems shall not impose an intake air system depression that exceeds the values given in Appendix F. Warning alarms shall be provided to indicate when the intake air system depression exceeds the acceptable operating limit for the intake system. Warning alarms shall be provided to indicate actuation of emergency air inlet and blow-in doors. The alarms shall input to MCCS.

3.258.3 COMBUSTION EXHAUST SYSTEMS

Each diesel engine shall exhaust to the weather via a dedicated system.

The design of the exhaust system shall ensure the exhaust plume clears the ship's boundary layer and prevents re-ingestion of exhaust gases into combustion air, ventilation, and replenishment intakes.

The design and arrangement of the engine exhaust systems shall ensure that pressure drop or back pressure, turbulence, noise, and shipping of water or spray, including countermeasure washdown water at weather openings, are within the manufacturer's defined limits. The exhaust systems shall not impose a back pressure that exceeds the values given in Appendix F for diesel engines. Diesel engine exhaust systems shall be provided with a normally closed pressure sensing port for a water manometer connection located immediately downstream of the engine.

Diesel engine exhaust treatment system(s) shall be provided to comply with the combustion exhaust emission requirements specified herein. If the engine exhaust treatment system uses a reducing agent, no less than two dedicated engine exhaust treatment reagent storage tanks of approximately equal capacity shall be provided. The combined capacity of engine exhaust treatment reagent storage tanks shall be sufficient to operate the engine exhaust treatment system for the duration of the operating profile in Table 3.258-1. Exhaust system materials exposed to engine exhaust treatment system reducing agent shall be in accordance with the exhaust treatment system manufacturer's recommendations.

Table 12: [3.258-1] Exhaust Reagent Operating Profile

Operating Condition	Days
Transit (12 knots) ¹	24
Cable Install w/out Sea Plow (3.5 knots) ¹	36
Total	60

Note:

1. Average speed in operating condition.

High and low-level alarms shall be provided on each tank to sound locally and via the MCCS. The high-level alarm shall be set at 95% tank capacity and the low-level alarm at 10% tank capacity.

Two dedicated discharge pumps shall be provided to transfer the engine exhaust treatment reducing agent storage tank contents selectively to a shore connection or to a system service tank(s). The pump shall discharge the total reagent volume to shore within four hours. Exhaust system materials shall be in accordance with Appendix F, with the exception of exhaust system materials exposed to engine exhaust treatment system reducing agent. Exhaust system

materials exposed to engine exhaust treatment system reducing agent shall be in accordance with the exhaust treatment system manufacturer's recommendations.

Exhaust terminals shall be located where exhaust gases will not contaminate ventilation or combustion air intakes, interfere with operating crews, impinge on ship equipment, or create a fire hazard.

Exhaust terminals shall be configured to prevent entry of rainwater.

Uncovered weather exhaust outlets shall be provided with portable covers of coated cloth and a means to secure them.

3.260 LUBE OIL

3.260.1 GENERAL

Each grade of propulsion/power generation lube oil shall be provided with independent fill and transfer systems. Independent purification systems shall be provided for each grade of lube oil serving machinery where the machinery OEM recommends purification. Independent filtration systems shall be provided for each grade of lube oil in accordance with machinery OEM recommendations. Provisions for water separation and removal shall be provided for each grade of lube oil in accordance with machinery OEM recommendations.

Independent shore connections shall be provided for each grade of propulsion/power generation lube oil used.

Sampling connections shall be provided at the purifier inlet and outlet.

Environmentally acceptable lubricants in accordance with the EPA Vessel General Permit shall be used in systems with an oil-to-sea boundary.

3.260.2 TANKS

A minimum of two lube oil storage tanks shall be provided for each grade of propulsion/power generation lube oil. The combined capacity of the storage tanks for diesel engine lube oil shall provide one complete change-out of machinery served. The combined capacity of the storage tanks for reduction gear and CP propeller lube oils shall provide one complete change-out plus 25% of additional volume. The combined capacity of the storage tanks for stern tube and strut bearing lube oil shall provide one complete change-out plus 25% of additional volume.

The Emergency Diesel Generator (EDG) shall be provided with a dedicated lube oil storage tank in the EDG Room. The storage tank capacity shall be no less than 150% of the EDG lube oil capacity.

Lube oil tanks and sumps adjacent to the shell are prohibited.

3.260.3 LUBE OIL FILL AND TRANSFER SYSTEM

With the exception of the EDG lube oil storage tank, the lube oil fill and transfer system(s) shall provide the following capabilities:

- Filling of lube oil storage tanks from the shore connections
- Gravity filling of sumps from the lube oil storage tanks
- Discharge of storage tanks to the shore connections

Positive displacement mechanical meter(s), with odometer-type readout, shall be provided on the discharge of lube oil transfer pump(s) and on gravity filling lines.

The lube oil transfer pump(s) shall be capable of filling the largest lube oil sump in two hours.

A means shall be provided to transfer lube oil to the EDG lube oil storage tank from lube oil storage tanks of the same grade and from lube oil barrels located on the weather deck. A powered means shall be provided to transfer lube oil from the EDG lube oil storage tank to the EDG sump. The EDG lube oil storage tank and the EDG sump shall drain to the WO/ST(s).

3.260.4 LUBE OIL PURIFICATION SYSTEM

Lube oil purification system(s) shall provide the following capabilities:

- Draw suction selectively from the storage tanks and machinery sumps
- Discharge of processed lube oil selectively to the storage tanks and machinery sumps
- Continuous re-circulation of oil in the storage tanks
- Continuous re-circulation of oil in machinery sumps where recommended by the machinery OEM

Machinery sump lube oil purifier suction and discharge connections shall be as widely separated as practical.

Where the diesel engine OEM(s) recommend(s) continuous recirculation of the engine sump, a dedicated lube oil purifier shall be provided for each engine. The dedicated purifiers shall be sized in accordance with the engine OEM purification requirements. For multiple engine installations, the purifiers shall be cross connected via suction and discharge piping with locked closed valves.

Lube oil sumps that do not require a dedicated purifier shall be provided with purifiers of sufficient capacity to meet the combined OEM purification requirements of all sumps served.

The lube oil purifiers shall be capable of the following:

- Processing contaminated lube oil at rated flow with 1% of water by volume and 2.0 grams per liter of solids
- Providing a purified oil output meeting the lube oil cleanliness requirements of the equipment served. The purifier shall provide a minimum effluent quality at rated flow with a maximum of 0.05% by volume of free water and a maximum of 0.02% of solids by volume
- Discharging contaminants to the sludge tank(s). Purifier sludge tank(s) contents shall be transferred to the Waste Oil/Sludge Tank(s) (WO/ST(s))

Lube oil purifiers shall be automatic and self-cleaning. The lube oil purifiers shall be provided with heaters capable of the following:

- Raising the temperature of the lube oil at rated flow from 4.4 °C to 82 °C
- Raising the temperature of the contents of the main propulsion, main generator, and propulsion generator machinery sumps from 4.4 °C to the manufacturer's recommended temperature for starting of the equipment served in a maximum of 8 hours

3.260.5 LUBE OIL SERVICE SYSTEM

Separate lube oil systems with self-cleaning back flush type strainers shall be provided for each main propulsion engine, main propulsion generator engine, and main generator engine. Back flush strainer effluent shall be filtered prior to return to the sump. Lube oil filtration, cooling, temperature control, pumps, and pump control shall meet equipment manufacturer's requirements.

3.300 GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS

3.300.1 GENERAL

Electrical systems shall comply with IEEE Std. 45.1 through 45.8 (hereafter referred to as IEEE 45).

Direct Current (DC) power distribution systems 1kV or greater, if used, shall be in accordance with IEEE Std 1709.

Electrical power distribution voltage for ship's service power, shore power, galley equipment, laundry equipment and mission system equipment shall be 480 Voltage Alternating Current (VAC) 60 Hz, 3-phase.

Accommodations, lighting, and instrumentation/alarm power shall be 120 VAC 60 Hz, 3-phase.

Switchgear contactor control shall be 120 VAC 60 Hz, single phase or 24 Voltage Direct Current (VDC). Where Uninterruptable Power Supplies (UPS) are provided, instrumentation/alarm power shall be 24 VDC.

Other nominal voltage distributions may be approved by the Government (e.g. mission or specialized equipment), such as 208 VAC/120 VAC, 3-phase, 4-wire.

The alternating current (AC) power generation and distribution systems below 1 kV shall be 60 Hz, three-phase, three-wire ungrounded utilizing recognized standard voltages. The AC power generation and distribution systems at 1 kV and above shall be 60 Hz, three-phase, three-wire, high-resistance grounded utilizing recognized standard voltages.

The design margin for ship service (including mission but not propulsion) electric power shall be a minimum of 10%.

3.300.2 ELECTRIC POWER

A service life allowance of 20% shall be provided for ship service and mission loads. A service life allowance shall not be applied to the following loads:

- Propulsion
- Steering systems
- Propulsion auxiliaries
- Thruster(s)
- Thruster auxiliaries
- Compartment heating systems
- Deck machinery
- Handling gear (see Section 3.573)
- CHE
- Sea Plow System
- ROV System
- Mission Sonar Systems

Service life allowance for electric heaters shall be 5%. The service life allowance shall apply to ship service generation and distribution system capacity as well as additional space reservations in cableways and cableway penetrations. The EDG rating and emergency switchboard shall include a 10% growth margin on emergency loads.

Other than the loads specified in Section 3.300.2.1, equipment requiring electric power with more stringent quality requirements than specified by the IEEE 45 shall be provided with its own individual power regulation equipment.

3.300.2.1 CLEAN POWER

Monitoring for equipment clean power requirements shall be provided on the MCCS.

A 480 VAC Clean Power System shall be provided to supply clean power with any input voltages, frequencies, and Total Harmonic Distortions (THDs) to the following spaces and systems:

- Sea Plow System
- ROV System
- Mission Sonar Systems

A 208 VAC/120 VAC Clean Power System shall be provided to supply clean power with any input voltages, frequencies, and THDs to the following spaces and systems:

- Plow, Projector, and ROV Control Room
- UUV Control Room
- Mission Control Room
- Pilot House Bridge equipment
- Splice Shop
- Test and Transmission Room
- Cable Handling Equipment (CHE) Control System
- Lithium Battery Room

Each Clean Power System shall be isolated from the upstream Electrical Distribution System such that harmonics and similar power quality issues are reduced to levels as defined in Table 3.300.2.1-1 and Table 3.300.2.1-2. The input power shall be fully isolated from the output power and frame ground. The clean power output of isolation device shall provide full power (kVA) into any power factor.

Isolation shall be achieved with an Uninterruptable Power Supply (online double conversion type), a solid state frequency converter or another equivalent method. One or more isolation devices may be used (i.e. forward/aft or port/starboard) for each system.

Table 13: [3.300.2.1-1] 480 VAC Clean Power System Requirements

Output of Isolation Device	
Voltage	480 VAC, 3-phase, $\pm 1\%$
Frequency	60 Hz, ± 1 Hz
THD	< 2%

Table 14: [3.300.2.1-2] 208 VAC/120 VAC Clean Power System Requirements

Output of Isolation Device	
Voltage	208 VAC/120 VAC, 3-phase, ± 1%
Frequency	60 Hz, ± 1 Hz
THD	< 2%

Each isolation device shall be supplied by two independent sources of power via an Automatic Bus Transfer (ABT) Switch.

Bypass switches shall be provided to allow operation during maintenance of the isolation device(s).

3.300.3 ELECTRICAL SYSTEMS

Electrical cable, equipment, and system designation and markings shall be in accordance with MSC QMS N0720-006.00-AQ except as specified herein. Colors of insulation on individual conductors within multi-conductor cables with more than three conductors shall be in accordance with IEEE Std. 1580. Conductors marked Green and Green/Yellow are reserved for insulated ground conductors. Cables above 1 kV shall have an orange or red exterior. Harmonic filters shall be provided with individual local monitors and remote monitoring and alarming capability via MCCS. Electrical distribution equipment shall be provided with arc-flash warning labels in accordance with NFPA 70E. The arc-flash incident energy level at enclosure boundaries shall not exceed 104 J/cm² (25 cal/cm²).

3.300.4 SHORE POWER

A dedicated shore power station(s) shall be provided and shall have a bus rated at 480 VAC, 60 Hz, three-phase power. The station(s) shall include circuit breakers with undervoltage trip units and shall have dedicated bus ties and circuit breakers to each ship's service switchboard. Control circuitry for the station(s) shall allow any number of shore power receptacles to be in use. Shore power shall have a capacity commensurate with the worst case functional in-port load, with service life allowance.

Shore power station installations shall meet MIL-STD-2003-2A. Shore power connections shall follow the US Naval Facilities interfaces described in Unified Facilities Criteria (UFC) 4-150-02. Shore power jumper assemblies, of 4 m length, shall be in accordance with MIL-C-24368 and consist of a Viking shore power receptacle plug with NATO standard two-hole lugs. An additional jumper cable comprised of LSTHOF 500 cable with NATO standard two-hole lugs on one end and one-hole lugs (PANDUIT LC600A-12 or equivalent) on the other end shall be provided. Pig tails and jumper cables shall be provided with a designated storage area near the shore power station(s).

Shore power receptacles shall be protected from weather and located inboard, at or near the weather deck (Main Deck preferred), close to the machinery space, and fitted inside weather

tight enclosures. Sun shielding shall be provided for the shore power receptacles. Each receptacle and associated cable shall be individually protected by a non-fused, current limiting, molded case circuit breaker installed in the set-up panel. A watertight set-up panel shall be provided in the vicinity of the receptacles to display the availability of shore power and the phase sequence and orientation at the facility prior to energizing the feeder to the switchboard. The panel shall be connected to the ship service switchboard through a draw-out, electrically operated power circuit breaker installed in the switchboard.

Shore power receptacles shall incorporate receptacle control switches and circuitry to trip their associated circuit breakers whenever the receptacle covers are opened, or the plug is removed. Receptacles shall be provided with white pilot lights marked “power on”.

A portable cable tray system shall be provided to support the shore power cable a minimum of 150 mm above the deck along the route from the shore power receptacles to the deck-edge rollers specified herein. The system shall consist of cable trays, support brackets, and cable securing devices.

A means to limit nuisance tripping of shore power breakers due to transformer inrush currents shall be provided.

3.302 MOTORS AND ASSOCIATED EQUIPMENT

3.302.1 MOTORS

The maximum voltage dip criteria shall be 10% for a cyclical load.

Anti-condensation heaters shall be installed within motors and their control enclosures of 20 hp (14.9 kW) and above. Heaters shall automatically de-energize when equipment is operating. Motors over 20 hp shall have continuous insulation resistance monitoring with monitors in accordance with ASTM F1134.

Three-phase induction motors, motors rated greater than 3 hp, motors located in the weather, and motors located in wet areas shall not have aluminum frames or parts.

General purpose motors with a power rating of at least 1 hp, but not greater than 200 hp, shall have a nominal full-load efficiency that is not less than the efficiency defined in NEMA MG 1 Table 12-12.

Any electric motor with a power rating of at least 1 hp, but no more than 200 hp, incorporating the design elements of a general purpose motor into any of the following motor designs: U-Frame motor, design-C, close-coupled pump, footless, vertical solid-shaft normal thrust (tested in a horizontal configuration), 8-pole (900 rpm), and poly-phase motor with voltage of no more than 600 V (other than 230 or 460 V) shall have a nominal full-load efficiency that is not less than as defined in NEMA MG 1 Table 12-11.

NEMA Design B, general purpose electric motors, with a power rating at least 200 hp, but no more than 500 hp, shall have a nominal full-load efficiency that is not less than as the efficiency defined in NEMA MG 1 Table 12-11.

Motors equipped with anti-friction bearings (except sealed, pre-lubricated types) shall have pressure grease fittings and relief plugs. Bearing housings shall be factory drilled, tapped, and closed with a pipe plug. Variable speed drive controlled motors shall be provided ceramic insulated bearings and grounded shaft brushes/rings. General purpose motors and motors on the Cable Highway, in the weather, in the cable tanks, in the cable gear stowage spaces, and in the reefer spaces shall have sealed, pre-lubricated bearings.

Axial flow fan motors shall be equipped with sealed pre-lubricated ball bearings.

Where motors require internal coolers, the heat exchangers shall be 90-10 Copper Nickel (Cu-Ni).

3.302.2 CONTROLLERS

Motor controllers shall be provided for all motors 20 hp (14.9 kW) and greater. Motor controllers shall not be located in refrigerated spaces unless otherwise approved. Variable Speed Drive (VSD) controllers shall provide for selection of automatic or manual means of operation. All motors shall be provided with local/remote and start/stop capability adjacent to the motor.

Systems with multiple units shall include switchable lead/lag functions where any unit can be selected as the lead, lag unit, or standby.

Hour run time meters, ammeters, and solid-state passive insulation resistance monitors in, accordance with ASTM F1134, shall be provided for motor controllers of motors of 20 hp (14.9 kW) or greater. For those motors monitored by the MCCS, run time meter readings shall be recorded and displayed by the MCCS.

3.302.3 GROUP CONTROL CENTERS

Group control centers shall be provided for propulsion auxiliaries, auxiliary machinery, Heating, Ventilation, Air Conditioning (HVAC) equipment, and cable handling machinery. Group control centers shall be free standing, dead front, of rigid drip-proof commercial marine quality construction similar to NEMA Class II Type B control centers. Control units shall be of the modular type. Each controller compartment shall be completely isolated by suitable means from adjoining compartments such that circuit faults will be confined to the compartment affected without disturbing the operation of other circuits. At least 20% of the control cubicle area of each group control center shall be reserved as spares for mounting future controllers. Spare spaces shall be complete with bus and blank filler doors. Cable entrances with gaskets shall be provided at the top and bottom of each section. Circuit breakers and overload relay reset buttons

shall be operable from the front of the controller without opening the door. Connections to the main bus shall be made by means of copper "stab" type fittings or equivalent.

3.303 PROTECTIVE DEVICES

Molded case circuit breakers and insulated case type power circuit breakers shall meet UL 489 including Marine Supplement SA or SB, or IEC 60947-2. Air frame circuit breakers shall meet IEEE Std. C37.13. Air frame circuit breakers shall be capable of being racked out to a maintenance position without de-energizing the switchboard or panel.

Protective devices shall be selected to achieve coordinated system protection in a fault event. The protective device(s) closest to the fault shall open first.

The generator circuit breakers shall be electrically operated.

Feeder management relays shall be provided where conventional relays cannot achieve circuit breaker coordination. The feeder management relays shall provide protection for long and short-time overcurrent, instantaneous overcurrent, undervoltage, overvoltage, and bus underfrequency. Feeder coordination relays shall be programmable logic units containing an operator display and user keypad interface.

3.304 CABLE

3.304.1 GENERAL

Electronic and electric cable shall be low smoke, halogen-free, non-flammable, and low toxicity in accordance with IEEE 45. Cable to rotating machinery equipped with commutators or slip rings shall not contain silicone unless the equipment terminal box is airtight with respect to the machine interior. Connection of OEM-provided equipment cables to ship's cables shall be via connection boxes. Splicing of cables 12 American Wire Gauge (AWG) (4 mm²) and smaller, coaxial cables, and fiber optic cables is not permitted unless approved.

Electric power cables for propulsion motors, thrusters, and variable frequency drive (VFD) units shall be constructed and installed in accordance with IEEE 45 and IEEE 1580.

MIL-SPEC equipment, when used, shall be sized to accommodate commercial cables.

3.304.2 CABLE ROUTING AND PENETRATION

Electronic and electrical cables shall be routed within the enclosed ship structure except for the parts of the cables connecting to components in the weather. Cables routed internal to the ship shall not be routed within 300 mm of weather openings and windows unless the cables have a double-optimized braid shield. Cables not terminating in the Naval Communications Center shall not be routed through the space.

Cables routed in the weather shall have continuous protection from Electromagnetic Interference (EMI) by one of the following:

- Cables shall be enclosed by continuous, supported, rigid conduit, flexible conduit, or metal cable trunks (for multi-cable runs).
- Cables shall be shielded between their termination points.

Pourable sealing methods shall not be used for cable weather penetrations.

Cables shall be continuous between outlet boxes, switchboard, and panel boards.

Any junction boxes, connection boxes, or other breaks in a continuous wiring run shall be labeled. Should this be behind joiner work, a label on the surface of the joiner work shall be installed.

3.304.3 CABLE SEPARATION

Cable separation shall be in accordance with IEEE Std. 518-1982, unless otherwise approved, except that the color coding in section 6.4.3.7.6 does not apply. Power cables serving systems above 1 kV shall be installed in cableways separate from those used for other electrical and electronic system cables. A minimum distance of 610 mm shall be maintained between power wireways above 1 kV and other wireways. Cables that cannot be routed with the required minimum separation shall be isolated through the use of rigid or flexible conduit.

Power cables shall not be installed in close proximity to low voltage signal cables. Power and control cabling shall be run in accordance with OEM requirements for connected service to prevent EMI.

3.304.4 CABLE CONDUIT

The surface transfer impedance of a conduit system shall not exceed 100 mΩ/m (milliohms per meter) over a frequency range of 100 kHz to 600 MHz.

Rigid metal conduit and terminations shall be Type 316L stainless-steel. Rigid conduit shall be seamless and have a minimum wall thickness of 3 mm. Rigid conduit runs of greater than 3 m shall have at least one grounding support for each 3 m of length. Bending shall not deform the inside diameter of the conduit pipe. A locknut shall be used with threaded pipe and fittings when the manufacturer's minimum torque requirement for the threaded joint cannot be met.

Flexible conduit and their terminations shall be of Type 316L stainless-steel and watertight.

3.310 ELECTRIC POWER GENERATION

The generators shall be 60 Hz, 3-phase rated at a power factor of lagging 0.8 for AC distribution systems and a power factor of 0.8 or greater for DC distribution systems. The generators shall be brushless and have minimum Class F insulation with a Class B temperature rise. The generators shall be a two-bearing design.

Harmonic filters shall not be used as the primary means of achieving the power quality requirements. Harmonic filters require Government approval. Additional harmonic mitigation measures are specified in IEEE 45.

The quantity and size of generator sets shall ensure that the load on each generator set driven by a dedicated prime mover, during any normal continuous operating condition, shall be a minimum of 30% of the full load rating.

The generators shall be capable of continuous parallel operation with automatic real and reactive load sharing. The system shall be configured to permit uninterrupted transitional paralleling of load during system operating and power transfer conditions, including transfer of power with shore power and emergency power sources. Generator sets shall only operate in parallel with shore power for the time required for transfer of load. When on shore power, means shall be provided to prevent paralleling or connecting generators with shore power other than to transfer load.

Load shedding arrangements shall maintain services in the following priority:

1. Emergency services
2. Primary essential services
3. Secondary essential services
4. Propulsion loads (for integrated electric plants)
5. Non-essential services

For purposes of load shedding, the following loads shall be incorporated as secondary essential services:

- CHE Control System
- Cable Drum Engines (CDEs)
- Draw-Off Hold Back (DOHB) Machines
- Linear Cable Engine (LCE) and Stonker

Each generator bearing shall have two independent RTD circuits, with one active and the other a spare. Each generator shall be provided with temperature detectors for the stationary windings at a minimum of one embedded and one spare per phase connected to digital displays in the ship temperature monitoring system. Each generator shall be provided with electric space heaters to prevent condensation of moisture during periods of idleness. Space heaters shall be connected so

they become energized when the generator circuit breaker is opened and de-energized when the generator circuit breaker is closed.

3.313 SHIP'S BATTERIES AND CHARGING EQUIPMENT

Lead acid batteries shall be sealed, valve regulated, gas recombinant, maintenance free type. Battery chargers shall have built-in filters and automatic voltage compensation.

3.314 CONVERSION DEVICES

The following systems shall be powered from ABS type approved UPS. UPS shall be provided with an external bypass to supply the connected loads during maintenance or repair of the UPS without power interruption to the connected loads. UPS shall be fed from a primary and secondary power supply. One of the power supplies shall be from the emergency distribution system and serve as the external bypass. UPS systems shall provide the required run time at full load for the following, either as a system or as a dedicated battery backup unless otherwise noted. Minimum required run times shall be as follows:

- MCCS, MCCS workstations, OEM provided engine control systems, and other computerized machinery automation systems, 30 minutes
- Integrated Bridge System (IBS), 30 minutes
- Propulsion consoles, 30 minutes
- DPS control system, 30 minutes
- Independent DP joystick system, 30 minutes
- Fire detection and alarm system, 30 minutes
- Private Branch Exchange (PBX) telephone system, 60 minutes
- External Intrusion Detection Security (IDS) system, 60 minutes
- Internal IDS system, 60 minutes
- Medical monitoring equipment and exam table lighting, 30 minutes
- Master clock, 30 minutes
- Motor Operated Valves, 30 minutes
- Ship's general announcing system/General Announcing Circuit (1MC), 30 minutes
- General emergency alarm system, 30 minutes
- Ship's whistle, 5 minutes
- Closed Circuit Television (CCTV) Systems, 30 minutes
- MCR Consoles and racks, 30 minutes
- CHE Control System, 30 minutes

Each UPS shall have an indicator to depict when the UPS is supplying the output from the incoming power line or from the battery.

3.320 POWER DISTRIBUTION SYSTEMS

The electric power distribution system, including electrical receptacles, shall meet the power quality requirements of IEEE 45 under all operating conditions and transients. Additional power quality shall be provided for the clean power equipment in Section 3.300.2.1.

3.320.1 RECEPTACLES

Receptacles - A receptacle shall be provided adjacent to each piece of fixed plug-in equipment, with voltage rating in accordance with equipment manufacturer's recommendations. Receptacles located in the weather and wet areas, except for sanitary spaces, messrooms, and the medical facility, shall be of corrosion-resistant materials and be provided with watertight covers. The receptacles shall maintain watertight integrity when not in use and when a cable is plugged into them.

General purpose 120 V alternating current receptacles - General purpose 120 VAC single-phase receptacle circuits shall be supplied from isolation transformers. Circuits shall be zoned by utility. Circuits supplying receptacles shall not supply other types of loads. The total length of cable from the load side of the transformer to the enclosure of the protective device, plus the sum of the lengths of cable in the receptacle circuits supplied by the transformer, shall be a maximum of 450 m. Receptacles shall be labeled as to the type of power available and their intended use. Receptacles shall be locally grounded.

General purpose receptacles shall be supplied by circuits rated at 20 amps. General purpose circuits serving an individual single person stateroom shall be allowed a maximum of seven general purpose, 15 amp, duplex receptacles. For other general purpose circuits, a maximum of four general purpose, 15 amp, duplex receptacles shall be allowed.

Unless otherwise specified, a minimum of two unassigned general purpose, 120 VAC, duplex receptacles shall be provided in normally manned spaces. A minimum of one unassigned general purpose, 120 VAC, duplex receptacle shall be provided in normally unmanned spaces. The receptacles shall be installed such that a 15 m extension cord provides total coverage within the space.

Two general purpose, 120 VAC, duplex receptacles shall be located adjacent to each LAN drop.

Spaces listed below shall also be provided with receptacles as indicated:

- Food service spaces - Messrooms, Galley, and Scullery shall be provided with four unassigned general purpose, 120 VAC, duplex receptacles fed from Ground Fault Circuit Interrupter (GFCI) circuit breakers evenly distributed around the periphery of each space.
- Workshops - Each workshop shall be provided with two 20 amp branch circuits with two unassigned general purpose, 120 VAC, duplex receptacles on each circuit. Receptacles

shall be provided at work benches and other work areas.

- Ship Store and administrative spaces - Four unassigned general purpose, 120 VAC, duplex receptacles shall be provided for each space. Receptacles shall be evenly distributed around the space.
- Medical facility - Flush, bulkhead mounted, hospital grade, 120 VAC, 15 amp, duplex receptacles shall be provided every 1.8 m throughout the medical facility. Three, overhead flush mounted, 120 VAC, 15 amp, duplex receptacles shall be provided at the head of the berths. Three overhead mounted, 120 VAC, 15 amp, duplex receptacles shall be provided for the double berths. The Hospital Bath shall be outfitted with one unassigned general purpose, 120 VAC, duplex GFI receptacle near the sink.
- Pilot House - Two unassigned general purpose, 120 VAC, duplex receptacles shall be provided for the Chart Table. One unassigned general purpose, 120 VAC, duplex receptacle shall be provided adjacent to the pilot plug.
- Permanent Quarterdeck Stations - General purpose, 120 VAC, duplex receptacles shall be provided adjacent to the radio racks for radio battery chargers.
- Main and Auxiliary Machinery Room (AMR) - General purpose, watertight, corrosion resistant, 120 VAC, 20 amp, duplex receptacles fed from GFCI circuit breakers shall be provided on each level, in quantities and locations such that any point in the machinery room can be reached with an 8 m extension cord.
- Passageways - General purpose, 120 VAC, 20 amp, receptacles shall be provided in quantities and locations such that any point in a passageway can be reached with an 8 m extension cord.
- Bridge Wings - A general purpose, 120 VAC, 20 amp, duplex receptacle shall be provided on each Bridge Wing. The receptacles shall be watertight and if exposed to the weather, shall be corrosion resistant and fed from GFCI circuit breakers.
- Weather decks - General purpose, watertight, corrosion resistant, 120 VAC, 20 amp, duplex receptacles fed from GFCI circuit breakers shall be provided at the following locations:
 - In the vicinity of mooring winches
 - In the vicinity of the anchor windlass power unit
 - In the vicinity of cranes
 - In the vicinity of lifeboats
 - In the vicinity of Work Boat
 - In the vicinity of the ROV and Sea Plow LARSSs
 - In the vicinity of all cable hauler locations
 - Forward and aft of the deckhouse
 - At each antenna/radar platform
 - Port and starboard on deckhouse weather deck levels
 - Moonpool Staging Bay – General purpose, watertight, corrosion resistant, 120 VAC, 20

- amp receptacles fed from GFCI circuit breakers
- Cable Highway - General purpose, watertight, corrosion resistant, 120 VAC, 20 amp, duplex receptacles fed from GFCI circuit breakers shall be provided in the vicinity of the Cable Highway Aft Door

480 VAC receptacles - Receptacles for portable welding machines and portable submersible pumps shall be provided on the bulkhead deck adjacent to machinery space accesses. Receptacles for portable welding machines shall be provided to allow coverage of topside areas, living spaces, electronics spaces, working spaces, moonpool staging bay, and workshops with a 30 m welding cable. The receptacles shall be interlocking, grounded (Symbol No 915.1) rated for 480 VAC, 30 amp, 60 Hz, three-phase.

Receptacles on the Cable Highway and exterior working areas shall be provided at various voltages and amperages.

3.320.2 EQUIPMENT LOCATED IN THE WEATHER

Electrical equipment and deck and bulkhead cable penetrations that are located in the weather shall be made of corrosion-resistant materials unless otherwise approved. Equipment and enclosures located in the weather shall be protected from water ingress based on the following:

- Operating environment
- Rated for a minimum of IP 56 per IEC 60529
- Mounted within an enclosure that provides the required level of ingress protection if the rating of available equipment is not sufficient

Equipment in the cable highway, moonpool, and Moonpool Staging Bay areas shall be treated as equipment in the weather for materials and sealing purposes.

3.320.3 EMERGENCY POWER DISTRIBUTION

The emergency power distribution system(s) shall be in accordance with ABS MVR, IEEE 45, 33 CFR, and 46 CFR and shall also provide emergency power to the following equipment:

- Firefighting systems
- MOVs
- Secondary DCC
- Vault alarms
- DC Locker receptacles
- Portable welding machine and submersible pump receptacles
- Hospital lighting, refrigerator alarm, and receptacles
- Breathing air compressor system
- Acoustic telephone booth flashing lights and annunciators
- Master/slave digital clock system
- Naval Communications Center services
- UPSs
- Refrigeration lock-in alarms
- Wireless Communication System

Each power panel in the Naval Communications Center shall be provided with a dedicated isolation transformer. The isolation transformer shall be in line between the emergency distribution system and each power panel.

3.324 SWITCHBOARDS AND PANELS

The use of aluminum terminals or lugs in electrical equipment is prohibited.

Spare circuit breakers shall be provided on switchboards and panels for 10% of each type and size used for active feeder circuits up to and including the circuit breaker with 400 amp trip element, but not less than one for each active frame size.

Load centers located outside the machinery spaces shall be located in dedicated electrical equipment space(s). Electrical distribution equipment, harmonic filters, and interphase reactors serving systems above 1 kV shall be located in dedicated, lockable compartments for personnel safety.

For integrated electric plants, switchboard metering shall include power quality and harmonic monitoring instrumentation.

The emergency switchboard and EDG shall be co-located.

The emergency switchboard shall include provision to feedback emergency power to ship service/Mission switchboards for dead ship start and EDG operational testing.

Switchboards and power conversion equipment shall be housed in dedicated HVAC controlled spaces. Electrical equipment in enclosed panels shall be rated for the interior cabinet temperature or shall be cooled.

3.330 LIGHTING SYSTEMS

3.330.1 GENERAL

Lighting requirements shall be provided in accordance with ABS Guide for Crew Habitability on Ships and IEEE 45.

All lighting fixtures and luminaires shall be LED ABS type approved light sources with UL certificates. Where LED are not type approved by ABS or do not meet illumination requirements specified in the ABS Guide, alternate light sources which meet illumination criteria may be utilized in accordance with IEEE 45.

LED lighting circuits shall “Fail-Safe”, ensuring that multiple open circuit or failed LEDs within an LED lamp assembly do not diminish the electrical energy to other LEDs.

The average illumination level maintained over the task area shall meet the minimum required illumination level.

LED light source shall have EMI filters. Lighting fixtures shall be located to facilitate safe replacement of lamps, routine maintenance, and cleaning.

Obstructions on the weather deck, abrupt changes in deck level, and walkways having a sharp bend or corner, shall have a light fixture located to permit visibility from both sides of the obstruction.

3.330.2 INTERIOR LIGHTING

All interior spaces, except voids and tanks containing liquids, shall be provided with white, overhead, general lighting.

Spacing between ceiling fixtures shall be arranged to provide uniform lighting. Lighting fixtures in joister ceilings shall be provided flush with the sheathing. Lighting fixtures in unsheathed spaces shall be located such that illumination is without interference from piping, ducting, wireways, and structure. Fixtures in storerooms and food service spaces shall be provided in the center of the space or passage.

Interior task-specific detail lighting shall be provided for reading areas, writing tables, desks, mirrors, berths, chart tables, workshop equipment, switchboards, and medical facilities.

Control of general interior lighting shall be provided inside the compartment, near the access in a location where door operation does not obstruct access to the switch. Switches for detail and decorative fixtures and floodlighting shall be independent of general lighting fixtures. Lighting in machinery spaces, passages, and stairtowers shall be controlled at local panel boards. Spaces such as storerooms, deck heads, lounges, and laundry spaces shall incorporate motion sensor switches to secure lighting when the space is vacant. Motion sensor switches shall be provided with a bypass capability.

Red and white lighting shall be provided in the light traps leading to the Pilot House and Pilot House deck head. Independent red and white select light switches shall be provided for red and white lights. Red and white lighting in light traps and the Pilot House deck head shall be independently controlled. If not fully enclosed, Bridge Wings shall have locally controlled independent red and white lighting.

All weather deck and exterior lighting fixtures shall be controlled from the Pilot House on the same lighting panel(s).

In the Pilot House and on the Bridge Wings, lighting shall have the capability to dim. Dimmer control shall provide linear dimming from full intensity illumination to zero illumination. All dimmer controls shall be fitted with positive on/off switching.

Fifty percent of Pilot House and light trap fixtures shall be fitted with battery backup supplying only the red light element. The fixture dimmers shall remain functional when on battery power. Chart tables shall be provided with red and white light fixtures that can be positioned by the operator, through the use of arrangements such as a swing arm or a telescoping flexible arm.

Lighting in messrooms, lounges and conference room shall be fed from multiple circuits to allow partial lighting of each space.

Lighting fixtures provided under machinery space deck plates and in exposed hazardous areas shall be fitted with guards.

Adjacent fixtures in machinery spaces and workshops shall be connected to different phases to prevent strobing effect on rotating machinery.

3.330.3 EXTERIOR LIGHTING

General flood lighting shall be provided to illuminate the following:

- Working areas
- Lifeboat, life raft, rescue boat, and workboat stations
- Accommodation ladder (including pier lighting)
- Foredeck (including anchor windlass)
- Mooring stations (including waterline lighting in way of anchors)
- Mission container locations
- Cranes and hatches
- Shore connection stations

The flood light brackets shall be trainable and rigid locking. The flood lights shall be controlled from the Pilot House by individual switches per functional area served.

3.330.4 WATERLINE/HULL SECURITY LIGHTING

Waterline security floodlights shall be man-portable and shall be located to give complete overlapping perimeter coverage of the light beam at the water surface. Waterline security floodlights shall provide average illumination of 50 lux (5 average fc) at the light load waterline, with a maximum uniformity ratio of 2:1, at a distance of 10 m from the shell. Waterline security floodlights shall be 120 VAC, bracket mounted, rigid locking, trainable over the side, and capable of being rigged and unrigged by a single person. Waterline security floodlights shall be provided with watertight plugs. Matching watertight receptacles shall be provided. Waterline security floodlight receptacles shall be arranged in groups and powered from dedicated 120 V distribution panels. The waterline security floodlight groups shall be controllable from a control panel located in the Pilot House. Security lighting storage lockers shall be provided adjacent to the weather deck in a forward and aft location.

3.330.5 EMERGENCY LIGHTING

Temporary and final emergency lighting requirements shall be in accordance with ABS MVR, IEEE 45, and 46 CFR 112.15. In the case of conflict, the more stringent requirement shall be met.

Temporary and Final Emergency lighting circuits shall be supplied from the emergency switchboard.

Temporary emergency lighting shall be provided by fixtures fitted with internal, rechargeable batteries capable of providing power for a minimum of three hours.

The internal batteries shall be the sealed type with a charging system and diagnostic test capability. The battery power shall energize upon loss of the power source. Emergency lighting in passageways and at the foot of ladders shall be mounted so the light shines approximately 30°

below the horizontal eye level. In other locations, emergency lighting shall be mounted to illuminate the principal work areas and accesses or escape hatches for which they are intended. Emergency lighting fixtures for red-lighted areas shall have switchable red LED light sources.

In addition to regulatory requirements, the following areas shall be provided with temporary emergency lighting:

- Breathing Air Compressor Room
- Medical Facilities
- Cable Highway, at each end and in the middle
- CHE Control Console
- Moonpool LARS Control Station
- Sea Plow LARS operating station
- ROV LARS operating station
- Over the front of safes and cabinets designated for stowage of classified material
- Naval Communications Center and Mission Conference Room, over outside of entrance door
- Mission Control Room, over outside of entrance door
- Interior passageways spaced every 12 m and one at each end

3.400 GENERAL REQUIREMENTS FOR COMMAND AND SURVEILLANCE SYSTEMS

3.402 SECURITY REQUIREMENTS

Spaces that may contain classified information shall be designated Vault, Secure Room (SR), Restricted Access Area (RAA), and Uncontrolled Access Area (UAA) as defined in IA PUB Module 5239-22. Construction of SRs and RAAs and installation of secure inter-compartment cables shall be in accordance with IA PUB Module 5239-22 and Module 5239-31, and Secretary of the Navy (SECNAV) M-5510.36. Construction of vaults shall be in accordance with Intelligence Community Directive (ICD) 705. The physical perimeter barrier of a SR shall be the deck, overhead, and the bulkheads that bound the space. Secure cables that pass through UAA spaces shall be fiber optic installed in a hardened carrier as defined by IA PUB Module 5239-22.

The spaces shall be designated as follows:

- a. Vault:
 - 1. Mission Control Room
 - 2. Mission Conference Room
 - 3. Naval Communications Center

- b. SR:
 - none

- c. RAA:
 - 1. Pilot House
 - 2. Master's Office
 - 3. Chief Engineer's Office
 - 4. Deck Office
 - 5. Supply Office
 - 6. Sponsor's Designated Representative (SDR) Office
 - 7. Test and Transmission Room
 - 8. Plow, Projector, and ROV Control Room
 - 9. Moonpool Staging Bay
 - 10. Gyro Room
 - 11. UUV Control Room

- d. UAA:
 - 1. All other compartments

Access to SRs and RAAs shall have label plates installed as follows:

**RESTRICTED AREA
KEEP OUT
AUTHORIZED PERSONNEL ONLY**

Communication networks shall meet the requirements of IA PUB Module 5239-31 and NSTISSAM TEMPEST/2-95, Red/Black Installation Guidance.

3.405 ANTENNA SYSTEMS

Antenna numbers shall be assigned to each antenna in accordance with NAVSEAINST 9405.1A.

3.405.1 SHIP ANTENNA SYSTEMS

Antennas, foundations, pedestals, and requisite cable hardware shall be provided in accordance with 47 CFR.

3.405.2 NAVAL COMMUNICATIONS ANTENNA SYSTEMS

Government Furnished Equipment (GFE) antennas and inter-compartment cables shall be installed in accordance with the Naval Communications System Turnkey Approach to be provided for DD&C. Approximately 1.5 MT of GFE topside equipment and antennas shall be installed.

3.406 BONDING AND GROUNDING

Bonding, grounding, and other techniques for Electromagnetic Compatibility (EMC) and safety shall be provided in accordance with MIL-STD-1310 (Navy), excluding Section 5.4, EMP Protection. Bonding provisions shall be compatible with requirements imposed on the system for corrosion control. Grounding of weather boundary cable penetrations shall be achieved using Type 316L stainless-steel devices such as shield ground adapters, cable shield ground adapters, frames of multi-cable EMC transits, or similar products that provide a 360° continuous and positive electrical path to ground at the weather boundary penetration points.

3.407 ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3)

The ship shall be electromagnetically compatible within itself and the external electromagnetic environment (EME) defined in MIL-STD-464 for maximum external EME such that the ship system operational performance requirements are met. Radiators and receptors of electromagnetic energy and related electronic systems on the ship shall be EMC and preclude hazards of electromagnetic radiation to personnel (HERP), ordnance (HERO), and fuels (HERF). The ship shall be compliant with NAVSEA OP 3565 for HERO, HERP, and HERF.

Sources of electromagnetic radiation shall be compliant with MIL-STD-461 RE-102 requirements for radiated emissions control. Radio Frequency (RF) E-field levels in areas of the ship with unrestricted access shall not exceed the most restrictive Permissible Exposure Limits (PELs) for HERP in IEEE Std. C95.1. Warning signs shall be in accordance with IEEE Std. C95.1.

Individual shipboard electrical and electronic equipment installations shall meet the requirements of IEC 60533. Equipment that emits or is susceptible to electromagnetic energy shall be located to ensure EMC, and avoid HERO, HERP and HERF. Electrical and electronic systems' performance shall not be degraded in response to spurious EMI generated by radiating sources, including high frequency (HF) transmitters, or transients on power lines. Weather exposed equipment containing solid-state devices shall meet the "Limits Severe Environment" levels specified in ANSI C63.12. Pilot House and chart room equipment containing solid-state devices shall meet the "Limits Industrial Environment" levels specified in ANSI C63.12.

Cabling and wiring runs shall account for EMI. Except for fiber optic cables, non-shielded signal cables for mission systems and for control, monitoring and safety systems essential for

propulsion and maneuvering of the vessel which may be affected by electromagnetic interference are not to be run in the same bunch with power or lighting cables. Fire suppression, detection, and alarm systems shall be protected from EMI in accordance with IMO FSS and shall be installed in accordance with selected OEM's recommendations.

3.420 DYNAMIC POSITIONING SYSTEM AND INDEPENDENT AUTOPILOT

3.420.1 DYNAMIC POSITIONING SYSTEM

An ABS approved DPS-2, Kongsberg K-Pos or equivalent, shall be provided. The DP operating stations (O/S) shall be integrated into the SCC and shall be located in the Pilot House. Communication systems (e.g. PBX, sound powered phone, CCTV displays and controls, and radios) shall be located to allow operator to use equipment without leaving the DP O/S. The DPS control system shall include a load limitation function for thrusters and other heavy consumers.

Two portable operator terminals with joystick (with full heading capability), remote controller, video display, and interface cable shall be provided. Joystick control response shall be adjustable by the operator to different scaling curves of thrust as a function of joystick deflection. DP O/S shall be designed to be viewable in direct bright sunlight. Remote plug-in watertight jacks for the portable terminal shall be provided at each bridge wing. Bridge wing control consoles shall include space to accommodate the portable operator terminals. Means of positively securing the portable operator terminals in the vicinity of the plug-in jacks shall be provided. Remote plug-in jacks and interface cables shall be configured so the operator terminal is oriented correctly for ship control regarding correct graphical user interface (GUI) orientation. DP station selection shall be located at the primary control in the Pilot House. Visual indications and voice channels shall be provided at the primary station and secondary stations to effect and accept control transfer. Full positive control shall be maintained during control transfer.

A third DP O/S shall be installed in the MCR. Remote DP displays shall be provided at the ROV Control Console, Plow Control Console, UUV Control Room, Aft Working Deck, and Stern Work Platforms.

A DPS color video display monitor and keyboard shall be provided at each DP O/S. Each DPS O/S shall have a menu selectable operating and setup capability and help library. Setup features shall include all modes of operation.

The DPS system shall have operator selectable heading, speed, and tracking. The DPS waypoints and tracks shall be capable of being uploaded from or downloaded to electronic storage media.

The DPS shall be capable of operating in the autopilot mode and shall automatically control the ship's heading within $\pm 2^\circ$ of the selected course at speeds from 0.5 knots to maximum. The DPS shall be capable of generating a survey track of multiple waypoints including parallel courses,

cross line courses, lead-in and lead-out line, and turns from 0° to 359°. This system shall allow course corrections without coming out of this mode.

The DPS shall be capable of operating in the Follow Target mode, following ROVs associated with the Acoustic Navigation and Tracking System. The Follow Target mode shall include operator adjustable settings for target reaction limits, position filtering, distance to target, vessel speed, vessel acceleration/deceleration, and rate of turn. The Follow Target mode shall also allow the operator to pause the movement of the vessel and then reactivate the mode to have the vessel move to be positioned at the previously defined distance from the target.

The DPS shall be capable of operating in Minimum Power mode. The DPS shall provide the operator with a choice of fully automatic operation at reduced power and/or response time to maintain position within a user-configured operating envelope for the purpose of reducing fuel consumption and/or reducing thruster/propeller force relative to the normal response.

The DPS shall be capable of operating in any mode with any combination of propulsor(s), rudder(s), and thruster(s) disabled. Operators shall be capable of enabling or disabling each thruster and propeller. Any thruster disabled by DPS, shall revert to manual control automatically.

The DPS shall be tuned to prevent cyclic loading and unloading of the propulsion motors, thruster(s), propulsor(s) and diesel generators. DPS command acceleration and deceleration ramp rates shall be tuned to match the time constants of each of the propulsors. The DPS shall accept industry standard interfaces for generator power, amperage, throttle commands, propulsor RPM, and other required interfaces with the ship's propulsion control and power generation systems.

The DPS shall be designed to operate continuously for long periods of on-station or trackline following work.

The following systems shall be integrated with DPS in addition to ABS requirements:

- doppler speed log input
- Plow tow wire tension
- position/motion sensing inputs
- ANTS for Follow-Target mode
- CHE Control System
- Cable software systems (Winfrog and Makai)

The DPS shall be capable of automatically transferring waypoint data with Electronic Chart Display and Information System (ECDIS) without manual data input. The DPS shall navigate tracks, routes, and position moves based on ECDIS generated waypoint tracks.

The DPS shall have two removable media storage devices (hard drives) for swap-out to support classified and unclassified operations.

3.420.2 DPS AUTOMATIC CONTROL MODE

Dynamic positioning shall be required with the ship in full load condition (with service life allowance) in the following conditions:

- Position Keeping – The ship shall hold position in sea conditions through sea state 5 (max wave height and most probable modal period as defined in Table D-1 of STANAG 4194), a wind speed of 35 knots, and a 2 knot current, with directions specified as follows:
 - Ship headed into wind and waves, with current from any direction
 - Ship headed into the current, with collinear wind and waves from any directionMaximum excursion allowed shall be ± 5 m (16.4 ft) in ship position and $\pm 5^\circ$ in ship heading. The DPS shall sound an alarm when the ship falls off position beyond a user-selectable limit. The DPS shall include the ability to move from present position to a selected location in any direction while maintaining ship's heading and rotating any amount up to 360° about any user-selectable point while maintaining position. Position moving overshoot of the target position shall be less than 5 m and less than 2° .
- Trackline – The ship shall follow a trackline at all headings over the bottom within ± 5 m (16.4 ft) of the planned trackline, with maximum excursion of $\pm 5^\circ$ in ship heading, in sea conditions through sea state 5 (max wave height and most probable modal period as defined in Table D-1 of STANAG 4194), a wind speed of 35 knots, and a 2 knot current, with directions and speeds specified as follows:
 - Ship headed into wind and waves, with current from any direction.
 - At any speed between 0.5 and 10 knots
 - At any speed between 0.5 and 2 knots, with a continuous tow line tension of 80 MT
 - Ship headed into the current, with collinear wind and waves from any direction.
 - At any speed between 0.5 and 10 knots
 - At any speed between 0.5 and 2 knots, with a continuous tow line tension of 80 MT

The DPS shall provide the capability of accepting multiple waypoints. Permissible maximum variation of the ship's heading from the track course (crab angle) shall be user-selectable. When following a multiple waypoint trackline that requires a change in course after a waypoint, the DPS shall be capable of changing the ship's heading automatically to follow the new course of the next track segment. The DPS shall alert the operator that a turn is impending by sounding a local alarm at a fixed time interval before the turn. The DPS shall alert the operator by alarm when the ship exceeds a user selectable lateral tracking error limit. Straight track segments shall be maintained without large and/or frequent heading changes.

3.420.3 INDEPENDENT AUTOPILOT

A self-tuning, adaptive autopilot shall be provided. The autopilot shall be designed for general navigation and shall be independent of the DPS system. It shall be fully integrated with the ECDIS system and capable of automatically steering a route with turns through multiple waypoints as specified by ECDIS.

The autopilot system shall be switchable from hand steering to autopilot steering and shall have a sensitivity adjustment for heavy weather. The autopilot shall be able to function without the DPS system being operational, including the ability to upload and download waypoint and track steering information from the ECDIS.

The autopilot shall automatically control the ship's heading within $\pm 1^\circ$ of the selected course at speeds from 0.5 knots to maximum.

Autopilot primary control shall be at the Pilot House.

3.421 NON-ELECTRICAL NAVIGATION AIDS

3.421.1 MAGNETIC COMPASS

A magnetic compass shall be provided. The magnetic compass shall be mounted so as to be legible from the Manual Steering Station. The magnetic compass shall have a minimum 190 mm diameter card. The magnetic compass shall include compensating equipment (for permanent and induced magnetic effects including degaussing). One magnetic compass cover, one azimuth mirror prism sight, and one spare compass bowl shall be provided. The magnetic compass shall have adjustable intensity electric lighting.

3.421.2 PELORUS STANDS

Pelorus stands shall be installed on the port and starboard Bridge Wings, and in the Pilot House on the centerline forward of the Manual Steering Station. Pelorus stands installed on Bridge Wings shall be located to provide, as a minimum, a view of the horizon from dead ahead to dead astern. Pelorus stands shall be provided with compatible telescopic alidades, gimbal rings, brackets, bearing circles, and azimuth circles as listed in the approved allowance documentation. Each pelorus stand shall be fitted with a gyrocompass repeater. A pelorus stand shall be provided that is capable of taking celestial azimuths.

3.421.3 BAROMETER

An aneroid barometer shall be provided in the Pilot House.

3.421.4 BINOCULARS

Big Eye binoculars and stands shall be installed on the port and starboard Bridge Wings.

3.422 ELECTRICAL NAVIGATION AIDS & NAVIGATION LIGHTS

Navigation, steering, task, and clearance and obstruction lights shall be provided in accordance with DoD-HDBK-289 and as specified herein.

Two 1,000 W (or LED equivalent) remote controlled focusable beam searchlights shall be provided. The searchlights shall be installed port and starboard on the Bridge Wing top. The searchlights shall be remotely operable from inside the Pilot House.

One daylight signaling lamp that meets the requirements of 46 CFR §111.75-18(a) and SOLAS Chapter 5 Regulation 19 paragraph 2.2 shall be provided.

A watertight combination receptacle/switch and searchlight shall be provided in accordance with Suez Canal regulations. The receptacle/switch shall have a heavy-walled cast bronze or heavy-walled cast marine brass enclosure. The receptacle/switch hardware shall be stainless-steel. The receptacle/switch shall have a mechanical safety interlock.

Redundant light sources or fixtures shall be provided for the task and masthead lights. Fixed task lights shall be provided. Task and masthead lights shall be Remote Source Lighting (RSL) or LED types. The masthead lights and task lights shall have screens attached to the base of the fixtures in accordance with DoD-HDBK-289.

A blue LED stern light, NAVSEA Symbol No. 197.2 or equivalent, shall be provided adjacent to the white LED stern light. The navigating light control panel shall provide switching capability for white or blue stern light.

An LED wake light, NAVSEA Symbol No. 200.2 or equivalent, shall be provided in accordance with Navy Tactics, Techniques, and Procedures (NTTP) 4-01.4.

Port and starboard LED hull contour lights, NAVSEA Symbol No. 164.3 or equivalent, shall be provided in accordance with NTTP 4-01.4.

The control of wake and hull contour lights shall be incorporated into the navigating light control panel.

3.426 NAVIGATION SYSTEMS

3.426.1 GENERAL

An IBS shall be provided in accordance with ABS Guide for Bridge Design and Navigational Equipment/Systems per the NIBS notation.

A dual redundant, non-proprietary data bus shall be provided to interconnect control and data signals within the IBS in a common digital format suitable for high-speed communication. IBS data, as specified in the GFI, to be provided in Phase 2, shall be exportable to SAMM. Redundant interface units shall be provided for the exchange of data with the IBS components, MCCS monitoring and alarm facilities, and for data display capability on personal computers in the Master's and Chief Engineer's Offices. An interface unit will be provided, as specified in the GFE, to be provided in Phase 2, as part of the SAMM system for the exchange of data between the IBS and the unclassified LAN. The IBS inputs shall also include relative humidity and barometric pressure. A minimum of 10 unassigned outputs shall be provided, including one unassigned network port reserved for the SAMM interface unit.

IBS displays for Radar, Automatic Identification System (AIS), ECDIS, Conning, Steering, and Monitoring shall be wide screen, high definition, and minimum 600 mm diagonal.

Navigation system equipment shall not respond spuriously to conducted or radiated electromagnetic energy or transients on power lines in accordance with IEC Publication 61000-4.

3.426.2 ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM

A four-node ECDIS shall be provided. The nodes shall be located in Primary Conning, Secondary Conning, Route Planning, and the Master's Office. Each node shall consist of a full function workstation. The ECDIS shall have redundant processors. Each ECDIS workstation shall be capable of overlaying X-Band radar video images.

ECDIS shall be upgradeable by software-only change for compliance with MSC's Guidance for Implementing and Validating MSC ECDIS with DNC[®] and TOD0 Capabilities. The ECDIS shall interface directly with the DGPS receivers for communication of ship's position, course, and speed over ground from the DGPS. Designation of primary DGPS shall be operator selectable. The ECDIS shall interface directly with the AIS to support bi-directional communication with the AIS. This interface shall include control of the AIS unit and presentation of reported AIS target information and other information provided by the AIS from ECDIS. The Secondary Conning ECDIS workstation shall provide remote Minimum Keyboard Display (MKD) functionality for the AIS. Communication between the AIS and ECDIS shall comply with ITU-R M.1371. Communication between the AIS and ECDIS shall be in accordance with IEC 61162-1 and IEC 61162-2.

3.426.3 SURFACE SEARCH RADAR

Two radars (matched X-Band and S-Band pair) shall be provided as part of the IBS. These radars shall provide a combined 360° coverage. Radars shall be installed to provide long range detection, short range performance, and no blind arcs or false returns. Two separate displays and

controls shall be provided with the capability to inter switch. All rotating antennas shall have a lockable disconnect switch for the antenna accessible from outside the swing circle and PEL area. The radars shall be backed up by an individual UPS system. Radars shall be provided with electric heaters and associated controls to prevent ice formation.

A HALO Series 6 Low Probability of Intercept (LPI) Radar, or equivalent, shall be provided for mission operations with controls and display in the Pilot House.

3.426.4 AUTOMATIC IDENTIFICATION SYSTEM

An AIS shall be provided (SAAB R5 or equivalent). The system shall be upgradable by software to tactical/secure mode and shall default to Silent Mode at start-up or upon resumption of power after a blackout.

3.426.5 SPEED LOG

A dual-axis Doppler speed log shall be provided. The installation shall include a sea chest and gate valve to permit removal and reinstallation of the transducer without drydocking the ship.

The speed log shall be capable of operating concurrently with all sonars without interference or degradation of performance of the speed log or the sonars.

3.426.6 GYROCOMPASSES

Three USCG-type approved DGPS receiver systems shall be provided. The DGPS receiver systems shall use passive antenna technology.

A reference system of permanently mounted benchmarks and an optical reference unit shall be provided, which establishes an X, Y, Z origin, referenced to the center of the baseline of the ship for alignment of the gyrocompasses. Local benchmarks shall be provided at navigation system installation locations.

The gyrocompass system shall provide redundant gyro signals as follows:

- One 400 Hz heading with 0.1° accuracy
- One 400 Hz pitch with 0.1° accuracy
- One 400 Hz roll with 0.1° accuracy

3.426.7 DEPTH SOUNDER

A depth sounder shall be provided in accordance with the depth sounder manufacturer's recommendations. The transducer shall be 200 kHz and the installation shall include a sea chest

and gate valve to permit removal and reinstallation of the transducer without drydocking the ship.

3.431 INTERIOR COMMUNICATIONS SYSTEMS

A wireless communications system, sound powered telephone, PBX telephone system, announcing system, and mission communications system shall be provided.

3.431.1 WIRELESS COMMUNICATIONS SYSTEMS

Wireless, hands-free communications shall be provided throughout the vessel in support of watch-standing, machinery control, maintenance, mooring and line handling, damage control, and physical security.

The system shall be capable of operating in the 380-400 and 406-420 MHz frequency bands. The system shall consist of shipboard radios with spare batteries for each radio and charging stations, headsets, repeater system(s) with UPS(s), and a Key Variable Loader with Advanced Encryption Standard (AES) 256-bit encryption with the ability to change keys. The systems shall have a current DoD frequency allocation and spectrum approval via a J/F-12 approved DD 1494 form.

The system shall provide 95% coverage of spaces excluding staterooms, armory and small arms lockers, tanks, and voids. The system shall provide 100% coverage of control spaces, administrative spaces, working decks, the Emergency Diesel Generator space, and Steering Gear Compartment(s).

3.431.2 SOUND POWERED TELEPHONE SYSTEM

The following circuits shall be provided:

- 1JV - Maneuvering and Docking
- 2JZ - Damage Control
- 2JV - Engineers Circuit
- 4JV - Mission
- 8XJ – Command, Control, and Operating Spaces
- 13JP - Anti-Terrorism/Force Protection Circuit

Connection points shall have the following features:

- Visual identification of call to remain actuated until a call is answered
- Speaker-microphone to originate calls and receive replies from other connection points

Handsets and microphones shall be provided. Positive securing devices shall be provided for handsets and microphones. Double jackboxes and a headset shall be provided for sound powered telephone connection points. A stowage box for the headset shall be provided adjacent to the connection points.

Amplified sound powered telephone circuits shall be provided for circuits and connection points in the Pilot House, EOS, Steering Gear Compartment(s), Bridge Wings, and DC Lockers.

Acoustic SPT telephone booths shall at a minimum be provided at the following locations:

- EDG Room
- Thruster Rooms
- Steering Gear Room
- Pump Rooms (Auxiliary and Cargo if applicable)
- Main Machinery Room

3.431.3 MISSION COMMUNICATIONS SYSTEM

A dedicated Mission Communications System (MCS) shall be provided.

The MCS shall be designed such that a master control station is used to designate which communications stations are active on the network. The MCS master control station shall be located in the Cable Engineer's Office with controlled access. All MCS stations selected at the master control station shall be able to hear all the other selected stations on a "party-line" and shall allow each operator to talk. Two additional lines shall be provided to allow simultaneous conversations. Each MCS station shall be equipped with a speaker, push-to-talk microphone, a headset jack, and a push-to-talk headset. The use of the headset shall not disable the speaker, and the speaker and the headset shall be functional simultaneously. The speaker shall have a separate on/off switch on the station. The speaker and the headset shall have independent volume controls.

The MCS shall be designed to be fault tolerant such that failure of any one or more stations does not affect functionality of the system or other stations.

MCS cabling, for communications and control, shall be integrated into the ship's unclassified fiber optic LAN system.

The MCS shall provide a network of communications stations at the following locations:

- Cable Operations Console in the MCR
- Communications System Console in the MCR
- Mission Conference Room
- Pilot House at DP console
- ROV Control Console in the Plow, Projector, and ROV Control Room
- Stern Work Platforms
- Plow Control Console in the Plow, Projector, and ROV Control Room
- UUV Control Room
- Sea Plow LARS Control Station
- Stern Frame Control Station
- ROV LARS Control Station
- Projector Winch Controls
- Moonpool Staging Bay
- Moonpool LARS Control Station
- CHE Control Console
- Cable Highway, forward, P&S
- Cable Highway, middle, P&S
- Cable Highway, aft, P&S
- Each cable load/offload location
- Each repeater rack
- Aft Working Deck near Cable Highway Aft Door and mid-deck P&S
- Splice Shop
- Test and Transmission Room
- Each main cable tank
- Each spare cable tank
- Each rope stowage space
- Cable Gear Storeroom
- Plow and ROV Workshop
- Projector Room

Other than at control consoles, shared stations are allowable if they are within 30 ft of each other.

3.431.4 PBX TELEPHONE SYSTEM

A Local Session Controller (LSC) Voice over Internet Protocol (VoIP) PBX telephone system shall be provided for voice communication. The PBX telephone system shall use standard commercial equipment with an open architecture design that accommodates standard commercial telephony signaling and interfaces. The PBX telephone system shall be in accordance with DoDI 8100.04.

The PBX telephone system shall have the following features:

- Session Initiation Protocol (SIP)
- Distinctive ringing
- Multi-level precedence and preemption
- Call forwarding
- Call transfer
- Voicemail
- Call accounting
- Reconfigurable number of Public Switched Telephone Network (PSTN) gateways and trunk lines
- Satellite interfaces
- Shore-line interfaces
- Cellular phone system interfaces
- Browser based configuration and management
- Centralized management of all phone parameters
- Centralized backup and restore of all phone connections
- Reconfigurable number of auto-attendants
- Selective call routing of incoming calls
- Public Address (PA) interface
- Hands-free talkback capability
- Operator-free dialing
- Unrestricted number of simultaneous calls
- Meet-me conferences, pre-set conferences, and ad-hoc conferences
- SIP trunking
- Priority Calling (EROW)
- Group Call - Calls ring to all MEMBER stations at once. When any MEMBER answers the call, it will stop ringing at the other MEMBER stations.
- Pickup Group - Assignment of stations into call pickup groups. MEMBER can answer another MEMBER station by typing a code.
- Station Group (Sequential Ring) - Calls will route to MEMBER stations in a top-down list. Calls will always ring to MEMBER 01 unless the member is busy or logged out.

The system shall provide for communication between all spaces except sanitary spaces, passageways, voids, vestibules, storerooms, fan rooms, tanks, cofferdams, and trunks. The system shall include a 10% growth margin.

The system shall be physically and operationally compatible with international phone systems. A 10-line shore telephone connection box shall be provided.

The system shall provide programmable emergency calling to single and multiple stations, simultaneously or in selectable priority rollover. PBX telephone system failure shall alarm at the permanent Quarterdeck Stations and the Pilot House.

3.431.5 ANNOUNCING SYSTEMS

A PA system shall be provided for passing general announcements and alarms to all personnel onboard the ship from the Pilot House and each permanent Quarterdeck Station, plus other locations as defined in the PBX/telephone plan. The Announcing System shall be backed up by an individual UPS system.

3.431.5.1 GENERAL ANNOUNCING CIRCUIT

A 1MC circuit shall be provided. The 1MC circuit shall distribute voice and alarm announcements to the following ship compartments and areas through functional groups:

- Crew - living spaces, normally manned non-engineering spaces, and non-engineering workshops and offices
- Topside - manned areas and work areas partially or totally in the weather
- Engineering - accessible machinery spaces, engineering workshops, Engineering Log Office, and passageways exclusive to engineering access
- All - all of the above

The system shall be provided with one amplifier module per functional group with the exception that the Topside group shall be separated in two zones, one forward and one aft.

Loudspeakers installed in vault, SR, and RAA spaces shall be equipped with a local audio amplifier in the signal line that prevents the associated loudspeaker and wiring from acting as a microphone.

Loudspeakers residing in the same space as their associated announcing circuit microphone stations shall automatically mute when the microphone is activated.

The system shall generate and transmit an electronic fog bell signal to the forward mooring area and a fog gong signal to the aft mooring area.

The system shall automatically disable the entertainment and training video and audio distribution systems upon activation for the duration of 1MC alarms and voice announcements. General emergency alarms shall have priority over other alarms. Alarm announcements shall override voice announcements. Alarm announcements shall be broadcast to all loudspeaker groups and interfaces.

The PA system shall interface with the PBX telephone system. The system shall interface with the 5MC to distribute 1MC alarms on a non-selectable basis to the 5MC loudspeakers.

The system shall include the ability to play repeatable announcements at specified intervals.

3.431.5.2 INTERSHIP ANNOUNCING (LOUD HAILER CIRCUIT) (6MC)

A 6MC circuit shall be provided. The system shall provide a means of transmitting orders, warnings, and information to nearby ships and to shore. The announcing circuit shall consist of one channel of the amplifier specified under circuit 1MC and two superpower loudspeakers installed in a topside location, one port and one starboard. Alarm signals shall not be transmitted over these loudspeakers.

The system shall include line-level input connection to support external playback devices.

3.431.5.3 BRIDGE ANNOUNCING CIRCUIT (18MC)

A dedicated, amplified talkback circuit shall be provided for communications between the Bridge Wings and the Manual Steering Station.

3.432 SHIPWIDE LOCAL AREA NETWORKS

Data transmission systems - The Government will provide and install equipment for two separate shipboard networks, one at the unclassified level and one to process classified information. Unclassified LAN servers, switching equipment, and routing equipment will be installed in the Naval Communications Center. Classified LAN servers, switching equipment, and routing equipment will be installed in the Naval Communications Center.

Inter-compartment cable and foundations shall be provided in accordance with the Naval Communications System Turnkey Approach to be provided for DD&C.

Unclassified LAN - The system shall utilize multi-mode fiber optic backbone cable and support a minimum of Optical Carrier (OC) transmission rate OC-12 throughput capability between the servers and backbone switches. The system shall utilize cable supporting OC-3 throughput capability to the LAN termination points. The system shall be fully redundant so as to survive any single point failure except that all inter-compartment cable shall originate from the Naval Communications Center. LAN interface with broadband satellite communications will be provided by the Government.

Inter-compartment unclassified LAN connections shall be provided as identified in the Naval Communications System Turnkey Approach to be provided for DD&C.

Classified LAN - The system shall utilize multi-mode fiber optic backbone cable and support a minimum of OC-12 throughput capability between the servers and backbone switches. The

system shall utilize cable supporting OC-3 throughput capability to the LAN termination points. The system shall be fully redundant so as to survive any single point failure except that all inter-compartment cable shall originate from the Naval Communications Center. LAN interface with broadband satellite communications will be provided by the Government.

Inter-compartment classified LAN connections shall be provided as identified in the Naval Communications System Turnkey Approach to be provided for DD&C.

Shore connections - The classified and unclassified ship-wide LANs will be connectable to the pier-side local Base Level Information Infrastructure (BLII). The BLII interface connection boxes will be provided.

3.434 ENTERTAINMENT AND TRAINING SYSTEM

The entertainment and training systems shall be distributed to each stateroom, berthing space, Master's Office, Chief Engineer's Office, messroom, Conference Room, Hospital Room, Gymnasium and leisure space. Means for controlling the entertainment and training systems signals shall be provided. The entertainment and training systems shall be capable of being connected to the local cable television system pier-side.

An antenna-preamplifier distribution system, with combination antenna, ground, and single duplex power outlet receptacles, shall be provided for the reception of Amplitude Modulation (AM), Frequency Modulation (FM), shortwave radio, and Television (TV) on U.S. and international broadcast bands. Broadcast and shortwave radio RF feed, Terrestrial digital TV, and FM radio RF feed shall be from an AM-SW-FM-TV Type antenna located topside. The antenna distribution system shall have three separate main coaxial distribution trunk lines; one for AM/SW, one for video entertainment system reception, and the other for TV/FM. Each receptacle shall have separate coaxial connectors. Cover plates shall be inscribed to indicate application of each receptacle.

A Television-Direct to Sailor (TV-DTS) antenna shall be provided to receive a satellite TV system signal. The satellite antenna system shall be a dual band, dual reflecting parabolic reflector, gyro-stabilized and capable of tracking the satellite signal during ship course changes and other motions due to sea state. The TV-DTS antenna cables shall be routed to an entertainment equipment rack. The TV-DTS antenna cables shall be provided with 6 m of slack. The TV-DTS antenna shall be switchable between C-Band and Ku-Band from the equipment rack control unit.

A satellite television system (Circuit 29TV) will be provided to receive the Armed Forces Network (AFN) satellite network and the AFN DTS network media.

3.436 ALARMS AND INDICATORS

3.436.1 GENERAL

Alarm, safety, warning, indicating, ordering, and metering systems shall be provided. Growth factor of 10% shall be provided. Alarms shall use the compartment numbering convention to identify device location.

3.436.2 CHEMICAL, BIOLOGICAL, RADIOLOGICAL (CBR) DETECTION

A chemical agent point detection system shall be provided. Foundations for the detection system shall be provided in accordance with GFI, Schedule C provided prior to DD&C. A remote display unit shall be mounted in the Bridge in the vicinity of the other detector displays and alarms. The control unit shall be mounted in the DCCC.

3.436.3 FIRE AND SMOKE DETECTION SYSTEMS

An addressable mode fire detection and alarm system shall be provided in the working and living spaces. Cable for the fire sensors shall be arranged in a looped NFPA 72, Style 6, Class A signaling line circuit. Isolators shall be installed on the sensor loop in series between groups of heat and smoke sensors. Heat detectors shall be of the resettable type.

Heat detectors shall be provided in machinery spaces and the galley.

In addition to the fire/smoke detectors required by regulatory bodies, heat detectors shall be provided in mission spaces and the cable highway.

Heat detectors not located in the Small Arms Magazine or Lithium Battery Room shall initiate a high temperature alarm when a threshold temperature of 57 °C is reached.

In addition to the fire/smoke detectors required by regulatory bodies, additional ionization smoke detectors shall be provided above each electrical generator.

Fire detection shall be provided in spaces sharing a common deck, bulkhead, or overhead with the Small Arms Magazine. Adjoining spaces that pose a low fire hazard, such as tanks, sealed voids, cofferdams, lavatories, or access trunks, do not require fire detection.

A Small Arms Magazine Fire Detection and Control System shall be provided. The system shall consist of electronic spot heat detectors, smoke detectors, a fire alarm control unit, and a sprinkling release valve. A minimum of two separate heat detectors shall be provided in the Small Arms Magazine. The heat detectors shall send an electronic actuation signal via the fire alarm control unit to open the sprinkling release valve and initiate sprinkling when a threshold temperature of 57 °C is reached on any heat detector in the Small Arms Magazine. A high temperature alarm shall be initiated when a threshold temperature of 40.5 °C is reached in the Small Arms Magazine.

A Lithium Battery Room Detection and Control System shall be provided. The system shall consist of electronic spot heat detectors, smoke detectors, a fire alarm control unit, and a sprinkling release valve. A minimum of two separate heat detectors shall be provided in the Lithium Battery Room. The heat detectors shall send an electronic actuation signal via the fire alarm control unit to open the sprinkling release valve and initiate sprinkling when a threshold temperature of 57 °C is reached on any heat detector in the storeroom. A high temperature alarm shall be initiated when a threshold temperature of 40.5 °C is reached in the Lithium Battery Room.

The central fire alarm control and display panel shall be provided at the DCCC. A fire alarm display repeater panel shall be provided in EOS, Secondary DCC, and each Quarterdeck Station. Fire detectors, smoke detectors, and sprinkling system alarms shall alarm locally, at a central fire alarm control and display panel, and at fire alarm display repeater panels. The fire alarm panels shall indicate the location of activated alarms. Activated alarms shall also initiate a summary alarm on the MCCS. Alarms shall be capable of being acknowledged through the fire alarm panels and the MCCS.

A manual call point shall be located within 1 m of each seawater sprinkling local activation point.

3.436.4 FLOODING ALARMS

Flooding alarms shall be provided in machinery spaces. Flooding alarms shall be annunciated via MCCS with an independent audible alarm in the affected space. Individual space flooding alarms shall be extended to the permanent Quarterdeck Stations.

If natural drainage is not provided for the Small Arms Magazine, a Small Arms Magazine Flooding Alarm shall be provided for the Small Arms Magazine. The Small Arms Magazine Flooding Alarm shall be initiated when a depth of 50 mm of water has accumulated at the lowest point in the Small Arms Magazine.

If natural drainage is not provided for the Lithium Battery Room, a Lithium Battery Room Flooding Alarm shall be provided for the Lithium Battery Room. The Lithium Battery Room Flooding Alarm shall be initiated when a depth of 50 mm of water has accumulated at the lowest point in the Lithium Battery Room.

Flooding alarms shall be installed in all interior spaces that are directly adjacent to the moonpool.

3.436.5 WATERTIGHT DOOR INDICATOR SYSTEM

A watertight door indicator system shall have displays located in MCCS, DCCC, and Secondary DCC.

3.436.6 EXTERNAL INTRUSION DETECTION SECURITY SYSTEM

An addressable mode IDS system shall be provided for indication of entry through each weather deck door, hatch, and scuttle. The main alarm panel shall be located in the Pilot House. Remote alarm panels shall be located at the permanent Quarterdeck Stations. The system shall have capability to selectively secure circuits for individual doors, hatches, and scuttles. UPS for the external IDS shall alarm at the main and remote alarm panels. The external IDS UPS alarms shall indicate:

- The affected UPS
- When the UPS is operating on battery
- When the UPS battery is low

The system shall allow for growth of 10% in additional circuits.

3.436.7 INTERNAL INTRUSION DETECTION SECURITY SYSTEM

An addressable mode IDS system utilizing the CCTV system shall be provided to monitor for unauthorized access to Vault and SR spaces, the Small Arms Magazine, and the Ship Armory. The system shall be capable of detecting movement. The system shall be provided with a delayed audible and visual alarm capability. The main alarm panel shall be located in the Pilot House. Remote panels shall be located at the permanent Quarterdeck Stations. When an IDS alarm occurs, an audible alarm and viewing of the alarming space shall automatically display on CCTV monitors in the Pilot House and the permanent Quarterdeck Stations.

The system shall be provided with a means to allow authorized access, into and out of spaces, without sounding an alarm. The system shall be provided with a means to selectively secure the alarm circuit for individual spaces when the space is manned, or continued access is required without securing the entire system.

UPS for the internal IDS shall alarm at the main and remote alarm panels. The internal IDS UPS alarms shall indicate:

- The affected UPS
- When the UPS is operating on battery
- When the UPS battery is low

The system shall allow for growth of 10% in additional circuits.

3.436.8 GENERAL EMERGENCY ALARM SYSTEM

The general emergency alarm system shall include manual activation from contact makers located in the Pilot House, DCC, EOS, portable Quarterdeck Station, and permanent Quarterdeck

Stations. Jack boxes shall be provided for connection of the portable Quarterdeck Station general emergency alarm contact maker at the flight deck and at each solid cargo transfer station. A cut-out switch shall be provided in the Pilot House that can isolate the portable Quarterdeck Station jack box circuit from the rest of the general alarm system. The system shall be interfaced with the Fire and Smoke Alarm system such that the general emergency alarm is activated automatically when the Fire Alarm is not acknowledged within two minutes.

The general emergency alarm shall be broadcast throughout the ship on the 1MC general announcing circuit. In addition to manual activation of the alarm, the system shall provide for manual activation of sounding the following preprogrammed alarm signals:

- Fire, Collision, General Emergency: steady sounding for at least 10 seconds
- Abandon Ship: seven or more short blasts followed by one prolonged blast
- Chemical, Biological, and Radiological Defense (CBR-D): steady sounding followed by short and prolonged blasts (Morse Code 'A')
- Man Overboard: three long blasts (Morse Code 'O')
- Steering Casualty: one long and two short blasts (Morse Code 'D')
- Dismissal from Drills: three short blasts

3.436.9 MEDICAL FACILITY ALARMS

Medical facility refrigerators and freezers shall be provided with power interruption alarms and high and low temperature alarms. The high and low temperature alarms shall have adjustable set points. Alarms shall be provided with local audible and visual indicators in a passageway adjacent to the medical facility, and remote alarm via the MCCS and at the permanent Quarterdeck Stations.

A hospital patient call alarm shall be provided. It shall alarm in the Medical Office, Pilot House, Medical Services Officer's (MSO) Stateroom (if applicable), and at the permanent Quarterdeck Stations.

3.436.10 REGRIGERATED SPACE LOCKED-IN ALARM

Refrigerated space locked-in alarms shall be provided. The alarm for each refrigerated space shall be activated by a pushbutton located inside the space next to the door. The alarm shall sound locally, in the Galley, remotely via the MCCS, and at the permanent Quarterdeck Stations.

3.436.11 STEERING CASUALTY ALARM

A steering emergency signal system shall be provided as a means of signaling that a steering casualty has occurred. The system shall consist of a self-locking manual release switch at the Manual Steering Station connected to an audible alarm located at the steering gear local control station.

3.436.12 TANK LEVEL INDICATORS (TLIs)

An electrical liquid level indicating system shall be provided for tanks. Radar type TLIs shall be provided for each tank larger than 2 m³ capacity or that requires automation. Radar type TLIs shall be provided for each independent propulsion system and ship service power generation lube oil sump larger than 2 m³.

Readouts for the tanks shall be located remotely via the MCCS and locally at the site where filling and emptying is controlled for each tank. TLI outputs shall be integrated into the trim and stability software package. The trim and stability software package shall include a trim optimization tool that generates structurally safe recommendations for trim and draft adjustments based on the ship's tank load and operating condition to optimize mobility performance for a desired speed. The trim optimization tool suggested trim and draft adjustment data points shall be exportable to SAMM. TLIs shall be capable of being serviced without entering the tanks.

Sight glasses with automatic shutoff valves shall be fitted to the following:

- Lube oil storage tanks
- Ship fuel settling tanks
- Ship fuel service tanks
- Ship potable water tanks
- Cooling head tanks
- Small Arms Magazine sprinkling head tank
- Lithium Battery Room sprinkling head tank
- AFFF tanks

Magnetic tank level sight glasses shall be installed for ship's fuel settling and ship's fuel service tanks.

3.436.13 PROPULSION SHAFT REVOLUTION COUNTERS

Propulsor shaft revolution counters shall be provided. The counters shall be capable of continuous accounting of shaft revolutions without resetting. The counters shall provide data locally and in the EOS. Counters shall rollover at 10,000,000 revolutions.

3.439 CCTV SYSTEM

Two independent CCTV camera and display systems, one for Ship's Systems and one for Mission Systems shall be provided. They shall consist of external and internal video cameras and video recording capability.

The Ship's and Mission CCTV Systems shall be integrated into the ship's Unclassified LAN network and viewable on LAN computers. The CCTV systems shall be programmable to allow feeds from any unclassified camera location to either the Ship's or Mission CCTV locations. The CCTV systems backbone shall be part of the ship's LAN multi-mode fiber optic cable network, and shall each be designed with equipment, racks, and network capacity to allow for CCTV growth for a minimum of 24 additional cameras on either CCTV system.

The CCTV systems shall support displaying four camera feeds simultaneously on one screen. The CCTV systems shall have uninterruptable power supplies with at least 30-minute run times. Each display shall be capable of selecting which camera is displayed. The CCTV systems shall have a minimum 24 hours recording capability and permanent storage of CCTV data for a minimum of two months. Cameras shall be digital and network-capable. A mix of fixed and pan, tilt & zoom (PTZ) cameras are acceptable.

Spaces monitored by the Internal Intrusion Detection System shall have integrated detection with the Ship's CCTV System.

Ship's CCTV System – Primary Control for the Ship's PTZ cameras shall be from the Pilot House. Secondary PTZ control locations shall be the EOS and Quarterdeck Station. The following PTZ control options shall be available for use (enable/disable) and configurable:

- Allow locations from a configurable list the ability to request PTZ control from the active PTZ control location (enabled by default).
- Allow the active PTZ control location the ability to choose a location from a configurable list and give that location PTZ control (enabled by default).
- Allow PTZ control to be taken by a secondary location without approval (prompt on screen or equivalent) from the active location (disabled by default).

The Ship's CCTV system shall provide coverage of the following areas (required camera types for select areas are denoted in parenthesis):

- Waterline and pier coverage around the ship out to a minimum of 450 m (PTZ)
- Machinery space areas and overview of equipment therein (PTZ)
- Access to Ship Armory (fixed camera)
- Access to Small Arms Magazine (fixed camera)
- Access to Mission Control Room (fixed camera)
- Access to Network Management Center (fixed camera)
- Access to SR spaces (fixed camera)
- Access to Vault spaces (fixed camera)
- Aft mooring area (fixed camera)
- Port and Starboard bridge wings

Cameras providing coverage for Vault and SR access shall be positioned such that they do not record the interior of the spaces.

Feeds from the Ship's camera system shall be programmable from MCR to provide display and or No Display in the following areas:

- Pilot House
- EOS
- Master's Office
- Chief Engineer's Office
- Quarterdeck Stations
- Mission Control Room
- ROV and Plow Control Room
- UUV Control Room
- Mission Conference Room
- Ship's Conference Room
- SDR's Office
- Cable Engineer's Office

Mission CCTV System – The Mission CCTV system shall be utilized for ship monitoring during all cable and submersible operations. Primary Control for the Mission PTZ cameras shall be from the MCR. Secondary PTZ control locations shall be the Plow, Projector, and ROV Control Room, UUV Room, SDR Office, and Pilot House. The following PTZ control options shall be available for use (enable/disable):

- Allow locations from a configurable list the ability to request PTZ control from the active PTZ control location (enabled by default).
- Allow the active PTZ control location the ability to choose a location from a configurable list and give that location PTZ control (enabled by default).
- Allow PTZ control to be taken by a secondary or tertiary location without approval (prompt on screen or equivalent) from the active location (disabled by default).

The Mission CCTV system shall provide coverage of the following areas:

- Each main cable tank with two or more cameras each
- Each spare cable tank with two or more cameras each
- Rope Stowage Spaces
- Entire cable highway with as many cameras as needed to show all work areas
- Each individual item of Cable Handling Equipment plus additional camera with all CHE

in view

- CHE control console(s)
- Aft deck from at least four aspect angles
- Area aft of the transom such that overboarding of anchors and the plow are visible from at least two aspect angles.
- Overboarding sheaves or rollers such that crab angle of any deployed cables, lines, or wires can be estimated
- Cable lead departing the ship
- Moonpool Staging Bay from at least two aspect angles
- Moonpool LARS location
- ROV LARS location
- ROV traction winch
- ROV umbilical storage reel (if separate space from traction winch)
- Sea Plow tow winch
- Sea Plow umbilical winch
- Moonpool Heavy lift system
- Aft deck crane(s)

Feeds from any Mission camera system shall be programmable from MCR to provide display and or No Display in the following areas:

- Pilot House
- Master's Office
- Chief Engineer's Office
- EOS
- Ships Conference Room
- Mission Control Room
- UUV Control Room
- ROV and Plow Control Room
- Mission Conference Room
- SDR's Office

Use of split screen displays is acceptable.

The video matrix controller that determines which camera sources are fed to which displays shall be located in the Mission Control Room.

3.440 EXTERIOR COMMUNICATIONS SYSTEMS

3.440.1 GENERAL

The ship will be required to operate in various emissions control (EMCON) conditions.

3.440.2 SHIP COMMUNICATIONS EQUIPMENT

A GMDSS integrated workstation with dedicated International Mobile Satellite Organization (INMARSAT) C and Very High Frequency (VHF) Radiotelephone shall be provided to meet Areas A1, A2, and A3 compliance. The system shall utilize FCC approved components.

A dedicated Long-Range Identification and Tracking (LRIT) system shall be provided that can support a Ship Security Alert System (SSAS). The system shall utilize a passive antenna system. The electronics, amplifiers, and pre-amplifiers for the passive antenna shall be located below decks.

3.440.3 NAVAL COMMUNICATIONS EQUIPMENT

The Mission communications equipment will be installed by the Government as part of the Naval Communications System Turnkey Approach to be provided for DD&C. The inter-compartment cable and foundations shall be provided as identified in the Naval Communications System Turnkey Approach to be provided for DD&C.

3.443 SHIP'S WHISTLE

Two whistles shall be provided. The ship's whistle control shall be provided with the following additional functions:

- Whistle selector to select either of the two whistles
- Manual whistle control
- Automation controls to select various whistle scenarios (e.g. fog, not under command, restricted ability to maneuver)

The system shall be provided with all the items to make a complete, operational system including mounts, automatic heaters, enclosures, and any incidental material.

3.455 IDENTIFICATION SYSTEMS

An Identification Friend or Foe (IFF) system will be provided and installed in the Naval Communications Center. The antenna inter-compartment cable and foundations shall be provided in the Naval Communications System Turnkey Approach to be provided for DD&C.

3.461 MISSION SONAR SYSTEMS (MSS)

MSS described in this section shall receive all required sensor data inputs, including input from the AHRS, DGPS, and gyrocompass systems. MSS shall provide data outputs to the MCR.

The following MSS transducers shall be located as far forward in the hull as possible: MBSS-DW, SBP, SBSS, ADCP, and Surface Sound Velocimeter System (SSVS) inlet. These MSS transducers shall be located forward of the moonpool in the forward third of the LBP.

Dedicated space(s) shall be provided where the MSS transducers (MBSS-DW, SBP, SSBS, ADCP, and SSVS inlet) are hull-mounted integral with the hull structure.

Software and automatic switching shall be provided as necessary to allow any sonar outputs to be viewed and controlled from any console in the MCR.

A Transceiver Room shall be provided for all MSS transceivers. The transceivers shall be mounted in 19-in racks or in cabinets supplied by the sonar manufacturer.

Cable from all mission sonar transducers shall be terminated with at least 39 in (1 m) of slack at the inboard end to allow subsequent re-terminations. Cables from all mission sonars shall be run up pipes to at least 0.5 m above the full load water line where they may be terminated in either a subsea rated connector or may be run through a stuffing tube at the OEM's recommendation. Cable pipes shall be sized with at least a 50% larger inside diameter than the largest cable end connector expected to be passed, or to a minimum of 2 in National Pipe Thread (NPT), whichever is larger. Bends in these cable pipes shall have a minimum bend radius recommended by the OEM.

The acoustic release shall be selected such that it can be controlled via the ANTS.

Shipboard EMI shall not interfere with the operation of all mission equipment.

The sonar arrangement shall take into account EMI and shall be arranged in accordance with the manufacturer's recommendations.

3.461.1 MSS REMOTE DISPLAY CONSOLE

Video feed to the displays shall be user-selectable at the console and allow for simultaneous viewing of up to four independent system outputs. The displays shall be provided with dimming controls for night use. The MSS remote display console shall be oriented facing inboard and have at least 4 ft (1.2 m) of clearance in front and sufficient clearance for personnel access in the rear.

3.461.2 SONAR SYNCHRONIZATION UNIT

The Kongsberg K-SYNC, or equivalent, sonar synchronization unit shall be provided with a triggering system that shall control the ping rate of all installed MSS echo sounders and sonars that could potentially interfere with the MSS. The triggering system unit, operating system computer, display, mouse, and keyboard shall be rack mounted in the MCR.

3.461.3 MULTIBEAM SURVEY SYSTEM – DEEP WATER

A MBSS-DW, Kongsberg EM 124, 1° x 2°, or equivalent, shall be provided. The transceiver unit, preamplifier unit, junction boxes, and power supplies shall be located in the Transceiver Room. The processing unit, displays, mouse, keyboard, and remote-control power switch unit shall be rack mounted in the MCR.

3.461.4 SUB BOTTOM PROFILER

An SBP system, Kongsberg SBP 29, or equivalent, shall be provided. The transceiver unit, junction box, and power supplies shall be located in the Transceiver Room. The processing unit, displays, mouse, keyboard, and control unit shall be rack mounted in the MCR.

3.461.5 ACOUSTIC NAVIGATION AND TRACKING SYSTEM

Two ANTS, Kongsberg HiPAP systems, or equivalent, shall be provided, with Hull Unit Model 3770 (gantry, shaft sleeve, transducer dock), or equivalent, gate valve, hoist control unit, mounting hardware, instrument rack, and operator station shall be provided. Each system shall include one HiPAP502 head, or equivalent, and one HiPAP102 head, or equivalent. The transceiver unit, hoist control unit, and remote-control unit shall be located in the gantry trunk. ANTS shall include indication for status of deployment and an alarm in the Pilot House, if stalled in retrieval position. The processing unit, displays, mouse, and keyboard shall be rack mounted in the MCR.

The ANTS shall be located in the middle third of the vessel with port and starboard locations that do not interfere with other shipboard operations. One HiPaP shall be located on the port side and the other on the starboard side. Hatches or BERPs shall be located above the HiPAP trunks for installation and removal.

3.461.6 SINGLEBEAM SURVEY SYSTEM

An SBSS, Kongsberg EA 640 kHz, or equivalent, shall be provided. The system shall consist of General Purpose Transceivers (GPTs), as required, three transducers (12 kHz, 38 kHz, and 200 kHz), an echogram color printer, processing unit with large color display, remote color display and control unit, and all required interconnecting hardware and cabling.

The large color display and processing unit shall be provided in the MCR. The GPTs and power supplies shall be located in the Transceiver Room. The processing unit shall be mounted in the MCR. The transducers shall be installed in seawater backed seachest(s).

3.461.7 ACOUSTIC DOPPLER CURRENT PROFILER

An ADCP, Teledyne RDI Pinnacle 45, or equivalent, shall be provided. The system shall include electronic processing units, transducers, and interconnecting hardware and cabling.

The processing units, displays, mice, keyboards, and control units shall be rack mounted in the MCR. The transducers shall be installed in freshwater backed seachests and shall be fully serviceable and permit removal and reinstallation without dry-docking the ship.

3.461.8 SURFACE SOUND VELOCIMETER SYSTEM

An SSVS, flow through system with tank assembly and sound velocity probe, AML XCH-SV-STD, or equivalent, shall be provided. The sound velocity probe shall interface with the MBSS-DW and the sampling inlet shall be in close proximity to the MBSS-DW receive array. The system shall include through hull fittings, piping, mounting hardware, and operator station installed in accordance with the manufacturer's recommendations.

3.461.9 EXPENDABLE SOUND VELOCITY PROFILER (XSVP)

A Sippican XSVP Win MK 21 system, or equivalent, shall be provided.

The system shall consist of one interior fixed launcher, Sippican Model LM-3A or equivalent, an oceanographic data acquisition system, Sippican Model MK-21/USB, or equivalent, and an acquisition computer and display system in accordance with manufacturer's recommendations.

The acquisition and display system and the oceanographic data acquisition system shall be rack mounted in the MCR.

The XSVP connector box shall be installed inside the storage box. The XSVP connector box shall provide an interface for communication from the oceanographic data acquisition system to the hand-held launcher.

System data outputs shall be provided in NEMA 0183 format.

3.461.10 ACOUSTIC MONITORING SYSTEM

Four wide band, low noise, omni-directional hydrophones shall be provided covering a frequency range of 10 - 100 kHz. The hydrophones shall be located such that they do not interfere with the acoustic performance of any mission sensor. One omni-directional hydrophone shall be installed in a floodable void or tank, above each propeller/main thruster

when oriented in the forward thrust navigation azimuth, and approximately within 39 in (1 m) of the propeller/main thruster. Two omni-directional hydrophones shall be installed in a floodable void(s) or tank(s) near the ends of the deep water multibeam receive array, with one hydrophone located port and starboard at the same frame.

Two accelerometers with a nominal sensitivity of 100 mV/g and a natural resonance above 40 kHz shall be provided. The accelerometers shall be mounted to an installed welded stud directly above each propulsor on the shell plating.

All sensors shall have an internal preamplifier located within the crystal assembly.

The cabling for the hydrophones and accelerometers shall be terminated in a junction box in proximity to the electronics racks located in the MCR with 39 in (1 m) of slack.

3.461.11 ATTITUDE, HEADING & REFERENCE SYSTEM/INERTIAL REFERENCE SYSTEM

One AHRS/inertial reference system, Applanix, Inc. Model POS MV Elite, or equivalent, shall be provided. The inertial reference system shall be the primary heading and position input for MSS. The processing unit, primary display, mouse, keyboard, and computer system shall be rack mounted in the MCR.

The IMU shall be located on or near the multibeam transducer heads. The system shall provide position, velocity, heading, heave, roll, and pitch output, as appropriate, to the MSS.

The IMU shall be installed on a rigid foundation welded to the ship's structure and oriented as follows:

- The "X" axis shall lie parallel to the centerline vertical plane with its positive toward the bow.
- The "Y" axis shall lie perpendicular to this plane with its positive toward starboard.
- The "Z" axis shall lie in a plane parallel to the ship's centerline vertical plane with its positive toward the keel.

3.500 GENERAL REQUIREMENTS FOR AUXILIARY SYSTEMS

3.503 PUMPS

Centrifugal and rotary pumps shall be selected for the intended service and shall have non-overloading power characteristics. All pumps shall have mechanical seals. Pump connections shall be in accordance with ASME 16.5 and 16.47 Pipe flanges and flanged fittings. Shafts of horizontal pumps shall be oriented fore and aft. Foundations for pumps handling oil shall be provided with oil troughs and fixed drains that convey oil to the WO/ST(s). A means for venting

seawater and freshwater pumps into the bilge shall be provided. Where two or more pumps of the same size and type are required for a particular service, they shall be identical in make and model. Each pump shall have a pressure gauge installed on the discharge piping between the pump and its discharge valve. Each pump shall have a compound pressure gauge installed on the suction piping between the pump and its suction valve.

Centrifugal pumps shall be in accordance with ASTM F998. Centrifugal pumps shall be selected to operate within the manufacturer's preferred operating range and shall operate within 10% of the best efficiency point (BEP) on the head-capacity curve. Each seal chamber of centrifugal seawater pumps with total head of 140 kPA or more shall be provided with cyclone separators with flushing lines. Restrictive devices, such as orifices, shall not be used to obtain satisfactory pump operation.

Systems conveying fuel and oil shall utilize positive displacement pumps. Rotary positive displacement pumps shall be in accordance with ASTM F1510. Rotary positive displacement pumps handling distillate fuel shall be in accordance with ASTM F1718.

Mechanical seals shall be in accordance with ASTM F1511. Pumps shall be provided with mechanical shaft seals as follows:

- Mechanical cartridge seals per ASTM F1511 Type A, Grade 2, Class 0 shall be provided for centrifugal pumps except as specified herein.
- Split cartridge seals per ASTM F1511 Type A, Grade 3, Class 4 shall be provided for horizontally mounted Type C-3 pumps per ASTM F998 Supplementary Requirement S3.8.5. Split seals shall not be used in hydrocarbon service.
- ASTM F1511 Type "C", "D", "E", or "F" seals shall be provided for critical, zero leakage, or low emission services.
- Sewage pumps shall be provided with double mechanical seals.
- The lower bearing configuration for vertical centrifugal pumps shall have a non-contacting labyrinth seal adjacent to the bottom mechanical seal.

Shafts of horizontal pumps shall be oriented fore and aft.

Foundations for pumps handling oil shall be provided with oil troughs and fixed drains that convey oil to the WO/ST(s). A means for venting seawater and freshwater pumps into the bilge shall be provided.

Where two or more pumps of the same size and type are required for a particular service, they shall be identical in make and model.

Each pump shall have a pressure gauge installed on the discharge piping between the pump and its discharge valve. Each pump shall have a compound pressure gauge installed on the suction piping between the pump and its suction valve.

ASTM F998 Type C-3 complying with Supplement S3, with the exception that materials shall be in accordance with Table 1.

3.504 INSTRUMENTS AND INSTRUMENT BOARDS

3.504.1 GENERAL

Instruments and their components shall be located to provide ready access. Instrumentation, microprocessors, and their components shall be constructed in a way that it will not be adversely affected by vibration, temperature, moisture, impact, or dust. Instrumentation, microprocessors, and their components shall be tailored to their applications. Instruments shall be waterproof. Means shall be provided to protect the sensing element of the instrument from the fluid being sensed. Instruments and their components shall be clear of or protected from high voltage, high temperature, and other damaging environmental impacts. Failure or removal of any individual instrument shall not cause an entire system to become inoperable.

Local instrumentation shall be provided to indicate pressures, temperatures, liquid levels, and flow rates. Local instrumentation shall be installed with a clear line-of-sight from equipment operating areas. If the operating area is not defined, the instruments shall be visible from the normal walk-ways or accesses.

Instruments for testing and trials shall be calibrated prior to Builder's Trials (BT) and recalibrated just prior to ship delivery. The date of calibration shall be affixed to the face of the instruments.

3.504.2 PRESSURE GAUGES

Pressure and differential pressure transducers shall be in accordance with ASTM F2070. Pressure gauges shall be in accordance with ASME B40.100 (B40.1). Pressure gauges shall be a minimum of 89 mm in diameter. Piping assemblies for pressure gauges and transducers shall be in accordance with ASTM F721 with materials for root valves and pipe in accordance with Appendix G. Regardless of service, pressure gauge assemblies shall be provided with pulsation dampeners in accordance with ASME B40.100 (B40.5). Gauge supports shall be in accordance with ASTM F707.

Gauge scales shall be selected such that normal operating pressure will be in the middle one-third of the scale range and maximum system pressure does not exceed the scale range. All gauge valves shall have an integral test connection.

Pipe of the same schedule wall thickness shall be used to connect the gauge root valve to the system pipe.

3.504.3 THERMOMETERS

Thermometers shall be in accordance with ASME B40.200. Temperature ranges shall be selected so normal operating temperatures shall not be more than 75% of the thermometer's scale range. The maximum system temperature shall not exceed the thermometer's range. Temperature monitoring devices shall meet the requirements of ASTM F2362.

Dry wells shall be Type 316 stainless-steel except Monel shall be provided in seawater systems.

3.504.4 CLOCKS

A master/slave digital clock system shall consist of bulkhead mounted digital clocks. System clocks shall display time in a 24-hour format. System clocks shall have a minimum numeral height of 25 mm. System clocks shall be located in the following spaces:

- Pilot House (Master Clock)
 - Pilot House at the chart table
 - EOS
 - DCC
 - Secondary DCC
 - Naval Communications Center
 - Transmitter Room
 - Network Management Center
 - Offices (one each)
 - Lounges (one each)
 - Conference Room
 - Messrooms (one each)
 - Galley
 - Scullery
 - Hospital
 - Mission Control Room

3.505 REQUIREMENTS FOR PIPING SYSTEMS

3.505.1 GENERAL

Spray shields shall be installed on takedown and flanged joints (including simplex strainer flanged covers) and flanged valve bonnets in piping containing hydrocarbon fluids. Spray shields shall be installed on flanged joints and flanged valve bonnets in piping located 10 ft or less from, and in the direct plane of, an electrical switchboard, electrical equipment enclosure, or motor. Protection is not required for electrical equipment which is watertight, spraytight, totally enclosed, submersible, or explosion proof.

Centrifugal pumps shall be installed to have positive suction either through submergence, foot valves, or priming systems as appropriate. The pump suction configuration shall provide the manufacturer's minimum Net Positive Suction Head Required (NPSHR) for the particular application. A minimum length of three pipe diameters of straight pipe shall be provided on the suction side of pumps. Where seawater service centrifugal pump suctions are not provided with the minimum NPSHR with up to 15° of roll under all loading conditions, the pumps shall be served by dedicated vacuum priming air-driven ejectors.

Piping shall not run through control spaces, electrical spaces, or electronic spaces unless the piping serves the equipment in the space. Flanges, cleanouts, and mechanical joints shall not be located above, below, or next to electronic and electrical equipment.

Piping shall not be exposed in accommodation spaces except for piping for service connections located within the space.

Pipe bends shall be provided in lieu of fittings where practical. Takedown joints shall be provided for removal of machinery, equipment, and sections of pipe. Isolation valves shall be provided in branch lines, in mains, and at equipment to facilitate operational and maintenance requirements of the systems and components. Equipment isolation valves shall allow equipment isolation without securing flow to other portions of the system. Wafer type butterfly valves shall not be used for the isolation of equipment. Automatic control valves shall be provided with a manual means of control.

“Y” type strainers shall be incorporated upstream of each automatic control valve. Strainers, except those for fuel oil, lubricating oil, and oily waste/waste oil services, shall have valved blow-off lines. Strainer blow-off lines shall discharge to the bilge or a suitable “blow-down” containment when installed in an area not accessible to the bilge.

Strainers in suction piping for fuel oil, lubricating oil, and oily waste/waste oil services shall be basket type with top vertical removal. Basket strainers greater than 50 mm nominal pipe size shall be provided with differential pressure gauges, valved vents, and valved drains.

Valves shall not be located inside of any tank.

Swing check valves, where required, shall be installed in horizontal pipe runs such that the disc of the valve swings in the fore and aft direction. If necessary, check valves may be installed in vertical pipe runs, but only in such runs where the fluid flow is in the upward direction.

The use of non-welded, gasket-sealed, socket and spigot type ship fittings shall be prohibited in all drainage and vacuum piping.

All piping, valves, fittings, components, actuators, valve operators, and sea connections shall be provided with a means of freeze protection suitable for the Baltic 1C.

All piping systems shall be fitted with low-point drains.

Unless otherwise specified, valve types shall be in accordance with Table 3.505-1. Butterfly valves shall not be used as shell valves. Application of resiliently seated valves shall be subject to the limitations of 46 CFR §56.20-15. Gate valves and ball valves shall not be used for throttling services.

Table 15: [3.505-1] Valve types by use and size

Pipe Size	Shut-off	Throttling
50 mm and below	Full port ball valves	Globe valves
Above 50 mm	Gate valves or butterfly valves	Globe valves, angle valves, or butterfly valves

Pipe containing seawater, brine, or other corrosive media shall be protected from the effects of galvanic corrosion and erosion corrosion by the following:

- Where joints of ferrous and non-ferrous materials cannot be avoided, a “waster piece” shall be installed between the dissimilar metal lines. Waster pieces shall be a minimum of 300 mm long. Waster pieces up to 500 mm diameter shall be Schedule 80 steel pipe. Waster pieces greater than 500 mm diameter shall have a minimum wall thickness of 25 mm. Waster pieces shall be replaceable and installed in accessible locations. Waster pieces required at hull connections shall be located inboard of shell valves.
- Changes in diameter of piping runs and connections shall be by means of gradual transitions.
- Long radius bends, sweep tees, and “Y” type fittings shall be provided unless otherwise approved.

Electric motor operated valve actuators shall be provided for remote valve operation. Valve operators shall comply with the following:

- Rated for a minimum duty cycle of 25%
- For open/close duty, stop immediately at any point in the valve travel when the stop button is pushed. The operator shall subsequently restart travel in the desired direction when the OPEN or CLOSED button is pushed.
- For modulating (throttling) duty, travel open or closed only as long as the corresponding pushbutton is held. The operator shall subsequently restart travel in the desired direction when the OPEN or CLOSED button is pushed.
- Be provided with local pushbutton control and local/remote valve position indication. Indication for quarter turn throttling valves shall, as a minimum, provide local and remote position indicators for closed, 1/4, 1/2, 3/4 and full open positions.
- Have epoxy encapsulated solenoid coils and motor windings where operators are installed on weather decks or in wet areas.

Valve operator electrical components installed on weather decks or in wet areas shall be fitted with watertight enclosures.

Remote operated valves shall be provided with a means of local, manual operation.

Expansion couplings shall not be located in tanks.

3.505.2 MATERIALS

Piping system materials shall be in accordance with Appendix G. Any piping system materials not specified in Appendix G shall be in accordance with ASTM F1155. System components and valves shall be accessible in accordance with ASTM F1166.

Mechanically attached fittings (MAFs) shall be prohibited.

3.505.3 FLOW VELOCITY

Fluid velocity limits shall be in accordance with Appendix G.

Unless otherwise specified, flow in piping systems shall meet minimum required inlet pressures of machinery, equipment, and components under maximum required flow conditions, and the inlet velocity limitations of installed machinery, equipment, and components.

3.505.4 SEACHESTS

Freshwater generating plants shall be supplied from a dedicated seachest(s). Seachests, with the exception of seachests serving fresh water generating plants, shall be provided with an electrolytic chlorine generator biofouling control system with feedback analyzer. The freshwater generating plant seachest(s) shall be located on the bottom shell. The freshwater generating plant seachest(s) shall be located forward of discharge connections to the maximum extent practical. Where it is not practical the seachest(s) shall be located on the opposite side of the ship from the forward discharge connection(s) and shall be approved.

Suction seachests shall be fitted with portable Monel or Type 316L stainless-steel strainer plates. Type 316L strainer plates shall be provided a marine-grade, epoxy, anticorrosive coating. Strainer plates shall be secured in place with Monel studs and nuts in such a manner as to be removable with no part projecting beyond the shell.

Means shall be provided to blank off the sea suction and underwater discharges to permit inspection of sea valves from inside the ship. Blanking plates or equivalent means of blanking hull penetrations shall be provided for each type of underwater hull penetration. A valved blowdown connection shall be provided at each suction seachest.

Sacrificial anodes shall be provided in seachests.

The seachests' seawater recirculation and heating requirements shall be in accordance with Baltic 1C environmental conditions.

3.506 OVERFLOWS, AIR ESCAPES, AND SOUNDING ARRANGEMENTS

Tank vents, air escapes, and raised sounding tubes shall have bolted flange connections above the deck at which they terminate.

Overflow lines terminating in overflow tanks shall be provided with overflow alarms. The overflow alarm shall sound via MCCS when an overflow condition to the overflow tank occurs.

Sounding tubes shall be of the raised type and shall have self-closing valves with vent cap and chain.

Sounding tubes shall be separate from TLIs.

The following tanks and spaces shall have a sounding tube:

- Fuel tanks
- Lube oil tanks
- Seawater ballast tanks
- Oily Waste Holding Tank(s) (OWHT(s))
- WO/ST(s)
- Voids
- Cofferdams

3.507 MACHINERY AND PIPING DESIGNATION AND MARKING

Designating and marking shall be in accordance with MSC QMS N0720-006.00-AQ.

3.508 THERMAL INSULATION FOR MACHINERY, EQUIPMENT, AND PIPING

Thermal insulation and lagging for piping, valves and equipment shall be provided in accordance with ASTM F683, except that the surface temperatures shall not be greater than 51°C (124°F).

3.509 THERMAL INSULATION AND ACOUSTIC ABSORPTIVE TREATMENT FOR DUCTING AND TRUNKS

HVAC systems shall be insulated to minimize condensation, external heat transfer, and noise.

Air conditioning preheaters, ducts, cooling coils, fans, and other equipment carrying chilled or recirculated air shall be completely insulated and installed with an approved vapor seal, unless condensation can be controlled by other means.

Acoustical treatment shall be provided to attenuate HVAC system generated noise. Where both thermal insulation and acoustic absorptive treatment are necessary, acoustic absorptive treatment only shall be provided.

Galvanized metal sheathing, guards, or other protection shall be provided in areas where insulation is exposed and may be subject to damage. Metal sheathing thickness shall be compatible with the area covered, but in no case less than 16 United States Steel Gauge (USSG) steel.

Fiberglass insulation exposed to air shall be lined. Lining shall be cleanable without deformation.

Air conditioning ducts which service the house shall not pass through machinery spaces.

3.512 HEATING, VENTILATION, AND AIR CONDITIONING

3.512.1 GENERAL

The ship's HVAC system shall be designed in accordance with SNAME T&R Bulletin 4-16 and the indoor climate control requirements per ABS HAB++ for manned spaces. Each air handler fan and coil shall have a 10% design margin. HVAC design temperatures shall be in accordance with Section 3.070.5.1.

The main machinery space shall be maintained at a minimum temperature of 10 °C (50 F). All other machinery spaces and non-air conditioned and unmanned spaces shall be provided with heating to maintain a minimum inside air dry bulb of 4.4 °C (40 F).

Variable flow systems are permissible as long as the system meets requirements of Section 3.407. Insulation shall be in accordance with the recommendations of SNAME T&R Bulletin 4-7.

The HVAC system shall provide automatic environmental control to meet the ship's heating, ventilation, relative humidity, and cooling loads. The HVAC system shall maintain compartments within the design temperature and humidity ranges specified herein. Preheating shall be provided by electric, auxiliary steam, or HVAC hot water. Reheating shall be provided by electric reheaters. Where spaces with either mechanical supply or recirculation systems require heating, heating shall be by means of duct type heaters with individually controlled room thermostats. Where sanitary spaces with natural supply require heating, heating shall be provided by convection heaters.

The Cable Highway, cable tanks, and machinery spaces shall be ventilated to a maximum temperature of 45 °C (113 F). The maximum air velocity in machinery spaces shall not exceed

17.8 m/s. The Cable Highway shall be provided heating to maintain a minimum temperature of 4.4 °C (40 F).

Repeater storage areas shall be HVAC controlled and shall maintain an interior dry bulb temperature between 3 °C (37 F) and 30 °C (86 F).

The Moonpool Staging Bay shall be HVAC controlled and shall maintain an interior dry bulb temperature between 4.4 °C (40 F) and 35 °C (95 F).

All workshops, electronic spaces, and clean power spaces shall be HVAC controlled and shall maintain an interior dry bulb temperature between 18.3 °C (65 F) and 26 °C (80 F). The Mission Electronics Storeroom, CHE Electrical Storeroom, and the Test and Transmission Storeroom shall be considered electronic spaces.

The Cable Highway shall be provided with spot cooling at the CHE control console and every 15 m port and starboard along the length of the Cable Highway. Each spot cooling location shall provide a minimum of 100 liters per second of cooling air at 27 °C (80 F).

All ventilated spaces except for machinery spaces shall be ventilated to limit temperature rise to 5.5 °C (10 F) above ambient temperature.

The Galley's exhaust system shall be ducted directly to the weather and interlocked with fire protection actuation. The amount of required air changes shall include exhaust hoods air requirements.

Ductwork and shapes shall be in accordance with ASTM F1005.

Ventilation louvers, screens, and dampers shall be constructed of corrosion resistant material.

Ventilation weather air intakes shall be located to avoid ingestion of fumes from the following:

- Tank vents
- Sump vents
- Galley Exhaust
- Diesel engine crankcase vents
- Ventilation exhaust terminals

Portable screens shall be provided for the ventilation weather inlets. The filter media shall have a Minimum Efficiency Reporting rating of 6. The screening shall be Type 316 stainless steel. The screens shall permit replacement of the disposable media. The screens shall permit replacement of the disposable media. A means to attach the screens shall be provided as follows:

- If there is weather deck access to the weather inlet connection and the supply fan takes

suction from a fan room serving as a plenum, the screen shall be installed on either the exterior or interior side of the weather inlet connection.

- If there is weather deck access to the weather inlet connection and the weather inlet is ducted to the supply fan, the screen shall be installed on the exterior side of the weather inlet connection.
- If there is no weather deck access to the weather inlet, the supply fan shall be installed in a fan room that also serves as a supply plenum and the supply fan shall take suction from the fan room. The screen shall be installed on either the interior side of the weather inlet connection or the inlet side of the supply fan.

3.512.2 AIR CONDITIONING (A/C) SYSTEMS

A/C systems shall be either individual air handling units or built-up systems consisting of a filter, evaporator, and a fan. A/C systems shall be remotely monitored from MCCS. The A/C systems shall be equipped with embedded diagnostic capability. The A/C systems shall be provided with filters with a Minimum Efficiency Reporting Value rating of 6 or higher. A/C system filters shall have locally monitored differential pressure gauges.

3.512.3 MACHINERY SPACE VENTILATION

Supply and exhaust fans shall be multi-speed. Supply and exhaust fans and dampers shall be controlled from the MCCS. Supply and exhaust fans and dampers shall be capable of being individually operated.

Enclosed spaces containing sewage treatment plant(s) (STP) shall be mechanically ventilated directly to the weather. A negative pressure differential shall be maintained in the STP Room with respect to adjacent spaces when the door is closed. The rate of air change in the STP Room shall be 10 air changes per hour. The space shall be equipped with an airflow alarm monitored by the MCCS.

Where two supply systems are used to serve a machinery space, the supply fans shall be located on the opposite sides of the ship, where practical. If both supply fans are on the same side, they shall be located as far apart as possible. The location of the supply fans shall be such that short-circuiting of exhaust air or stack gas is avoided. Heating, cooling, and ventilation of machinery and equipment shall be in accordance with equipment manufacturer's recommendations.

3.514 AIR CONDITIONING MACHINERY

The A/C machinery plants shall have a service life allowance of 15%.

The A/C machinery plants shall be of identical design and capacity. The A/C machinery plants shall supply 100% of the total A/C load with one A/C machinery plant in reserve. The A/C

machinery plants shall have freshwater cooled condensers. The A/C machinery plants shall have an automatic pump-down feature.

The A/C machinery plants shall operate automatically from 10% to 100% of rated capacity. The A/C machinery plants shall be sized according to the following criteria:

- Chilled water outlet temperature of 6.7 °C
- Chilled water inlet temperature of 12.7 °C
- Fresh water velocity in the tubes (maximum) of 1.8 m/s

A refrigerant pump-out capability shall be provided to service the A/C machinery plants. The refrigerant pump-out system shall be located adjacent to the A/C machinery plants. The refrigerant pump-out system shall be capable of evacuating refrigerant down to 500 microns from each A/C machinery plant. A pump-out tank shall be provided. The pump-out tank shall be sized for 120% of the refrigerant capacity of a single plant.

Spaces containing A/C machinery plants shall be provided with a refrigerant leak detection monitor. Sensor lines shall monitor the compartment and refrigerant leakage in and around the base of each A/C machinery plant. The monitor shall provide a warning inside and outside the space and remotely at MCCS. The monitor shall provide three levels of warning: at 500 ppm refrigerant detection shall provide an "Alert"; at 800 ppm "Danger"; and at 1,000 ppm "Evacuate" in the space being monitored.

Stowage racks shall be provided to hold sufficient amount of spare refrigerant bottles for charging a single A/C machinery plant. The stowage racks shall be located adjacent to the A/C machinery plants.

Integrated centralized addressable control and performance monitoring of A/C machinery plants and chilled water pumps shall be provided via the MCCS and with local indicators.

3.516 REFRIGERATION

3.516.1 GENERAL

A ship service refrigeration system shall be provided. The refrigeration plant shall operate automatically in response to demand and shall be provided with remote stop and monitoring capability via the MCCS. Each refrigeration plant condenser shall be fresh water cooled.

Each refrigeration plant shall have a dedicated receiver sized to store 120% of the total system refrigerant charge of its respective system. Each refrigeration plant receiver shall be provided with a liquid level indicator.

Spaces containing the refrigeration plants shall be provided with a refrigerant leak detection monitor that alarms audibly and visually inside the compartment, directly outside the compartment, and remotely via the MCCS. The monitor shall provide three levels of warning: at 500 ppm refrigerant detection shall provide an "Alert"; at 800 ppm "Danger"; and at 1000 ppm "Evacuate" in the space being monitored.

Stowage racks shall be provided to hold spare refrigerant storage bottles sufficient for charging the full refrigeration system. The stowage racks shall be located adjacent to the refrigeration plants.

A refrigerant pump-out system shall be provided to service the refrigeration plants. The refrigerant pump-out system shall be located adjacent to the refrigeration plants. The refrigerant pump-out system shall be capable of evacuating refrigerant down to 500 microns from each refrigeration plant. A pump-out tank shall be provided. The pump-out tank shall be sized for 120% of the refrigerant capacity of the system.

All plants shall use a refrigerant with an ozone depleting potential of zero and that are classified as Safety Group A1 per ASHRAE Std. 34.

3.516.2 SHIPS SERVICE REFRIGERATION SYSTEM DESIGN

The ship service refrigeration plants shall be identical, self-contained units. The ship service refrigeration system equipment shall be provided with remote stop and monitoring capability by the MCCS.

The refrigeration system shall maintain the design conditions of the boxes served with one plant off-line, with the average operating load of the running unit(s) not exceeding 75% in a 24-hour period. The system shall be sized to allow all plants to be online simultaneously during pulldown. Ship service refrigeration plants shall have sufficient capacity to "pull down" refrigerated compartments to design temperatures within 48 hours after loading.

The ship service refrigeration systems shall meet the design conditions listed in Table 3.516-1 and the following:

- Thaw Storeroom shall be maintained at the chill storeroom conditions.
- Infiltration heat load shall be included in the compartment cooling load.
- Ventilation air is not required during pull down conditions.
- The ventilation heat load and respiration heat load of refrigerated Food Service Storerooms shall be included in the compartment cooling load.
- The refrigeration systems shall perform such that under steady state conditions for the maximum load, the temperature difference between the dry-bulb temperature of the air entering the unit cooler and the saturation temperature corresponding to the refrigerant

pressure at the suction connection of the unit cooler is a maximum of 10 °C.

Table 16: [3.516-1] Refrigeration system design conditions

Condition	Chill Space(s)	Freeze Space(s)
Maximum steady state temperature, °C	2	-17.8
Minimum steady state temperature, °C	0.5	n/a
Product entering temperature, °C	13	-9
Maximum pull-down time (ship's storerooms), hours	48	48
Weight of product, kg/m ³ of usable volume	476	575
Specific heat of product, kJ/kg°C	3.56	1.67
Weight of packaging, kg/m ³ of usable volume	51	58
Specific heat of packaging, kJ/kg°C	2.72	2.72
Respiration (entering condition), kJ/day per kg of product as calculated above	7.44	n/a
Respiration (steady state), kJ/day per kg of product as calculated above	2.51	n/a

3.516.3 REFRIGERATED STORAGE COMPARTMENTS

Temperature sensors in refrigerated storerooms shall not be located next to the access doors. A minimum of two stainless-steel unit coolers shall be provided in each refrigerated storeroom. Unit coolers shall be bulkhead mounted or suspended from the overhead. Thermal breaks shall be provided to prevent thermal short circuits. Each unit cooler shall be sized for the steady state refrigeration load. Unit coolers shall be capable of being isolated for servicing of individual coolers. Each unit cooler shall have a stainless-steel drain pan and drain piping shall be provided.

Compartment drains shall be provided with P-traps and heat tracing. Compartment drains and unit cooler drains shall be independent of other drainage systems.

Each freeze unit cooler shall be provided with its own defrost timer to control the defrost cycle based on unit cooler operation. Freeze space unit cooler drain pans with an electric defrosting heater that is energized during the defrosting cycle and drain piping shall be insulated and heat traced. Doors to freeze spaces shall be provided with a means to prevent door gaskets from freezing.

3.521 FIREMAIN SYSTEM

A minimum of three equally sized fire pumps shall be horizontally mounted and segregated longitudinally between a minimum of three watertight subdivisions. The forward- and aft-most fire pumps shall be separated longitudinally to the maximum extent practical. The total fire pump capacity shall be capable of meeting the largest of the following demands with one fire pump offline:

- Regulatory body required firefighting services
- Washdown Countermeasure (WDCM) Demand
- Seawater sprinkling
- Aqueous Film Forming Foam (AFFF) system (if used)

The firemain shall supply the fire stations, seawater sprinkling systems, washdown, and countermeasure washdown. For other intermittent seawater demands (such as for anchor washdown) where seawater service from another source is not practicable, supply via a branch line at the discharge of the nearest fire pump is permitted if arranged to not require pressurization of the entire firemain. Pressurization of the firemain shall serve as the back-up supply for these services.

The firemain shall deliver a minimum design pressure of 689 kPa at each fireplug.

Motor operated isolation valves shall be remotely operated via MCCS. Motor operated isolation valves shall be provided at the junction of each fire pump supply riser with the main.

The firemain system shall be zoned and fitted with isolation valves. Firemain piping in the weather shall be fitted with cutout valves and drain valves. All firemain stations shall be fitted with cutout valves and drain valves. Freeze protection shall be provided for any wet portions of the firemain system in the weather and machinery spaces per Baltic 1C.

Seawater fire stations shall be equipped with 1-3/4 inch fire hoses with 1 1/2 inch, National Hose (NH) thread hose fittings. Fire hoses shall be fitted with 360 lpm, variable pattern, constant flow type, Akron Brass style 3020, NH thread nozzles or equal. Each fire station shall be fitted with a gated wye valve. Gated wye valves shall have 2 1/2 inch female NH threaded inlets and 1 1/2 inch male, NH threaded outlets. Gated wye valves shall have shutoff ball valves on each 1 1/2 inch outlet. The handles to the shut-off ball valves shall be brass.

Each fire station shall be equipped with two appropriate spanner wrenches, secured with clamps or clips and shall require no tools for removal. Fire hoses shall be stowed on racks or reels and be arranged for easy unobstructed removal. Hose racks and reels mounted in passageways shall be recessed. Hose racks mounted in the weather shall be located on the side of deckhouse and be enclosed in CRES cabinets recessed where practicable and arranged such that the isolation valve is located within the cabinet. All firehose cabinets shall be fitted with CRES hinges, anti-rattle latches, and snubbers. Fire hose cabinets shall be located to minimize impact by heavy seas.

In addition to the regulatory requirements, washdown coverage is required at:

- Stern Frame/Plow
- ROV LARS
- Moonpool Staging Bay

3.523 COUNTERMEASURES WASHDOWN

Clips and brackets shall be installed for attaching fire nozzles in washdown countermeasure position. The WDCM capability shall provide strategically located Vari-Nozzle hose clips built in accordance with MSC plan 123-6633920 “CBR-D Vari-Nozzle Hose Clip”. The clips and brackets shall be located so that spray coverage is obtained for lifeboat stations, weather decks, side deckhouse, housetop and bulkhead areas.

3.528 MAIN AND SECONDARY DRAINAGE SYSTEMS

The main drainage system shall consist of piping installed low in the ship with suction branches to spaces to be drained, and with direct connections to pump/eductors which shall discharge overboard via a swing check valve and gate valve located approximately one foot above the full load waterline. The suction main shall be the same size from the foremost to the aftermost pump/eductor. Extensions forward of the foremost and aft of the aftermost pump/eductor connections may be reduced in size to suit the drainage service required.

Secondary drainage systems shall be installed to supplement the main drainage system wherever the main drainage system cannot be extended to provide drainage because of interference of spaces through which the passage of piping is prohibited, or because the lengths of piping would be too great for efficient drainage. Each of these systems shall be independent of the main drainage system and shall have its own eductor and sea connections.

3.528.1 GENERAL

Gravity drain piping shall be pitched, relative to baseline, at least:

- 20 mm/m for drains running aft in the longitudinal direction
- 30 mm/m for drains running forward in the longitudinal direction
- 45 mm/m in the athwartship direction

Drains and vents shall be designed and installed in accordance with the International Plumbing Code (IPC) unless otherwise specified herein.

3.528.2 DECK DRAINS

Deck drains shall be provided to prevent accumulation of water on weather decks, in weather deck hatch coamings, spaces with false decks that have piping containing liquids, and wet areas.

Removable strainer plates shall be provided for deck drains. Strainer plates shall be brass, bronze or stainless-steel. Strainers for weather deck drains shall be of the flat surface type, installed flush with the deck. Strainers shall have an available inlet area of not less than two times the cross-sectional area of the pipe to which the drain is connected.

A deck drain shall be provided in each weather air supply and exhaust fan plenum. Plenum deck drains shall be located to prevent the accumulation and ingestion of shipping seawater, driving rain, and spray. Plenum drains may be combined with other weather deck drains.

Deck drains and freeing ports shall be provided to maintain the weather areas free of standing water. Freeing ports may be used in other locations. The use of mastic, underlayment compounds, or other nonstructural materials to pitch a weather deck to prevent the accumulation of water is prohibited. Means of containing fuel, oil, and grease run-off, such as coamings and catch basins, shall be provided in way of potential sources on the weather deck. Vent plenums, spill containment coamings, and other exterior areas where standing water can accumulate shall be fitted with a CRES ball valve and drain plug or cap with retaining chain.

Deck drains near the refueling station shall be provided with expandable plugs. The expandable plugs shall be provided with a tether at their location of use. The tether shall be provided with a clip to facilitate removal. Strainer plates shall be flush with the deck when the plug is installed and when the plug is removed.

Weather deck drains shall be a minimum diameter of 50 mm. Weather deck drains shall accommodate the equivalent rainfall per hour produced by the maximum countermeasure washdown flow in accordance with IPC. Decks exposed to weather without camber or sheer shall be provided with deck drains on both port and starboard extents of the entire deck area. Weather deck drains from the lowest weather decks shall run internally and discharge overboard at the ballast arrival water line.

Drain piping from upper levels shall discharge as near as practical to the deck drain on the deck below. Weather deck drain discharges shall not be located in way of manned equipment or across normal traffic routes between ladders, hatches, or doors. In these areas, drain piping may penetrate the deck or decks below, be combined with drains from the lower decks, or led forward or aft to prevent the accumulation of water.

3.528.3 PLUMBING DRAINS

Systems shall be provided to carry the discharge from plumbing fixtures, miscellaneous water users, and interior deck drains for disposal. Fixtures equipped with drains shall be provided with trap seals. No plumbing drains shall be combined with machinery space drains or oily waste/waste oil.

A/C cooling coils shall be provided with condensate drains. Condensate drains shall be fitted with seal traps and air gap covered funnels. Seal traps on condensate drains shall have sufficient

height of seal to prevent blowout by the fan system pressure. Condensate drains may be connected to plumbing drains or directed overboard as clean water drains, but they shall not be combined with machinery space drains or oily waste/waste oil. Condensate drain piping shall be insulated where required to prevent condensation.

3.528.4 CLEANOUTS

Cleanout connections shall be provided in accessible locations for drains. Cleanouts shall not be more than 15 m apart. Cleanouts shall be provided in drain piping at the second of every two changes of direction greater than 45°. Cleanouts shall be installed so that the cleanout opens in a direction opposite to the flow of the drainage. A minimum clearance of 500 mm shall be provided at the termination of cleanouts. Cleanouts shall not be installed in the hospital. If the installation of cleanouts in the overhead of living spaces, control spaces, electronics spaces, and electrical spaces cannot be avoided, the cleanouts shall either extend to the deck above or include a full port ball or plug cutout valve.

3.528.5 PLUMBING VENTS

Gray water gravity drains shall be vented. Trap seals of fixtures and deck drains shall be protected from siphonage or backpressure. Fixtures may be vented by means of air admittance valves constructed of non-corrosive material with replaceable neoprene flap-valves. Air admittance valves shall be accessible for maintenance. Vents terminating in the weather shall be located such that they are not subject to over pressure.

3.529 BILGE AND BALLAST SYSTEM

3.529.1 GENERAL

Bilge and ballast system piping shall be arranged with no low points, and pockets between suction tailpieces and pump suctions.

3.529.2 DEWATERING BILGE SYSTEM

A bilge system shall be provided that is capable of pumping from and draining each bilge. The bilge system shall be controlled and monitored from MCCS.

Bilge pumps shall be provided with vacuum priming by dedicated air-driven ejectors. The vacuum priming ejectors shall be capable of priming the suction line in no more than three minutes. The vacuum priming ejectors shall be configured for local manual operation and remote automatic operation via MCCS. The MCCS shall alarm when priming has not been achieved within the specified time.

Each bilge pump shall be provided with a simplex suction strainer. Bilge wells in machinery spaces shall be fitted with strainer plates.

3.529.3 BALLASTING/DEBALLASTING

A ballast system shall be provided to fill and empty the seawater ballast tanks separately and simultaneously. The ballast system shall be operated locally and remotely via the MCCS. The ballast system shall be capable of maintaining the ship within the limits of trim, list, and stability as specified herein, and within the structural limits of the ship without requiring intra-ship transfer of other loads.

The internal arrangements of seawater ballast tanks and ballast water piping inlet and outlet arrangements shall be in accordance with IMO Resolution MEPC.209(63).

A USCG approved ballast water treatment system shall be provided. The treated ballast water shall be compatible with the seawater ballast tank coating specified herein.

3.531 FRESHWATER PRODUCTION AND SERVICE

Two freshwater generating plants shall be provided to produce potable and distilled water. Each freshwater generating plant shall selectively discharge to the ship's potable or distilled water tanks. Freshwater generating plants shall be capable of operating simultaneously at rated capacity.

If freshwater generating plants utilize waste heat, booster heaters shall be provided to supplement the waste-heat freshwater generating plants as needed for simultaneous operation at rated capacity in low load conditions.

The seawater sides of heat exchangers shall be provided with valved freshwater flushing and drainage connections.

Each fresh water generating plant shall have a freshwater production capacity equal to the daily demand plus a 10% margin. The total daily freshwater demand for each plant shall incorporate the following:

- 230 L per accommodation
- 8 L per accommodation for sanitary flushing
- 190 L for cooling water system makeup
- 3,000 L for mission loads

The freshwater generating system shall produce water with pH between 6.5 and 8.0.

A dedicated distilled water system, tanks and pumps shall be provided to provide technical water engine make-up jacket water, purifier sealing water, cooling water to electrical or electronic equipment, watermist, and lithium battery/small arms magazine sprinkling head tanks. A

distilled and potable water fill line shall be fed to the chill water make up and freshwater cooling systems. Distilled and potable water tanks shall have shore fill connections. Distilled water tanks shall not be disinfected or cross connected to potable water tanks.

Where reverse osmosis units are provided, additional second pass membranes shall be provided for technical services water.

3.532 FRESH WATER SERVICE SYSTEMS

3.532.1 CHILLED WATER SYSTEM

The chilled water system shall have service life allowance of 15%. The chilled water system shall circulate freshwater through the A/C machinery plants to A/C cooling coils and fan coil units located throughout the ship. The system operation shall be controlled and monitored via the MCCS. The system distribution piping shall be zoned to match the ventilation zones. The system shall be provided with automatic high point air vents and manual low point drains.

A chilled water pump shall be provided for each A/C machinery plant. The chilled water pumps shall provide a minimum discharge head of 2 bar differential at the highest, most remote service coil or load.

Chilled water cutout valves shall be provided in the supply and return mains to isolate each chilled water zone and other service branches 50 mm in diameter and above.

Three-way control valves shall be provided to bypass flow to the main when individual A/C cooling coils are not actuated. A wye-type strainer with a blow-down valve shall be provided upstream of the three-way control valve. Constant flow fittings, three-way control valves for balancing the water flow through the coils and isolation valves on the supply and return for each piping branch shall be provided. Cooling coils shall be provided with isolation valves. Coils shall be equipped with manual vents and drain valves piped to a deck drain via a funnel with a 25 mm air gap.

The system shall have a pneumatic compression-type expansion tank located adjacent to the A/C machinery plants. The tank shall accommodate expansion from 0 °C to 49 °C of the entire system capacity plus a 10% margin. The expansion tank shall maintain a minimum of 34.5 kPa throughout the system under all operating conditions. The expansion tank shall be provided with a vacuum relief valve, a pressure relief valve, and a sight glass. A low-level alarm shall be provided and activate locally and via the MCCS at 10% expansion tank capacity.

A chilled water fill connection with backflow preventer shall be provided for refilling the expansion tank and chilled water system from the freshwater system. The fill connection shall be located adjacent to the A/C machinery plant.

A dedicated connection with a globe stop check valve shall be provided at the chilled water pump suction header for adding chemical treatment. A chilled water sampling connection shall be provided adjacent to the A/C machinery plants.

Chilled water supply and return shore connections shall be provided. The shore connections shall be sized based on the capacity of one of the ship's A/C machinery plants. The chilled water system shall be configured to provide the following capabilities:

- Circulate shore chilled water to the ship's chilled water loads using the ship's chilled water pumps
- Circulate shore chilled water to the ship's chilled water loads using the circulating pumps of the shore supply
- Isolate the ship's A/C machinery plants when chilled water is supplied from shore

3.532.2 FRESHWATER COOLING SYSTEMS

Freshwater cooling heat exchangers shall have a 10% service life allowance.

A dedicated connection with a globe stop check valve shall be provided at the freshwater cooling pump suction header for adding chemical treatment.

3.532.2.1 LOW TEMPERATURE FRESHWATER COOLING SYSTEM(S)

A freshwater cooling system(s) shall be provided to supply the water-cooled equipment loads within the main machinery space(s), AMR(s), and other equipment. The LTFW cooling water systems shall be arranged in independent closed loops.

Diesel engines shall be provided with LTFW cooling water systems and in accordance with manufacturer's recommendations. Each engine's LTFW cooling water system shall be capable of isolating service to and from each engine without affecting the cooling of the remaining engines.

All water-cooled mission equipment loads shall be cooled using the freshwater cooling system(s).

3.532.2.2 HIGH TEMPERATURE FRESHWATER COOLING SYSTEM(S)

Diesel engines shall be provided with HTFW cooling water systems and in accordance with manufacturer's recommendations. Each engine's HTFW cooling water system shall be capable of isolating service to and from each engine without affecting the cooling of the remaining engines.

3.532.3 COOLANT WATER DRAINS

A dedicated system shall be provided for drainage, collection, and transfer of coolant water from the freshwater cooling system and engine cooling water systems. The system shall gravity drain to a dedicated coolant water drain tank. The drain tank capacity shall hold the entire cooling system volume of the two largest diesel engines.

A dedicated discharge pump shall be provided to transfer the drain tank contents selectively to a shore connection or to return the coolant to its system. The pump shall discharge the total tank volume to shore within two hours.

3.533 POTABLE WATER SYSTEMS

3.533.1 GENERAL

The potable water systems shall be in accordance with the IPC and USPHS Publications No. 393 and No. 68.

3.533.2 BROMINATION SYSTEM

A bromination system(s) shall be provided for the potable water systems. Proportioning brominators shall treat the output from each freshwater generating plant prior to entering the potable water tanks. Proportioning brominators shall also be provided to treat water stored in the ship's potable water tanks by means of tank-to-tank recirculation.

3.533.3 SHIP'S POTABLE WATER

Hot and cold potable water systems shall be provided. Isolation valves shall be provided to segregate service to decks and main sub-divisions. Potable water shore connections shall be provided. The system shall be capable of receiving and discharging through the shore connections.

A minimum of two equally sized potable water storage tanks shall be provided. The minimum combined total capacity of the tanks shall be 7-day supply based on the total daily freshwater demand plus a 5% margin. The tanks shall be cross connected with a manual shutoff in the cross connect piping.

3.533.3.1 COLD POTABLE WATER SYSTEM

The cold potable water system shall provide water from the potable water tanks to the hot potable water system and to cold potable water system fixtures and services. The system shall include two pumps of equal capacity and a hydro-pneumatic tank. Each pump shall supply the entire system demand with the other pump on standby.

Potable water used as make-up to freshwater systems shall have a maximum chlorine content of 40 ppm and a maximum conductivity of 150 $\mu\text{S}/\text{cm}$.

Point-of-use filters with replaceable elements (for improving taste and odor) shall be provided at drinking water fixtures, ice makers, beverage dispensers, and coffee makers.

Potable water hose bibbs shall be provided at the following locations:

- On the Bridge Wings (if not fully enclosed)
- In the vicinity of the lifeboats
- In the vicinity of the Rigid Hull Inflatable Boats (RHIBs)
- At each level of the machinery spaces
- At each ship's crane
- In the vicinity of refrigerated spaces
- In the vicinity of the solid waste processing facility
- On each weather deck level with sufficient number of bibbs to provide complete coverage using a 20 m length hose
- ROV LARS
- On the Cable Highway and Moonpool Staging Bay with sufficient number of bibbs to provide complete coverage using a 20 m length hose

All hose bib outlets shall be provided with backflow preventers, drains, and cutout valves.

3.533.3.2 HOT POTABLE WATER SYSTEM

A centralized hot water system shall be provided. The hot potable water system shall provide water at 49 °C within 10 seconds at fixtures and services. A minimum of two hot water heaters shall maintain potable water at 59 °C. Each hot water heater shall be capable of providing 100% demand. Hot water circulating loops shall be provided in accordance with the American Society of Plumbing Engineers Domestic Water Heating Design Manual. Recirculation pump(s) shall be controlled by thermostat(s).

Water heaters shall have storage and recovery capacities in accordance with ASHRAE Handbook - HVAC Systems and Equipment using the following classifications:

- Accommodation spaces shall be classified as motel units.
- Food service areas shall be classified as Type A, full-service.

Dedicated hot water loops and water heaters shall be provided for the food service area and Ship's Laundry. Water heaters shall be located in the vicinity of the spaces they serve.

3.541 SHIP'S FUEL SYSTEMS

3.541.1 GENERAL

A ship's fuel system shall be provided and designed to allow operation in Emission Control Areas (ECAs) with Ultra Low Sulfur Fuel Oils (ULSFO) Distillate Marine (DM) and ISO Global Fuel operating areas with Very Low Sulfur Fuel Oils (VLFSO) DM. Main and auxiliary machinery shall be selected to operate and be compatible with the following fuel grades:

- ASTM D975 Grade No. 2-D S15 diesel fuel (60 °C minimum flash point)
- Naval Distillate Fuel in accordance with MIL-DTL-16884P (60 °C minimum flash point)
- ISO 8217:2017 DMA, (60 °C minimum flashpoint) with regulatory and statutory limitations on sulfur limits for ISO 8217 DMA. Sulfur limits shall be:
 - Ultra Low Sulfur Fuel Oils (ULFSO) DM (MGO ≤ 0.1% S ECA Fuel)
 - Very Low Sulfur Fuel Oils (VLFSO) DM (MGO ≤ 0.5% S Global Fuel)

The ship's fuel system shall consist of tanks, a fuel fill and transfer system, fuel purification systems, fuel service systems, overflow systems, and a fueling station(s) for the workboat and rescue boat.

The system shall be designed for segregation of two independent fuel(s) types considering ECAs and ISO Global Fuel via locked closed valves that allow the system to be combined and merged to one combined fuel system via locked closed valves.

3.541.2 TANKS

The ship's fuel system shall be provided with storage tanks, settling tank(s), service tanks, overflow tanks, and clean and dirty leak-off tanks. Suction tailpipes shall be fitted with non-vortex bellmouths. Ship's fuel settling tank(s) shall have a total minimum capacity equal to the combined capacity of the service tanks serving propulsion engines, propulsion generator engines, and ship service generator engines. The service tanks shall have a combined capacity of at least 24 hours at a Maximum Continuous Rating of the propulsion plant and normal operating load at sea of the generator plant.

Storage, settling, service, and overflow tanks shall be arranged to allow the management and segregation of the two independent fuel types. The independent and segregated fuel systems shall be provided with the ability to combine both fuel types into one combined system and tanks. Segregation is not required for overflow tank(s).

Settling and service tanks shall be arranged to promote separation of water from fuel. Settling and service tanks shall be provided with a means of draining water from the bottom of the tanks. Tank drain connections shall be fitted with globe valves in series with spring-loaded, self-closing valves, and threaded caps. Drain connections shall terminate at funnel drains. Funnel drains shall be hard-piped to the WO/ST and shall be sized for the maximum continuous flow from the drain.

All fuel oil tanks shall be provided with high level, high-high level, and low-level alarms that activate locally, and via the MCCS.

A clean leak fuel tank shall be provided in each machinery space in which a diesel engine is installed with the exception of the EDG room. Engine clean leak fuel shall be led to the clean leak fuel tank(s). The clean leak fuel tank(s) shall be sized for 200% of the maximum clean leak fuel of the engines served by the tank during a 24-hour period. A high level and a high-high level, alarm shall be provided and activate locally and via the MCCS.

A dirty leak fuel tank shall be provided in each machinery space in which a diesel engine is installed with the exception of the EDG room. Engine dirty leak fuel shall be led to the dirty leak fuel tank(s). The dirty leak fuel tank(s) shall be sized for 200% of the maximum dirty leak fuel of the engines served by the tank during a 24-hour period. A high level and high-high level, alarm shall be provided and activate locally and via the MCCS.

An incinerator service tank shall be provided in the Incinerator Room. The incinerator service tank shall be sized for 12 hours of normal incinerator fuel consumption. Means shall be provided to selectively drain the incinerator service tank to the WO/ST, to the settling tank, or to the clean leak fuel tank. A high level and high-high level, and low-level alarms shall be provided and activate locally and via the MCCS.

3.541.3 FUEL FILL AND TRANSFER SYSTEM

A fuel and transfer system shall be provided. The fuel fill and transfer system shall have port and starboard shore connections and fill any storage tank. The ship's fuel shore connections shall be capable of refueling all fuel tanks in eight hours and receiving ship's fuel at a minimum rate of 3.8 m³/min (1,000 gpm), whichever is more stringent and at a riser pressure of 276 kPa. The connections shall terminate in a 200 mm flanged gate valve(s). The outboard flange of the gate valve(s) shall connect to a 200 mm blind flange. A service air connection and pressure gauge shall be installed at each fuel shore connection.

The fuel fill and transfer system shall be provided a minimum of two main fuel transfer pumps and two auxiliary fuel transfer pump.

The main fuel oil transfer pumps shall:

- Transfer from any storage tank to either fuel oil shore connection
- Transfer from any storage tank to any other storage tank with locked closed valves for fuel segregation and redundancy for up to two different fuel types
- Transfer from any storage tank to the settling tank(s) with locked closed valves for fuel segregation and redundancy for up to two different fuel types

- Transfer from any storage tank to any service tank with normally locked closed stop-check valves
- Transfer from any settling tank(s) to any storage tank via normally locked closed stop-check valves
- Transfer from any settling tank(s) to any service tank via normally locked closed valves
- Transfer from the overflow tank to any settling or storage tanks via normally locked closed valves
- Transfer fuel from any service tank to any storage tank via normally locked closed stop-check valves
- Transfer fuel from the clean leak fuel tank(s) to the storage tanks

The auxiliary fuel oil transfer pumps shall:

- Transfer fuel oil from the service tank(s) to the emergency generator service tank, incinerator service tank, and the fueling station(s) for fast rescue boat and workboat
- Transfer fuel from the settling tank(s) to the emergency generator service tank, incinerator service tank, and the fueling station(s) for workboat and rescue boat via a normally locked closed stop-check valve
- Fitted with a remote means of starting and stopping at each tank and fueling station
- Have a backpressure regulating valve installed to protect the pump from overheating

The emergency generator service tank and incinerator service tank shall have a sight glass fitted to each tank. The remote means for starting and stopping the auxiliary fuel oil pump shall be positioned so the operator has an unobstructed view of the sight glass.

The capacity of each main fuel transfer pump shall be a minimum of four times the ship's full power fuel consumption.

Powered actuators for the fuel tank fill valves shall be capable of throttling the valves from fully opened to fully closed. Remote control and operation of the fuel fill and transfer system shall be provided via the MCCS.

3.541.4 FUEL PURIFICATION SYSTEMS

The fuel purification system shall be served by a minimum of two equally sized, self-cleaning, centrifugal type purifiers. Each purifier shall purify fuel at a rate no less than 120% of the ship's full power fuel consumption with one purifier in reserve and shall be capable of operating in parallel and at all flow rates via back pressure regulation and recirculation to the purifier inlet or segregated for operation via two independent fuel types at all flow rates. The fuel purification system shall be capable of re-circulating fuel in the ship's fuel service, settling, and storage tanks.

The purifiers shall also be capable of the following:

- Transfer fuel from the settling tanks(s) to any service tank via normally locked closed valves
- Transfer fuel from any storage tank to any service tank via normally locked closed valves

The purifiers and main fuel oil transfer pumps shall be capable of operating simultaneously.

Each purifier, tank, and fuel system shall be monitored at the MCCS and provided local instrumentation.

Sludge tanks are required for each purifier. The purifiers shall discharge contaminants to the sludge tank(s). Means shall be provided to transfer sludge tank(s) contents to the WO/ST(s). A workbench with tool rack, vise, and rail and hoist system for handling purifier bowls shall be provided. The workbench shall be fitted with a stainless-steel deep basin. The basin shall have the capability to drain to either the WO/ST(s) or to a 20 L container. The sides and back of the workbench top shall be fitted with a splashguard.

3.541.5 FUEL SERVICE SYSTEMS

The fuel service system shall supply fuel from the fuel service tanks to fuel consuming equipment. Service tank suction tailpipes shall be provided with sampling connections fitted with globe valves and threaded caps. Sample connections shall allow filling of a 1 L sample bottle. Sample connections shall be provided with containments. Containment drains shall be hard piped to the WO/ST. The fuel service system shall also return excess fuel from fuel consuming equipment to the associated service tank. Each fuel return line shall be provided with a check valve to prevent back flow of fuel to secured equipment.

Where two or more fuel service tanks are provided for one piece of equipment, tank cutout valves shall be provided in the return lines to each fuel service tank. Relief valve protection shall be provided around one of the tank cutout valves to prevent backpressure in the recirculating line in the event of closed return line valves. Pressure setting of the relief valve shall not affect the operation of the equipment. The fuel suction from each service tank shall provide a means for isolation in addition to required remote means of emergency closure.

Mass flow meters shall be provided for measuring total ship fuel consumption and individual engine fuel consumption with compensation for fuel re-circulation and normal fuel leak-off. Total ship fuel consumption and individual engine fuel consumption shall be monitored via the MCCS.

A remote means of isolating the fuel supply and spill (return) piping to individual engines shall be provided. The isolation of one engine shall not affect the operation of all other engines.

The means of isolation shall be operable both locally, and from a readily accessible, safe position outside of the space in which the engine is located.

A means shall be provided to maintain the temperature of the fuel being supplied to the engines below 45 °C or as recommended by the engine manufacturer(s), whichever is lower.

3.541.6 WORKBOAT AND RESCUE BOAT REFUELING STATIONS

A fueling station(s) shall be provided to refuel the workboat and rescue boat. The location and hose length of the fueling station(s) shall permit the workboat and rescue boat to be refueled in their stowed location. The workboat and rescue boat fueling station(s) shall be provided with a hose reel in accordance with ASTM F1347 Type 4, hose and a self-regulating fuel dispensing nozzle (without hold-open means). Flow rate at the nozzle shall be a minimum of 11.4 lpm at 34 kPa. A means of preventing the over pressurization of each fuel hose upon securing the fuel dispensing nozzle shall be provided. A means to contain spilled fuel shall be provided under the fueling station hose reel(s).

3.541.7 TANK VENTING AND OVERPRESSURIZATION PROTECTION

The ship's fuel service tanks serving the propulsion engines, propulsion generator engines, and ship service generator engines shall overflow to the ship's fuel settling tank(s). The settling(s), storage, and all the remaining service tanks shall overflow to the fuel overflow tank via an overflow main. Overflow pipes shall connect to the overflow main through the top via goosenecks. Height of overflow pipe goosenecks shall be located above the top of the overflow main and overflow tank.

3.541.8 FUEL STRIPPING SYSTEM

A fuel stripping system shall be provided. An independent stripping tailpipe shall be provided for each fuel storage tank, dirty fuel leak-off tank, fuel settling tank, and fuel service tank. Each tailpipe shall terminate in the lowest portion of the tank. Each stripping tailpipe shall connect to the stripping pump suction header. Each stripping tailpipe shall be sized for the maximum flow rate of a single fuel stripping pump.

Two fuel stripping pumps shall be provided. The fuel stripping pumps shall be connected in parallel to their respective suction and discharge headers. The stripping pumps shall take suction from the stripping tailpipes, via the manifolds or cutout valves and from the fuel service pump suction headers via locked closed stop-check valves. The pumps shall discharge to the WO/ST, settling tank, and the fuel transfer system via normally closed locked stop-check valve.

3.551 COMPRESSED AIR SYSTEMS

3.551.1 GENERAL

Compressed air systems shall be provided for mission systems, diesel engine starting air systems, instrument and control service, and other general ship services. Each compressed air system shall supply the total demand for the services supplied by that system that operate simultaneously at the quantities and pressures required.

Each receiver shall be provided with an automatic and valved bypass drain valve at its lowest point. Air treatment shall be provided as necessary to supply air to services at the following pressure dew points:

- Starting air: 4 °C
- Ship's service air (heated space): 4 °C
- Ship's service air (weather deck and unheated space): -40 °C
- Control air: -40 °C

The location and arrangement of air inlets for air compressors shall prevent combustible vapors, smoke, dirt, grit, water, or other contaminants from entering compressors.

Piping low point drains shall be provided. Dead-end piping shall be prohibited.

Isolation valves shall be provided to segregate service to decks and main sub-divisions. Valves shall be provided to permit isolation of portions of the air systems for the purpose of maintenance. The isolated portions of the air system shall be provided with means of bleeding down the air pressure.

The start air system shall cross connect to the ship's service and control air systems via a pressure reducing valve.

3.551.2 STARTING AIR

Where air starting of engines is recommended by an OEM, a starting air system(s) shall be provided. Identical make and model compressors shall be provided to supply air for starting of the engines, as necessary. The compressors shall be provided with lead/lag/unload control features.

Remote control and operation of the system shall be provided via the MCCS.

3.551.3 LOW PRESSURE AIR

At least two identical make and model rotary compressors shall be provided to supply air for ship's service and control air services. The compressors shall be rated for continuous operation. The compressors shall be provided with lead/lag/unload control features.

Remote control and operation of the system shall be provided via the MCCS.

3.551.3.1 SHIP'S SERVICE

An 860 kPa (125 psi) ship service system with dedicated air receiver(s) shall be provided for the Low Pressure (LP), operation of pneumatic tools and equipment, and for general use throughout the ship. Total receiver volume shall equal a minimum of 20% of the capacity (normal liters per minute) of one ship service air compressor. The following spaces shall be provided with ship service air stations:

- Workshops - The number of stations in each workshop shall provide complete coverage of the workshops using a 10 m length of hose.
- Machinery spaces - A minimum of two stations shall be provided on each level of the machinery spaces. The number of stations on each level of the machinery spaces shall provide complete coverage of the level using a 30 m length of hose.
- Main engines - A minimum of one station shall be provided with a 25 mm diameter hose connection adjacent to the main engines.
- Weather decks - The number of stations shall provide complete coverage of the weather decks using a 30 m length of hose.
- Fan rooms - The number of stations in each fan room shall provide complete coverage of the fan room using a 10 m length of hose.
- Exterior decks - The number of stations on exterior decks shall provide complete coverage of the deck using a 30 m length of hose.
- Shore fueling connections - One connection adjacent to each shore connection station
- Cable highway, Moonpool Staging Bay, and aft working deck - The number of stations on the cable highway shall provide complete coverage of the deck, port and starboard, using a 15 m length of hose.
- Plow and ROV Workshop
- Cable Gear Storeroom
- Splice shop
- Aft working deck, multiple locations on port and starboard
- Container locations
- Projector Room

Each station shall consist of a cutout valve, pressure regulator, relief valve, pressure gauge, filter, moisture separator, lubricator, and two quick disconnect fittings. One ship set of 30 m, 15 m, and 10 m hoses shall be provided with quick disconnect fittings for use with the ship service air stations. The air supply to one of the quick disconnect fittings shall bypass the lubricator to provide air for general use. The pressure regulators of air stations shall be adjusted to provide a minimum of 620 kPa (90 psi) at the air inlet connection of the tools.

Means shall be provided for compression tank charging and seachest blowout. Lubricators shall not be provided for compression tank charging and seachest blowout.

Ship service shore connections shall be provided. The connections shall be sized equal to the capacity of an LP air compressor.

3.551.3.2 CONTROL AIR

Control air shall be supplied from a dedicated air receiver, providing oil-free (maximum 5 ppm) air to control services as needed.

3.551.4 BREATHING AIR COMPRESSOR SYSTEM

A breathing air compressor system shall be provided for refilling 60-minute, high pressure Self-Contained Breathing Apparatus (SCBA) cylinders. The breathing air compressor system shall be located in a dedicated Breathing Air Compressor Room.

The breathing air compressor system shall consist of a compressor, containment fill station with a cascade filling system, and storage cylinders.

The breathing air compressor shall be equipped with low voltage release type controllers. The compressor shall be rated at a minimum of 450 normal liters per minute free air delivery at 41,300 kPa (6,000 psi). The compressor shall produce Compressed Gas Association Grade E air. The compressor shall be equipped with an hour meter, start/stop automatic air pressure switch with indicator light, discharge temperature gauge, high temperature shutdown switch, low oil pressure shutdown, discharge check valve, pressure maintaining valve, emergency stop button, automatic condensate drain system, and final purification filter system. The compressor inlet shall not be adjacent to ventilation exhaust terminals.

A carbon monoxide monitor, alarm, and automatic shut-down shall be provided on the discharge side of the air compressor. The carbon monoxide alarm shall be connected so as to secure the compressor if carbon monoxide limits are exceeded.

The containment fill station shall be in accordance with NFPA 1901. The station shall include a cascade control panel, adjustable regulator, air sample outlet port, relief valve, fill hoses with bleed valves, inlet pressure gauge, outlet pressure gauge, and a safety door interlock. The relief valve shall ensure SCBA cylinders cannot be pressurized above 33,000 kPa (4,786 psi). The containment fill station shall provide the capability to simultaneously fill up to three SCBA cylinders selectively from the compressor or the cascade storage cylinders.

The breathing air compressor system shall provide the capability to fill SCBA cylinders in the containment fill station from one bank of cascade storage cylinders while simultaneously charging the other bank from the compressor.

The storage cylinders shall be rated for a working pressure of 41,300 kPa (6000 psi) with a safety factor of 3:1 in accordance with the ASME Boiler and Pressure Vessel Code (BPVC). Total free air capacity of the storage cylinders shall be a minimum of 108 m³ arranged in two equal cylinder banks of equal volume. Individual storage cylinder free air volume shall be a minimum of 13.5 m³.

Shipyard installed piping, valves and fitting materials shall be Type 304L or Type 316L stainless-steel. Piping shall be seamless type.

3.555 FIREFIGHTING SYSTEMS

The following spaces shall be protected by either a fixed flooding system in accordance with NFPA 2001, or a seawater sprinkling fire suppression system:

- Solid Waste Processing Facility
- Non-flammable Hazardous Materials Storeroom
- Used Hazardous Materials Storeroom
- Gas cylinder (flammable) storage area
- Flammable Liquid Storeroom
- Paint Locker
- Pyrotechnic Storeroom

Fire dampers shall be installed as required by regulatory bodies with dampers of stainless-steel construction and fitted with an indicator to show the position of the damper blade. Access shall be provided for the purpose of damper inspection.

3.555.1 FIXED FLOODING SYSTEMS

Fixed flooding systems shall be in accordance with NFPA 2001, USCG, and SOLAS.

The use of carbon dioxide in total space flooding systems is prohibited.

The fire suppression system activation shall be interlocked with the ventilation system. The fire suppression system activation shall shut down the ventilation fans and shut the ventilation dampers.

Propulsion motors and thruster motors (where provided) with enclosed ventilating systems shall be provided with a fixed flooding system for the motors.

3.555.2 MACHINERY SPACE FIREFIGHTING

Category A machinery spaces shall be provided with a bilge fire suppression system that provides coverage over the entire tank top or bilge.

Fixed, water-based, local application fire extinguishing systems shall be provided to protect the fire hazard portions of the Main Engines, Ship Service Generators, Emergency Diesel Generator, and the Fuel Oil Purifiers. The system shall meet the performance criteria specified by IMO in MSC/Circ. 913 and shall be capable of being actuated both automatically and manually.

3.555.3 GALLEY FIRE SUPPRESSION

Galley grease extraction hoods shall be provided with a fire suppression system. A remote manual actuation mechanism for the galley fire suppression system shall be provided outside the entrance of the galley. The activation of the galley fire suppression system shall:

- De-energize the galley ventilation hoods
- De-energize all equipment served by the galley ventilation hoods
- De-energize the galley supply intake and exhaust fans
- Close the galley supply and exhaust dampers

An aqueous potassium carbonate system listed by Underwriters' Laboratories shall be provided for each deep fat fryer (if applicable). A local manual actuating mechanism for the deep fat fryer fire extinguishing system shall be provided within the galley. A remote manual actuating mechanism for the deep fat fryer fire extinguishing system shall be provided outside the entrance to the galley.

3.555.4 FIRE EXTINGUISHERS

Extinguishers on weather decks shall be provided in weathertight enclosures.

Extinguishers on weather decks shall be provided. Extinguishers on weather decks shall not have loose tags.

At a minimum, the following portable fire extinguishers shall be provided:

- Foam fire extinguishers
- Carbon dioxide fire extinguishers
- Carbon dioxide hose reel extinguishers
- Dry chemical fire extinguishers

In addition to fire extinguishers required by regulatory bodies, CO₂ hose reels shall consist of two 45 kg CO₂ cylinders and one 34 m reeled hose with horn and valve assembly. CO₂ hose reel extinguishers shall be provided in each of the following locations:

- Switchboard room(s)

- Power conversion room(s)
- Thruster machinery room(s)
- Each level in the main machinery space(s)
- Each level with power distribution transformer(s), motor control center(s), or power conversion equipment in AMR(s)

3.555.5 SMALL ARMS MAGAZINE SPRINKLING SYSTEM

An automatic dry-type magazine sprinkling system shall be provided. Remote system activation and shutoff shall be via the MCCS. Local manual system activation shall be provided via pushbutton adjacent to the Small Arms Magazine.

The system shall be supplied from a head tank and the firemain. The head tank shall provide a 10-minute supply of fresh water to the sprinklers. The head tank shall maintain pressure up to the sprinkling release valve. The head tank shall supply the Small Arms Magazine sprinkling until seawater is provided by the firemain. The firemain supply to the Small Arms Magazine sprinkling shall bypass the head tank. The freshwater system shall fill the head tank.

The sprinkling rate shall be 32.6 lpm/m² of overhead area where the molded deck height is 2.4 m or less. Where the molded deck height exceeds 2.4 m, 13.4 lpm/m³ based on additional gross volume shall be provided. The minimum pressure provided at each sprinkling nozzle shall be 100 kPa.

The head tank shall have the capability of being drained overboard. The head tank shall be equipped with an inspection port. A low-level alarm shall be annunciated via MCCS with an independent local audible alarm when the head tank level is less than 95% full.

The sprinkling release valve shall be a motor operated ball valve located within the skin of the vessel.

A water switch shall be provided on the underside of a horizontal run of piping immediately downstream of the sprinkling release valve. Activation of the water switch shall initiate a Small Arms Magazine Sprinkling Alarm. The Small Arms Magazine Sprinkling Alarm shall be annunciated via MCCS with an independent local audible alarm.

The sprinkling system alarms, distribution piping, and nozzles shall be in accordance with publications NAVSEA OP 4 and NAVSEA S9522-AA-HBK-010 except as specified herein.

3.555.6 LITHIUM BATTERY ROOM SPRINKLING

An automatic, dry-type, Lithium Battery Room sprinkling system shall be provided. Remote system activation and shutoff shall be via the MCCS. Local manual system activation shall be provided via pushbutton adjacent to the Lithium Battery Room.

The system shall be supplied from a head tank and the firemain. The head tank shall provide a 10-minute supply of fresh water to the sprinklers. The head tank shall maintain pressure up to the sprinkling release valve. The head tank shall supply the Lithium Battery Room sprinkling until seawater is provided by the firemain. The firemain supply to the Lithium Battery Room shall bypass the head tank. The freshwater system shall fill the head tank.

The sprinkling rate shall be 10.2 lpm/m² of overhead area. The minimum pressure provided at each sprinkling nozzle shall be 172 kPa.

The sprinkling release valve shall be a motor operated ball valve.

The head tank shall have the capability of being drained overboard. The head tank shall be equipped with an inspection port. A low-level alarm shall be annunciated via MCCS with an independent local audible alarm when the tank level is less than 95% full.

A water switch shall be provided on the underside of a horizontal run of piping immediately downstream of the sprinkling release valve. Activation of the water switch shall initiate a Lithium Battery Room Sprinkling Alarm. The Lithium Battery Room Sprinkling Alarm shall be annunciated via MCCS with an independent local audible alarm.

3.556 HYDRAULIC SYSTEMS

Hydraulic oil coolers shall be fresh water cooled. All hydraulic fittings and piping exposed to the weather shall be CRES 316. Common filter elements shall be utilized to the maximum extent practical. The hydraulic system(s) shall use a common fluid to the maximum extent practical. The need to carry multiple hydraulic fluids on board for make-up or maintenance purposes shall be avoided.

3.562 STEERING SYSTEMS

The steering system shall be selected to meet noise, maneuvering, and DPS requirements and shall be configured to accept control from the DPS. Heaters shall be provided for hydraulic oil reservoirs. Hydraulic oil coolers shall be provided as recommended by the manufacturer.

A local control station shall be arranged such that the operator is facing forward. The local control station shall be provided with a gyrocompass steering repeater, sound powered telephone, and PBX telephone. In addition to regulatory body requirements, the local control station shall have an analog steering order telegraph and a power unit motor run indication.

An audio and visual MCCS summary alarm shall be provided in the Steering Gear Room.

Where the rudder blade is not designed to be unshipped separately from the rudder stock, propulsion shafting shall be removable without unshipping any rudders. Where the rudder blade

is designed to be unshipped separately from the rudder stock, propulsion shafting shall be removable without unshipping any rudder stock.

Rudders (if used) shall not extend below a point at least 300 mm above the baseline of the ship. Rudders shall have streamlined cross-sections. Rudders shall minimize turbulence and resistance. Rudder steering gear shall be provided with hardover stops.

3.565 ROLL STABILIZATION

A roll period indicating system shall be provided in the Pilot House to provide an accurate assessment for control of stabilization system operation.

If a roll stabilization tank is provided, tank coatings shall be compatible with the tank fluid, and be designed to withstand high liquid flow velocities. The roll stabilization tank, if fitted, shall be provided with the following minimum features:

- A means of filling the roll tank
- Water level indication and fill/drain controls in the Pilot House
- Acoustic treatment to prevent transmission of fluid flow noise into adjacent compartments
- A provision for rapid dumping of the roll stabilization tank. Discharge from the dump valves shall be directed over the side and shall not discharge directly on the deck below.
- Dump valve controls that shall be powered by emergency power and shall be protected from freezing
- Vents that shall be positioned and constructed to prevent water discharge under the full range of vessel motions
- A sounding tube for the roll tank that shall be located on centerline

3.568 AUXILIARY THRUSTER(S)

Thruster(s) shall be sized to meet maneuvering, docking/undocking, and dynamic positioning requirements. Thruster(s) and associated auxiliary systems shall be capable of a 100% continuous duty cycle. Thruster(s) auxiliary systems shall be freshwater cooled.

Thruster(s), equipment loads, and auxiliary systems shall be freshwater cooled.

Thruster(s) openings shall not cause bubble sweepdown, turbulence, or flow noise at the sonar locations. Thruster(s) hull penetrations shall be configured to minimize the effects of drag.

RPM and load azimuth indicators shall be provided at DPS, MCCS, and the port and starboard bridge wing stations. Manual controls, separate from the DPS, shall be provided at the SCC and

port and starboard bridge wings. Instrumentation shall be provided for Condition Based Monitoring (CBM) as specified herein.

Auxiliary azimuthing thruster(s) shall be capable of unlimited 360° azimuthing rotation.

Tunnel thrusters shall be in accordance with ASTM F841. Tunnel thruster(s), if provided, shall be outfitted with readily removable bar-type grating in the thruster hull penetrations. Tunnel thruster(s) hull penetrations shall be flush.

3.573 HANDLING GEAR

3.573.1 GENERAL

Wet weight handling gear shall be in compliance with 46 CFR 189.35 requirements for the strongest cable that the system is specified to handle.

The main crane(s), stores crane(s), cable highway overhead gantry crane, Moonpool Staging Bay overhead gantry crane, Sea Plow LARS, ROV LARS, moonpool LARS, and moonpool heavy lift system shall be certified in accordance with the ABS Guide for Certification of Lifting Appliances, Notation CRC.

The main crane(s) shall be certified as an Offshore Crane in accordance with Notation CRC (OC). The stores crane(s) shall be certified as a Shipboard Crane in accordance with Notation CRC (SC).

The Sea Plow LARS, ROV LARS, moonpool LARS, and moonpool heavy lift system shall be certified as Offshore Cranes in accordance with Notation CRC (OC-Subsea). Loads and dynamic loading factors for all systems, except the moonpool LARS and moonpool heavy lift system, shall take into account ship motions and accelerations through sea state 5. Loads and dynamic loading factors for the moonpool LARS and moonpool heavy lift system shall take into account ship motions and accelerations through sea state 3.

The vessel shall be capable of simultaneously operating a single main crane plus either the Sea Plow LARS or ROV LARS at sea. Handling gear in its stowed position shall not interfere with the operation of any other piece of handling gear. Weight handling appliances shall be provided with markings and means to protect personnel from injury at pinch points. Handling gear hydraulic rams and pins shall be constructed of CRES 316 or 316L. Handling gear hydraulic rams shall be designed to be retracted in the stowed condition.

Winch systems shall also have commonality among components for operating controls, power systems, and level wind systems to minimize the spare parts needed to maintain operations.

3.573.2 CRANES

Crane(s) shall be provided with a boom angle and load indicating device with a digital readout that sounds an alarm and lights a warning light when the load exceeds the crane rating. The controls for the crane(s) shall permit the operator to have full visibility of the lifted load from the pier or barge to the deck.

Crane(s) shall have a lighting system to illuminate the load at all boom angles. Light power switches shall be installed inside the operator cab, as applicable. Where multiple lights are used, each light shall have its own switch. The lights shall be LED-type and provide luminance of at least 110 lux within a radius of 2 m horizontally from the hook where the hook is 3 m above the lightest operating waterline. The crane(s) lighting system shall not interfere with retracting/extending of boom or storage on the boom rest.

Crane(s) shall have a run-time meter to facilitate scheduling of routine maintenance and servicing. Hydraulic hoses shall be double wall jacketed. Means shall be provided to contain leakage from the hydraulic package.

A crane collision avoidance system shall be provided for cranes with the possible motion range to strike ship structure or other lifting devices.

Crane boom securing cradle(s) shall be provided. The hoist shall include a mechanical means to lower the load in a controlled manner, in the event of a power failure. Platforms with ladder access shall be provided to access to the crane's electric motor and motor brushes.

All cranes shall be provided with an OEM cable tensioner/depressor device on each wire rope or spool to prevent slack and overwrap during operations.

3.573.3 MAIN CRANE(S)

Crane(s) shall provide coverage of all aft working deck areas and be capable of loading and offloading mission vans and equipment pierside weighing up to 10 MT at 10 m beyond the side shell. The crane(s) shall be capable of loading and offloading mission vans with dimensions in accordance with ISO 668, freight designation 1CC, to their stowage locations.

The crane(s) shall provide coverage of all aft working deck areas and be capable of moving equipment from stowage to staging locations. The crane(s) shall be capable of deploying and recovering buoys, anchors, and other equipment weighing up to 2.5 MT up to 4 m over the transom, and port and starboard sides through sea state 5. The location(s) of the crane(s) shall minimize impact on useable working deck space and shall maximize ability to achieve reach and load requirements.

The crane(s) shall be provided with a cab to protect the operator and enclosures to protect the crane machinery, brakes and clutches from the weather. The cab shall be mounted to the revolving upper structure. The cab shall be air conditioned, heated, and illuminated. A windshield wiping and defrosting system shall be provided. The ladder to the cab shall be

provided with a climber safety rail, if necessary, and shall be oriented athwartships on the after part of cab platform.

3.573.4 STORES CRANE(S)

A stores crane(s) shall be capable of loading a 5 MT payload from a distance of 10 m outboard of the shell of the ship on both port and starboard sides, reaching the pier or a barge alongside.

3.573.5 OVERHEAD LIFTING DEVICES

All gantry type cranes shall be equipped with redundant position locks. Locks shall require power to release and shall clamp to the rails by spring force or other non-powered means to prevent motion when power is off.

3.573.5.1 MISSION OVERHEAD LIFTING DEVICES

All cable highway overhead lifting devices shall be powered for travel and lift. Overhead lifting devices travel shall maintain positive position control by use of fixed rack and powered pinion gear drive systems for use through sea state 5.

3.573.5.1.1 CABLE HIGHWAY OVERHEAD GANTRY

The cable deck overhead gantry crane shall have the capability of lifting 2 m high loads of up to 10,000 lbs to a height of 0.5 m above the deck.

The lifting envelope of the Cable Highway Overhead Gantry Crane shall cover as much of the Cable Highway as possible, and at a minimum shall include the footprint of the CHE, all cable tanks, and all cable troughing on the Cable Highway. If repeater racks cannot be serviced by the Overhead Gantry Crane, then additional lifting device(s) shall move repeaters to within reach of the Overhead Gantry Crane.

3.573.5.1.1.1 MOONPOOL STAGING BAY OVERHEAD GANTRY

The Moonpool Staging Bay overhead gantry crane shall have the capability of lifting the UUV and Package herein, to a height of 0.5 m above the deck/moonpool upper door. It shall be capable of moving the payloads between their staging areas and the moonpool LARS, without interference or the need to remove, uninstall or temporarily modify other support systems.

A means shall be provided to move UUV batteries between the Moonpool Staging Bay and the Lithium Battery Room, and other smaller loads throughout the Moonpool Staging Bay.

3.573.5.1.2 ADDITIONAL LIFTING DEVICES

For any locations on the Cable Highway that cannot be reached by the Cable Highway Overhead Gantry Crane, additional powered overhead lifting devices shall be installed. These shall move

the loads between storage locations and within reach of the overhead gantry crane. The lifting capacity shall be 3 MT. Examples include, but are not limited to, moving repeaters between repeater racks and troughing, moving repeaters to and from the splice shop, moving haulers to and from storage to operational positions, etc.

A means shall be provided to move hardware of up to 0.5 MT between the Plow and ROV Storeroom and the Plow and ROV LARS locations.

A means shall be provided to move hardware of up to 0.5 MT between the Plow and ROV Workshop and the Plow and ROV LARS locations.

A workbench with tool rack and vise shall be provided adjacent to the purifiers. A rail and hoist system shall be provided for servicing the purifiers and handling the purifier bowl from the purifiers to the workbench. The workbench shall be fitted with a stainless-steel deep basin. The basin shall have the capability to selectively discharge to the WO/ST(s) and a 20 L container. The sides and back of the workbench top shall be fitted with a splashguard.

3.573.5.2 SHIP OVERHEAD LIFTING DEVICES

Overhead lifting devices shall be provided in equipment rooms as required for maintenance and repair. This shall include:

- A rail and hoist system in the lube oil purifier space(s) for servicing the purifiers and handling the purifier bowl from the purifiers to the workbench
- A means to lift the shore power cables from the pier to the service plug location - this may be an existing ship's crane or a local, dedicated folding crane
- An overhead handling system in the Main Machinery Space that can lift heads or pistons from any of the diesel engines to and from the Diesel Repair Shop

3.573.5.3 ROV LARS

The ROV LARS shall launch and recover the ROV over the side through sea state 5 at best heading.

The ROV LARS shall be located such that the distance between the moonpool and the ROV LARS shall be maximized to avoid line entanglement.

The stowed position for the ROV shall be the same as the ready launch position.

The ROV LARS shall include but not be limited to the following subsystems:

Frame

An A-Frame, J-Frame, telescoping boom, or other suitable device rated and configured for the selected ROV shall be provided. The frame shall be designed such that the ROV nor the umbilical shall contact the hull during launch and recovery operations through sea state 5 at best heading. The frame shall be fitted with an overboarding sheave of a diameter and groove geometry appropriate for the selected umbilical. The frame shall be able to pivot full range from maximum inboard position to maximum outboard position, in one minute or less, at the rated load. A docking head shall be provided that acts as a mechanical interface between the ROV and the ROV LARS and restricts the motions of the ROV throughout the range of motion of the frame. A motion compensation (MOCOMP) system shall be provided that reduces the vertical motion of the ROV in the water column and eliminates snap loads on the umbilical. Vertical ROV motion shall be limited to 0.3 m through sea state 5. Clearance between the side shell and the closest part of the ROV shall be at least 2 m.

Traction Winch

The traction winch shall consist of one traction unit and one umbilical storage reel. The traction winch shall be rated for the selected ROV and umbilical. The traction winch shall be capable of deployment speeds of at least 180 ft/min (0.9 m/sec) and recovery speeds of at least 160 ft/min (0.8 m/sec) with the ROV in the water column.

The traction winch shall have the following requirements:

- An automatic level wind system shall be integrated with the umbilical storage reel.
- An ROV umbilical shall be provided of armored construction containing cables for ROV electrical power and at least 12 Corning fibers. The umbilical length shall be 3,700 m plus the reeving length from the ROV LARS to the storage reel plus five wraps on the storage reel.
- The umbilical storage reel shall be capable of storing the full length of the umbilical.
- Turning sheaves as needed to route the umbilical from the overboarding sheave to all components of the ROV LARS System. All turning sheaves shall have a diameter and groove geometry appropriate for the selected umbilical.
- Hydraulic Power Unit (HPU(s)) supplying the frame, MOCOMP, Traction Winch, and umbilical storage reel shall be provided. The HPU(s) do not have to be dedicated.
- A hydraulic/electric interface to the ROV when on-deck testing or troubleshooting will exceed the tie at which the ROV onboard HPU system can run before overheating.
- Load Cells shall be integrated into the overboarding sheave to provide umbilical outboard tension.
- Line counters shall be provided that measure and display the length of umbilical deployed and the umbilical line speed in the pay-out and haul-in directions.
- The Control Station shall be positioned such that the operator can see the ROV LARS

winch and the ROV from deck to water surface.

- Lights shall be provided that illuminate the ROV throughout the range of motion, at all positions, where possible, on the frame. Lights shall provide an illumination value of at least 200 lux.

The ROV LARS system, excluding the frame and the Control Station, shall be located below deck or in an enclosed space.

The space in which the umbilical storage reel is located shall include a system to provide freshwater cooling of the ROV umbilical. Drainage will be provided in this space.

3.573.5.4 SEA PLOW LARS

A Sea Plow LARS shall be provided to launch and recover the Sea Plow through sea state 5 in any heading.

The Sea Plow LARS shall be capable of accommodating plow tow wire tensions of up to the maximum bollard pull of 120 MT, and capable of continuous plow tow wire tension of up to 80 MT.

The Sea Plow LARS shall include but not be limited to the following subsystems:

Stern Frame

A Stern Frame rated and configured for the selected Sea Plow shall be provided. The headpiece of the Stern Frame shall be traversing such that the Sea Plow can be moved between its stowage location and launch location. The Sea Plow stowage location shall be to port of centerline and shall not interfere with any cable pathway. Additional features include:

- Hydraulic cylinder rams that shall be fully retracted when the stern frame is in the inboard stowed position
- A docking head that acts as a mechanical interface between the Sea Plow and the Stern Frame shall be provided that restricts the motions of the plow throughout the range of motion of the Stern Frame. The docking head shall have hydraulic cylinders capable of adjusting the plow orientation when latched into the docking head.
- Physical stops that shall be provided in the maximum inboard and maximum outboard positions
- A stern frame rotation period of no more than 90 seconds from fully inboard to fully outboard
- A stern frame capability to be rotated by an alternate means in case of hydraulic power failure
- Lights that shall be provided to illuminate the Sea Plow throughout the range of motion,

at all positions, where possible, on the frame. Lights shall provide an illumination value of at least 200 lux.

- Auxiliary padeyes rated for the stern frame Safe Working Load (SWL)
- Cleats on inboard and outboard sides of the Stern Frame
- A service platform and access ladder for maintenance of the docking head, sheaves, lights, etc. on the stern frame
- Clearance between the transom and the closest part of the Sea Plow of at least 2 m

Work Platforms

Work platforms shall be provided at the stern on the port and starboard sides adjacent to the overboarding sheaves. The Stern Work Platforms shall be at a location and height off the deck that allows operators to view cable angles in the vertical and horizontal planes, and to observe the plow between the water surface and the docking head on the Stern Frame. The Stern Work Platforms shall each have CID displays, a DP display, a Mission Communications Station, and a Sound Powered Phone.

Tow Winch

The tow winch shall have the following requirements:

- A tow wire of 3,500 m length shall be provided.
- The tow wire winch shall be capable of line speeds of 160 ft/min (0.8 m/sec) on deployment and at least 120 ft/min (0.6 m/sec) on recovery. The tow winch shall be capable of rendering at an operator-selected tension setpoint and shall be sized to contain the entire length of the tow wire.
- A tow wire sheave shall be mounted on the stern and be capable of sustaining a tow wire tension of 120 MT. The tow wire sheave shall be a flagging sheave, located on centerline, and be equipped with a cable keeper mechanism.
- A tow wire load cell shall provide tow wire outboard tension. A tow wire tension output shall be provided to the Sea Plow LARS control station and the plow console in the Plow, Projector, and ROV Control Room, and to the DP system.

Umbilical Winch

The umbilical winch shall have the following requirements:

- An umbilical winch rated for the selected Sea Plow and umbilical shall be provided. An umbilical shall be provided that is 4,000 m long, positively buoyant or neutrally buoyant, with Sea Plow electrical power cables and at least four Corning fibers.
- An automatic umbilical level wind system integrated with the umbilical winch drum shall

be provided.

- An umbilical winch drum capable of storing the full length of the umbilical shall be provided.
- Turning sheaves, fairleads, and chutes shall be provided to route the tow wire and umbilical from the Sea Plow LARS equipment to their overboarding locations. All such hardware shall be compatible with the selected umbilical and tow wire.
- HPU(s), or electric power, shall supply the Sea Plow Tow Winch and the Umbilical Winch. The HPU(s) do not have to be dedicated.
- A hydraulic/electric interface to the Sea Plow when on-deck testing or troubleshooting will exceed the time at which the Sea Plow onboard HPU system can run before overheating.
- An Umbilical Load Cell shall provide plow umbilical outboard tension.
- A Line Counter shall be provided that measures and displays the length of tow wire deployed and the tow wire line speed in the pay-out and haul-in directions.
- A Line Counter shall be provided that measures and displays the length of plow umbilical deployed and the umbilical line speed in the pay-out and haul-in directions.
- The Stern Frame Control Station located on the aft working deck shall allow the operator to see the Stern Frame and the Sea Plow throughout the Stern Frame's range of motion. The Stern Frame Control Station shall include controls for the Stern Frame, the Docking Head, including latches, and Mission Communications Station and sound powered phone.
- The Sea Plow LARS Control Station shall be located such that the operator has a clear view of the aft working deck, the Stern Frame throughout its range of motion, and the Sea Plow. The Sea Plow LARS Control Station shall be an enclosed space of approximately 6 ft x 8 ft x 7 ft with HVAC and at least one operator chair. The Control Station shall have the controls for the tow wire winch and the umbilical winch, camera displays of the plow in the outboard position from the Docking Head to the waterline, and Mission Communications Station, ship's telephone, and sound powered phone.

The Umbilical Winch shall be located below deck or in an enclosed space.

3.573.5.5 MOONPOOL LAUNCH AND RECOVERY SYSTEM

The moonpool LARS shall be capable of deploying and recovering the following payloads through sea state 3:

- A UUV weighing 13.6 MT (7 m length x 1.5 m diameter)
- A Package weighing 9 MT (6.1 m length x 2.4 m width x 2.6 m height)

The payloads shall interface with a cursor and rail system to prevent pendulation and potential snap loads when transiting the air sea interface. The cursor and rail system shall guide the payload from the moonpool bay to the point where the payload is released from the cursor.

An IP54 Moonpool LARS control console with visibility of the moonpool down to the waterline shall be provided for operation of the moonpool lower and upper doors and LARS. The moonpool lower doors open and closed condition shall be indicated on the console, MCR, and bridge.

The moonpool LARS shall release the payload 100 ft below the keel.

3.573.5.6 MOONPOOL HEAVY LIFT SYSTEM

A Moonpool heavy lift system shall be provided. The Heavy Lift system shall be capable of deploying and recovering Packages through the moonpool through sea state 3. The Heavy Lift System shall include but not be limited to the following:

- Synthetic lift line made of material, such as Vectran or equivalent, that has low stretch, low creep, good self-abrasion resistance, and good external abrasion resistance. Kevlar, PBO, and Ultra-High Molecular Weight (UHMW)-based materials are unacceptable. The Heavy Lift line shall have a SWL based on a Package weighing 20,000 lbs. The Heavy Lift Line shall have a length of at least 3,500 m plus the reeving distance from the water surface through the Heavy Lift System to the storage reel plus five wraps on the storage reel drum.
- A MOCOMP system that reduces the vertical motion of the Package in the water column up to 0.3 m through sea state 3.

Traction Winch

The traction winch shall have the following features:

- A traction winch that shall be provided rated for the weight of Package and lift line. The traction winch shall be capable of deployment speeds of at least 150 ft/min (0.75 m/sec) and recovery speeds of at least 100 ft/min (0.5 m/sec) with a 20,000 lb Package in the water column.
- An automatic level wind integrated with the storage reel
- A storage reel sized to contain the full length of the Heavy Lift Line
- An HPU supplying the MOCOMP, Traction Winch, and Storage Reel
- Turning sheaves, as needed, to route the Lift Line from the center of the moonpool, to the rest of the Heavy Lift System. All turning sheaves shall have a diameter and groove geometry appropriate for the selected Lift Line.
- A Load Cell integrated into the overboarding sheave, or other appropriate system components, to measure outboard Lift Line Tension. Lift Line Tension shall be

displayed at the Heavy Lift Control Station and Mission Control.

- A Line Counter that measures and displays the length of Lift Line deployed and the Lift Line speed in the pay-out and haul-in directions
- A Control Station adjacent to or integrated with the Moonpool LARS Control Station. The Control Station shall be designed for one operator in the seated position and shall be equipped with one operator chair.

The Heavy Lift System shall interface with the ROV LARS system with details to be provided in Phase 2.

3.573.5.7 MOONPOOL PAYLOAD STOWAGE AND MOVEMENT

Stowage location(s) shall be provided to stow two UUVs. Stowage location(s) shall be provided to stow six Packages. UUV and Package stowage locations can be the same, and the payloads do not have to be stowed simultaneously.

A means shall be provided to move the payloads between their loading location(s), stowage location(s) (if different than the loading location(s)), and the Moonpool Staging Bay (if different than the stowage location(s)).

3.573.5.8 MISCELLANEOUS HANDLING GEAR

Six recessed/retractable padeyes rated for a constant load of 100,000 lbs (45.4 MT) shall be installed in the aft working deck. Two per cable pathway shall be adjacent to each cable pathway for use when stoppering while transferring loads. The padeyes shall be sized to accept a 2 in bolt type anchor shackle. The maximum lift angle of the padeyes and the size and shape of their well socket shall facilitate cleanout, dewatering, coatings maintenance, and lubrication.

3.581 ANCHORING SYSTEMS

The anchor handling system shall be in accordance with SNAME T&R Bulletin No. 3-15. The anchor windlass shall be a two-speed unit and have a bolted attachment to the deck. The anchor chain locker and sumps shall be provided with access for chain cleaning and flushing with seawater.

Anchors, chain, and anchor system and handling equipment shall be based on an ABS equipment numeral that is two numbers higher than the calculated equipment numeral. Reduction in anchor weight due to high holding characteristics is not permitted. Reduction in anchor chain diameter due to higher grade steel is not permitted.

Anchor and anchor chain arrangements shall not foul or cause structural damage to the hull, hull appendages, bulbous bow, or equipment when weighing, releasing, or riding at normal conditions of list and trim.

Chain shall be self-stowing within the chain lockers. Chain lockers shall incorporate the following:

- Interior access by manholes
- Non-tight false bottom and means for dewatering

The anchor system shall stow the anchors securely without moving or banging in a seaway. Devil's claws or roller chain stoppers shall be provided to positively secure anchors. The stowed anchor shall rest against the hull with three points of contact. The location of the anchor windlass controls shall afford the operator clear and unobstructed visibility of the anchor windlass, chain stopper, hawse pipe, and surrounding deck area.

The anchor windlass(es) shall be in accordance with ISO 4568. The wildcats shall be in accordance with ASTM F765. The dimensional, whelp, and pocket shape requirements of Section 7 of ASTM F765 shall apply to all anchor wildcats, regardless of ASTM F765 wildcat Type (I, II, III and IV). Anchor windlass controls shall be located to give the operator a clear view of anchoring operations.

No chain skipping is allowed during in-haul or payout of anchor.

A system shall be provided to rinse the anchor and chain of sediment and biota as it is raised.

Means shall be provided to prevent anchor chain runout during weighing operations.

3.582 MOORING AND TOWING SYSTEMS

A conventional mooring system (bitts and chocks) shall be provided.

The belaying and riding surfaces shall have a maximum surface roughness of 125 micro-inches.

Mooring line stowage shall be provided out of the weather.

Electric or electro-hydraulic, split drum type, constant tension mooring winches in accordance with ISO 3730 shall be provided. Where practical, they shall be positioned a sufficient distance from the first fairleader to keep the rope's fleet angle less than 1.5°. The winches shall be provided with warping heads in accordance with ISO 6482 or ASTM F1106. Winch controls shall be located to provide the operator a clear view of mooring operations.

The constant tension winches shall be capable of operation with 1 in thickness of ice on all exposed surfaces.

The capstans and/or warping heads shall be provided and arranged such that all mooring lines can be served.

Bollards shall be in accordance with ISO 13795. Bollards shall be provided with a padeye at the base for use with a rope stopper. The minimum distance between chocks and bollards shall be 1.5 m.

Bits and chocks shall be fitted directly to the deck plating. On the working deck areas, they shall be bolted in place using dedicated bolt sockets. Bits and chocks shall meet Panama Canal transit requirements.

Chocks shall not be recessed. Chocks shall be suitable for use with Ultra-High Molecular Weight Polyethylene (UHMWP) lines and constant tension winches. Chock openings shall be equivalent in size to a Panama Canal double chock. Chocks shall have a minimum radius on their riding surfaces of 3.5 times the largest diameter rope used in each location.

A minimum of two deck-edge chocks and bits shall be provided within one-quarter of the ship's length forward and aft of amidships on each side of the ship. Fairleads shall be provided to allow lines at the deck-edge chocks and bollards to be tended with powered warping heads on winches.

Mooring lines shall be provided in accordance with sizes listed in ABS 3-5-1/Table 2. Lengths of mooring lines shall be in accordance with ABS recommendations. Mooring lines shall be UHMWP rope suitable for use on winches. Mooring lines that are not to be used on winches shall be braided or plaited polyester.

Mooring lines shall be provided with nylon or polyester pendants. Pendants shall be linked to the mooring lines with Tonsberg or Mandal shackles.

Mooring lines shall be fairled to the pier via closed Type 316L stainless-steel chocks or chocks with Type 316L stainless-steel inserts. Stainless-steel chock inserts shall have a minimum thickness of 12 mm. Welds on stainless-steel chock inserts shall be ground smooth. The installation of chock inserts on chock castings shall be free of voids. The rubbing surface of chocks shall have a maximum surface roughness of 3.175 μm in accordance with ASME B46.1.

A row of Dutch bollard type recessed mooring bits shall be provided on each side of the ship. The bits shall be located approximately 1 m above the Full Load Departure condition waterline. The longitudinal locations of the bits shall be as follows:

- Spaced to land on frames a maximum of 12 m apart
- At the bow and stern to facilitate tug handling

The ship shall be capable of being towed. A bow chock and padeye, and stern chock and padeye shall be provided for fairleading and attachment of the towing hawser. They shall be located so that a towline can be deployed and retrieved using a powered warping head. The towline shall be double-braided nylon, sized in accordance with ABS recommendations. It shall be provided with thimbles and shackles, and with a Smit Bracket or other means to allow release under load.

3.582.1 FENDERS

A minimum of two fenders shall be provided. Each fender shall have the capacity to absorb the berthing energy associated with mooring in the Full Load Departure condition with a relative velocity of 100 mm/s without exceeding the allowable pressure load of the hull structure. Fender end fittings shall be provided with shackles and swivels sized in accordance with the fender manufacturer's recommendations. The end fittings shall be in accordance with ASTM A123 and ASTM A153.

Fittings shall be provided to hold the fenders in their deployed locations. Means shall be provided to deploy and recover fenders without pierside support. A means shall be provided for securing the fenders in their stowed position.

3.583 FAST RESCUE BOAT, LIFEBOATS, AND WORKBOAT

A SOLAS and USCG approved fast rescue boat shall be provided. The rescue boat shall be a RHIB and have a minimum length of approximately 7 m and diesel engine(s) rated for a minimum of 230 hp and be waterjet driven.

Diesel powered SOLAS approved lifeboats shall be provided port and starboard in the quantities necessary to accommodate all accommodations in the boats on either side. Lifeboats shall have diesel propulsion. Lifeboats shall be fitted with diesel engine block heaters and battery chargers.

One Navy-standard 7 m RHIB shall be provided as a workboat. Means for stowing the workboat shall be provided. The workboat shall be stowed oriented with the bow facing forward.

A davit or man rated crane shall be provided for launching and recovering the workboat through sea state 3. The workboat davit/crane shall be certified in accordance with the ABS Guide for Certification of Lifting Appliances, Notation CRC. The workboat davit/crane shall be certified as an Offshore Crane in accordance with Notation CRC (OC-PL).

The workboat davit/crane shall be installed such that launch and recovery operations:

- Occur a minimum of 15 m (50 ft) forward of the propulsors
- Occur along the wall sided portion of the hull
- Are visible from the Bridge Wings
- Maintain 150 mm (6 in) clearance from the boat to deck edge and deck mounted items

with the ship at a 10° adverse list

3.588 AIRCRAFT INTERFACE

Hoisting facilities shall be provided to support emergency medical evacuation via helicopter. Hoisting facilities shall be in accordance with USCG NVIC No. 9-81. Markings indicating clear and maneuvering zones shall follow the guidance of International Chamber of Shipping publication “Guide to Helicopter/Ship Operations”.

3.589 ELEVATORS AND DUMBWAITERS

A personnel elevator shall be provided. The personnel elevator shall meet the requirements of ASME A17.1 Section 5.8. The personnel elevator shall have a minimum capacity for six persons and sized to accommodate a Stokes litter. The personnel elevator shall be located adjacent to a main stairtower. The personnel elevator car deck shall stop flush with the serviced level. The personnel elevator shall service each accommodation level from the level below the Pilot House to the level of the EOS. The personnel elevator shall not open directly to the machinery spaces. The personnel elevator machinery room shall be a dedicated, lockable space. The elevator trunk shall not interfere with the cable highway.

If dry, chilled, and frozen storerooms are on a different level than the galley, dumbwaiter(s) and/or elevator(s) shall be employed to facilitate strikedown/strikeup of stores.

3.593 ENVIRONMENTAL POLLUTION CONTROL SYSTEMS

3.593.1 SEWAGE AND GRAY WATER SYSTEMS

The vessel shall be provided with separate sewage, gray water, black water, and food waste collection, holding, and transfer systems. Sewage tanks and gray water tanks shall be aerated separately. Sewage and gray water tanks shall be equipped with TLIs designed for wastewater application. Sounding tubes shall not be provided in sewage and gray water tanks. Tank structural elements shall be located external to the tank to the maximum extent possible.

Internal fixed seawater washdown systems shall be provided for the sewage Vacuum Collection Holding Tank (VCHT), gray water holding tank, intermediate gray water holding tanks, and the sewage treatment plant chambers. The seawater washdown system shall supply seawater of sufficient flow, velocity, and pressure to scour accumulated sludge from tank surfaces. The structure of the tanks and pipes located inside of tank shall be arranged to facilitate an interior washdown. A seawater hose connection shall be provided to facilitate flushing the sewage and gray water discharge piping in the space.

The sewage, food waste, and gray water shore discharge piping shall be combined. The discharge piping shall contain a check valve or a bypass valve that can be manually opened to

allow residual wastewater to drain back to the collection tanks before disconnecting the shore connection hoses. The combined sewage and gray water shore discharge connections shall be provided in accordance with NAVSEA Dwg. No. 804-4444650, using a male 100 mm camlock style fitting for connection to a transfer hose. A 100 mm IMO flange adapter shall be provided. The discharge riser shall have a flushing connection.

3.593.1.1 SEWAGE TREATMENT PLANT SPACE

The sewage VCHT, gray water holding tank, and sewage treatment plant shall be located in the same space. None of these systems shall overflow to an Oil Pollution Abatement System (OPAS). The sewage treatment plant space shall be equipped with a loss-of-airflow alarm and hydrogen sulfide (H₂S) detection and alarm system. The H₂S detection sensor shall be located 230 mm above the deck. The H₂S detection and alarm system shall visually and audibly alarm inside the space, at the entrance of the space, and remotely via the MCCS.

A stainless-steel deep sink shall be provided in the sewage treatment plant space. The drain piping of the sink shall be plumbed to the sewage VCHT.

3.593.1.2 SEWAGE TANKS

The ship shall be provided with a sewage treatment system sized for the ship's complement. The VCHT shall be capable of holding untreated sewage generated for seven days. The sewage system shall be sized with a generation rate of 11 liters per person per day.

The STP shall be a U.S. Coast Guard certified unit in accordance with 33 CFR 159 and 40 CFR 140, IMO Resolution MEPC.227(64), and shall be certified to treat sewage, meeting the standards required by MARPOL Annex IV. The STP shall be sized to treat the daily generation of sewage. Treated sewage effluent shall be capable of being selectively discharged overboard or to the shore connections. The overboard discharge rate shall not exceed the maximum permissible rate allowed by IMO Resolution MEPC.157(55) for a speed of four knots at ballast arrival draft.

A vacuum collection sewage system, including freshwater flushing fixtures, shall be provided. Vacuum shall be generated using sewage powered ejectors. An anti-foaming system shall be included. The sewage VCHT shall be capable of selectively discharging directly overboard, to the shore connections, and to the STP.

The vacuum collection sewage system shall use long radius bends, sweep tees, and wye type fittings. Short radius fittings shall only be used where allowed by the vacuum collection system equipment OEM's recommendations. Additionally, freshwater flushing shall also be provided for the VCHT header. The VCHT header shall be constructed of Cu-Ni 90/10.

Isolation and bypass valves shall be provided for equipment to allow removal of components without securing the entire systems and emptying tanks. Equipment requiring maintenance, inspection, or repair shall not be installed inside or under tanks.

All sewage drains from the hospital shall be plumbed to the STP.

3.593.1.3 GRAY WATER SYSTEM

The system shall be sized to a capacity of 178 liters per person per day and 80 liters per person per day for galley wastewater. The gray water holding tank(s) shall be sized to hold seven days of shipboard use.

All gray water drains from the hospital shall be plumbed to the STP.

All other gray water drains shall be collected by gravity. Gravity gray water drains shall be plumbed to the gray water holding tank or to an intermediate gray water holding tank(s). If an intermediate gray water collection tank is provided, it shall be capable of moving its contents to the gray water holding tank(s) via pump. The gray water drain piping shall be capable of selectively discharging gray water directly overboard, discharging to the gray water holding tank(s). The gray water tank(s) shall be fitted with multiple pumps capable of discharging gray water overboard and to a shore connection.

3.593.2 OIL POLLUTION SYSTEMS

An OPAS in accordance with ASTM F2283 and supplements shall be provided. Compliance with MIL-STD-167/1 and MIL-S-901 is not required.

Clean water drains shall not discharge to the bilge, WO/ST, or OWHT. Clean water drains shall be managed separately from all other drains. A means to selectively pump clean water drains directly overboard and to the shore connections shall be provided.

Direct connections to the WO/ST shall be limited to those specified herein and equipment, systems, and tanks whose contents contain only petroleum-based oils during normal operation.

3.593.2.1 OILY WASTE AND WASTE OIL PUMPS

The oily waste transfer pumps shall take suction from the bilge wells. The oily waste transfer pumps shall be operable locally and remotely via MCCS in automatic and manual modes. The oily waste transfer pumps shall have the capability to transfer oily waste from the OWHT to the shore connections.

A waste oil transfer pump shall be provided. The waste oil transfer pump shall provide the following capabilities:

- Transfer waste oil from the WO/ST(s) to the shore connections
- Transfer waste oil from the WO/ST(s) to the incinerator feed tank
- Transfer oil from the diesel engine sumps to the WO/ST(s)
- Transfer oil from the lube oil storage tanks to the WO/ST(s)
- Transfer oil from thruster oil systems to the WO/ST(s)

The waste oil transfer pump shall be capable of discharging contents of the largest lube oil sump in two hours.

Lube oil storage tanks less than or equal to 2.5 m³ may use a gravity drain via valve in lieu of the waste oil transfer pump to transfer oil to the WO/ST(s).

3.593.2.2 OILY WASTE HOLDING TANK(S)

The OWHT(s) shall be sized to accommodate seven days of oily waste. A valved hose connection shall be provided for draining the tank(s). The OWHT(s) shall be located such that they do not impart a positive head on the oil water separator system. The OWHT suction line opening(s) shall be located in the lowest part of the tank(s). The OWHT inlet line(s) and return line(s) for effluent that exceeds the oil content limit shall be placed as far from the suction line as practical. The OWHT(s) shall have level indicators to indicate the content level and the oil/water interface in the tank. The OWHT level indicators shall have low and high-level alarms that display via the MCCS.

A means shall be provided to store and prevent the introduction of synthetic oils, lubricants, and hydraulic fluids into bilge water or into the oily waste treatment system. Synthetic oils shall be pumped to shore facilities, to the waste oil tank, or into drums.

3.593.2.3 OILY WATER SEPARATOR (OWS) SYSTEMS

An oily water separator system in accordance with IMO Resolution MEPC.107(49) shall be provided. The oily water separator system shall process the oily water at a minimum rate of 95 lpm.

The OWS and oil content monitor (OCM) shall be a U.S. Coast Guard certified unit in accordance with 46 CFR 162.050. The OWS shall be capable of both manual and automatic operation.

3.593.2.4 WASTE OIL AND SLUDGE TANKS

The WO/ST(s) shall be sized to accommodate seven days of waste oil. The WO/ST(s) shall be equipped with a tank level indicating system and high-level alarm that display via the MCCS.

3.593.2.5 OILY WASTE AND WASTE OIL SHORE CONNECTIONS

A means shall be provided to prevent pumping waste oil to the OWHT(s) by the common shore connection piping. An emergency stop shall be provided to shut down the transfer of waste oil/oily waste at the shore connections.

The shore connections shall be provided, using a male 50 mm camlock style fitting for connections to a transfer hose. A 50 mm IMO flange adapter shall be provided.

3.593.3 SOLID WASTE HANDLING SYSTEMS

Solid waste handling systems shall be provided that meet Annex V of MARPOL 73/78. The daily quantities of solid waste generated are listed in Table 3.593.3-1.

Table 17: [3.593.3-1] Solid Waste Generation Rates

	Accommodation/day (kg/lb)	Accommodation/day (L/ft³)
Paper and Cardboard	0.50/1.10	3.30/0.12
Metals	0.21/0.46	1.40/0.05
Glass/Ceramic	0.04/0.09	1.40/0.05
Plastic	0.09/0.20	4.30/0.15
Food	0.55/1.20	0.80/0.03
Wood	0.02/0.04	1.00/0.04
Medical	0.01/0.20	0.01/0.003
Total	1.42/3.29	12.21/0.443

A solid waste processing facility shall consist of a trash room, a solid waste processing room, frozen processed waste storage, a processed waste storage room, and an incinerator room. The facility shall be located in the vicinity of the food service spaces, but not adjacent to the messrooms. Movement of trash and solid waste to and from the facility, and between the individual spaces of the facility, shall not require passing through living and personnel service spaces. The solid waste processing facility shall be pallet jack accessible for transporting palletized solid waste.

The trash room shall be a minimum of 25 m². The trash room shall provide segregated storage for a minimum of five days of unprocessed trash for all personnel based on the daily solid waste generation rates listed and be located adjacent and have direct access to the solid waste processing room.

The solid waste processing room shall be provided with a pulper, metal/glass shredder, plastics processor, and trash compactor, and shall be located adjacent and have direct access to the processed waste storage room and the incinerator room.

The processed waste storage room shall be capable of holding 60 days of processed solid waste per Table 3.593.3-1 with direct access to the weather deck. The processed waste storage room shall provide segregated storage for 200 L drums of ash, processed plastic waste, and paper and cardboard waste. The room shall include a sink and washdown facilities including hot and cold hose bib connections and drain.

The incinerator room shall include an incinerator which shall be provided to process waste oil, synthetic lubricant, paper and cardboard, textiles, wood, and mixed waste. The incinerator shall be in accordance with ASTM F1323 and MARPOL Annex VI. The incinerator shall be a continuous feed-type and have automatic combustion controls. The incinerator shall be capable of processing the daily production of paper and cardboard, textiles, wood, and mixed waste specified herein in 8 hours of continuous operation. The incinerator shall be capable of processing the daily production of waste oil and synthetic lubricants in 8 hours of continuous operation.

Combustion air for the incinerator shall have a dedicated intake. The incinerator shall exhaust to the weather via a dedicated system in the ship's uptake. The design of the exhaust system shall ensure the exhaust plume clears the ship's boundary layer and prevents re-ingestion of exhaust gases into combustion air, ventilation, and replenishment intakes. The exhaust terminal shall be located where exhaust gases will not contaminate ventilation or combustion air intakes, interfere with operating crews, impinge on ship equipment, or create a fire hazard. The exhaust terminal shall be configured to prevent entry of rainwater. The weather exhaust outlet shall be provided with a portable cover of coated cloth and a means to secure it. The exhaust systems shall not impose a back pressure that exceeds the manufacturer's maximum allowable exhaust back pressure.

Incinerator emergency stops and ventilation control shall be provided outside the Incinerator Room.

Dedicated frozen processed waste stowage shall be provided for three m³ of boxes of compacted metal and glass waste.

3.593.4 FOOD WASTE

Drains from the galley and scullery garbage grinders shall be led to the food waste tank. The food waste system shall be capable of selectively discharging the food waste tank contents either overboard or to the shore connections. The food waste tank shall be provided a minimum capacity of seven days storage and shall be aerated. The food waste tank shall have a high-level alarm provided locally and in MCCS.

3.593.5 MEDICAL WASTE

Means shall be provided to comply with the collection, handling, processing, storage, transfer, and disposal requirements for infectious solid and liquid medical waste in accordance with OPNAV M-5090.1. Dedicated stowage shall be provided for 14 days of treated medical waste based on the total number of accommodations per Table 3.593.3-1.

3.595 CABLE MISSION SYSTEMS

The Mission Systems encompass all of the equipment and facilities necessary for the ship to perform its many missions that include:

- Cable operations including loading and offloading cable, laying cable, burying cable, and repairing cables at sea
- Bathymetric surveys
- Projector tows
- UUV operations
- Package deployments and recoveries to/from the seafloor

The ship shall perform cable installation without burial at a speed of up to 7 knots.

The ship shall be capable of Sea Plow and ROV operations without requiring a return to port via independent launch mechanisms.

3.595.1 CABLE HIGHWAY

The ship shall have an enclosed Cable Highway internal to the ship. The Cable Highway shall provide a smooth and continuous path for the cable from each cable tank to Cable Highway Aft Door and shall include the cable tank tops, cable troughing, repeater racks, and cable machinery.

At the interface between each cable tank and troughing on the Cable Highway, permanent fairings that prevent bends of less than 1.5 m in both directions of cable travel shall be provided. The vessel shall be outfitted with a sufficient number of portable vertical and horizontal turning quadrants, overboarding chutes, and troughing to maintain minimum bend radius of cables during loading, offloading, and tank-to-tank transfers of cables. Additional portable bend restrictors shall be provided for rope bins where built-in permanent fairings/bend restrictors are not fitted.

The deck of the Cable Highway shall be continuous except in areas where cables or ropes exit their storage areas.

The Cable Highway shall be outfitted with suitable non-ultraviolet (UV) LED lighting to prevent damage from long term UV exposure to unarmored cables. Lighting shall provide illumination

of 300 lux measured at 1 m from the deck.

The ship shall be able to simultaneously load stores and cable.

The ship shall be able to load and offload cable to/from all cable tanks from port and starboard sides of the vessel. Cable loading/offloading locations shall be provided forward of the forward-most cable tank on the port and starboard side, and aft of the aft-most cable tank on the port and starboard side. Aft cable loading/offloading may be through the Cable Highway aft door.

The ship shall be capable of “dual-line” loading and offloading in which two product cables are unloaded or offloaded simultaneously and independently from either port or starboard.

3.595.1.1 CABLE PATH

Pathways on the Cable Highway, to and from each cable tank, to and from each of the three main CHE components (two CDEs and one LCE) shall be provided. Cable pathways shall be provided from each CHE component to and from the overboarding locations. The cable path through the LCE and each CDE shall be parallel to the centerline.

Internal cable troughing shall be provided from cable tank openings on the Cable Highway to the aft weather deck closure. The cable path shall have a minimum bend radius of 1.5 m in areas of low cable tension (inboard of the CHE), and 2.3 m in areas of high cable tension (outboard of the CHE). The troughing shall support the geometry and weight of repeaters. All cable troughing shall not have offset discontinuities greater than 5 mm. Unsupported cable spans shall not exceed 2.5 m. Inboard fairleading equipment shall be designed to avoid impact loading for repeaters. Troughing shall be designed in standard lengths and with a common bolt pattern for attachment to the deck to the maximum extent possible and shall be moveable by the Cable Highway Overhead Gantry Crane.

The cable troughing shall be designed to interface with the cable handling equipment selected and cable tank exit geometry. The inside dimensions shall be approximately 0.41 m wide x 0.41 m deep. The troughing support structure shall be bolted to the deck and stiff enough to avoid excessive vibration during high speed (7 knots) cable laying. Interior surfaces shall be painted with primer and multiple coats of epoxy paint and have a maximum finished surface roughness of 125 micro-inches.

If needed to meet airborne noise requirements, outside surfaces of the troughing can be coated with acoustic tile or other treatment equivalent to the acoustic tiles to reduce airborne noise.

Portable cable troughing shall be provided from the Cable Highway Aft Door to the overboarding location. The troughing shall support the geometry and weight of repeaters. Design details of the portable troughing are the same as the cable troughing above. The portable troughing shall be bolted in place on the aft working deck. Provision shall be made to store

portable troughing sections on or near the Cable Highway when not in use.

Each of the two CDEs and the LCE shall have a dedicated, corresponding cable overboarding location for the product cable that passes through each piece of equipment. Each of the three overboarding locations shall be at the transom on a straight line parallel to the vessel centerline from the cable exit point from each of the two CDEs and the LCE to the transom. Cable overboarding devices shall be located at all cable overboarding locations and shall consist of sheaves or rollers or combinations thereof. If sheaves are used, each sheave shall be dedicated to a particular CDE or the LCE. If rollers are used, a roller may be shared between the LCE and one CDE as long as the roller has a minimum width equal to the distance between the two overboarding locations plus 0.40 m.

All overboarding devices shall have the following features and characteristics:

- A minimum radius of 2.3 m
- Rated for cable tensions of 50 MT
- Fixed, adjacent, bend-limiting structures outboard of the sheaves or rollers that prevent cable bends of less than 2.3 m for all cable angles in any plane. The surface of all bend-limiting structures shall be smooth with all welds ground.
- Gaps and discontinuities between overboarding devices and bend-limiting structures of less than 5 mm
- Capable of passing 0.34 m diameter repeaters and 1.2 m diameter cylinders
- Groove geometries that are not curved but have a flat bottom and form a 90° angle between the bottom of the groove and the cheek wall

3.595.1.2 CABLE HIGHWAY AFT DOORS

A weathertight Cable Highway Aft Door shall be installed at the aft end of the Cable Highway to accommodate the cable pathways. The door shall be hinged at the top and open outwards. The door shall have a vertical clear opening of at least 3.05 m (10 ft). Provisions shall be made for locking the door in the open and closed positions.

Three weathertight cable access doors shall be provided in the Cable Highway Aft Door in way of the three cable pathways from the CHE to the stern sheaves such that cable operations can be conducted with the main door closed and any combination of the cable access doors open. The cable access doors shall have a 1 m (39 in) wide clear opening, within the envelope of the main door and extending from the bottom of the main door to a height of 0.5 m above the cable pathway. The cable access doors shall be lockable in the open and closed positions and operable regardless of the position of the main door. All doors shall be designed such that the main door may be opened and closed during cable operations and such that the cable may be transferred among the CDEs and the LCE in any combination.

All doors shall be designed to withstand 6 ft of seawater head and a slam load of 500 lb/ft².

3.595.2 CABLE TANKS LAYOUT & DESIGN

The ship shall have at least two main cable tanks with a total capacity of at least 3,200 m³ and at least 4,812 MT.

All cable tanks shall be located below the deck of the Cable Highway. The cable tanks and associated equipment shall be designed to optimize cable storage and facilitate cable movements.

Cable tanks shall have a circular configuration (not oblong) and the cone shall have a minimum diameter of 3 m at the base. Cable tanks shall have a constant diameter from top to bottom, excluding bight slots and ladders. Cable tank walls and cones shall be solid plate not open frame construction. The spherical radius at the top of the cone structure in all cable tanks shall be at least 12 in.

Main cable tanks shall have a crinoline, or other suitable device, to dampen cable bight swing during cable installation.

Each cable tank shall have a Bight Slot consisting of a recessed area/bump-out to serve as a vertical pathway for bights of cable to exit the tank vertically upwards, connect to a repeater stored in racks on the Cable Highway, and return to the cable tank vertically downwards. The Bight Slots shall be located on centerline at the forward portion of each main cable tank. The Bight Slots of main cable tanks shall be a minimum of 1.75 m wide x 1.75 m deep (5 ft, 9 in x 5 ft, 9 in). The Bight Slots shall be located at the forward portion of each spare cable tank on the longitudinal centerline of each tank. The Bight Slots of spare cable tanks shall be a minimum of 1.0 m wide x 1.0 m deep (39.4 in x 39.4 in). Each Bight Slot shall be equipped with a means to secure each cable bight in place along its vertical path.

Each cable tank shall have a Cable Slot above the cable tank and above or incorporated into the cable deck that provides the cable path between the tank and troughing on the Cable Highway. The Cable Slot shall extend longitudinally from the forwardmost edge of the Bight Slot to approximately 1m aft of the center of the cable tank cone. The underside of the Cable Slot shall have permanent smooth fairings of at least 1.5 m radius around the entire periphery of the slot. The Cable Slot of each main cable tank shall be fitted with a permanent fairing structure at the top of the cable slot that provides a cable path with at least 1.5 m radius that (1) allows cable to be loaded/unloaded from a forward loading location, (2) allows cable to be loaded/unloaded from an aft loading location, (3) allows cable to be deployed aft, (4) provides a diverter/crossover capability that allows cable to be deployed from the tank to multiple cable pathways leading to any CDE and the LCE. The Cable Slot of each spare cable tank shall meet the same requirements as for main cable tanks except that the top fairing structure may be temporary and portable instead of being permanently installed, for all but one spare cable tank which shall have a permanent fairing structure.

Each main and spare cable tank shall have a Gallery Platform near or at the top of the cable tank and around the tank's periphery external to the cable tank wall. The Gallery Platform shall:

- Allow personnel access around the periphery of the cable tank to the maximum extent possible, except in way of the Bight Slot, and allow personnel visibility into the interior of the cable tank
- Provide safety railing at least 1.1 m high measured from the top surface of the Gallery Platform to the top of the railing. The cable tank wall may serve as the safety railing.
- Allow personnel access to the cable tank's recessed vertical caged ladders
- Provide mounting positions for the CTE and FTJ junction boxes, crinoline controls, CCTV cameras, and MCS station
- Provide storage for dunnage in bins. Storage volume shall be at least 8 m³ for each main cable tank in two or more bins, and at least 2.5 m³ total for the spare cable tanks, divided approximately equally among the spare cable tanks.

The ship shall have a total spare cable tank capacity of at least 500 m³ and at least 688 MT. At least two, and up to four separate spare cable tanks shall be provided. Each spare cable tank shall be equipped with removable intermediate dividing rings of open frame construction to subdivide each spare cable tank into three different cable coiling sections of approximately equal volume. This allows immediate access to different spare cable types. The spacing between vertical structural members shall not be greater than 60 in and each member's facing shall be at least 12 in in width.

All surfaces of cable tanks, cones, intermediate dividing rings, and cable fairleading surfaces shall be smooth and free of weld beads or other protrusions. Cable tanks, including the tank floor, ladder well(s), cone, up-and-down runners, and cable paths to junction boxes shall be clean and free of all debris, soap, grease, wet paint, bilge water, or any other chemicals or finishes that may be harmful to the cable dielectric material. All tanks shall have a low point drain such that water can be pumped out.

All cable tanks shall be outfitted with suitable non-UV LED lighting in order to prevent damage from long term UV exposure to unarmored cables. Lighting shall provide illumination of 200 lux measured at 1 m from the deck.

Receptacles shall be provided at each cable tank for portable air conditioning units.

Two recessed vertical caged ladders with a climber safety rail allowing for the use of personal fall arrest systems, one on port side and one on starboard side, shall be provided for personnel access in each tank.

Vertical access ladders shall be located in the center cones in each main cable tank. Means shall be provided to enable climbers to safely make transfers between ladder and cone. Two sets of foot and hand holes shall be cut in the cone in each cable tank. The horizontal portion of the

hole shall have a 0.5 in half round for a tread if plating is less than 0.5 in thick. A 21 in diameter scuttle shall be furnished on the top of the cone. A fixed grating platform with a hinged opening shall be installed inside each cone three feet below the top of the cone. No equipment shall be mounted inside or underneath any cable tank cone.

Manhole openings shall not be installed in any cable tanks, except on the deck within the center cones and personnel access ladder areas.

Cable termination enclosures (CTEs) junction boxes and Fiber Termination junction boxes (FTJs) shall be provided as follows:

- Two at each cable tank
- One at each repeater rack
- One in the Splice Shop

Cables shall be run from each CTE junction box and each FTJ to the Test and Transmission Room.

All cable tanks shall be marked with cable layer depth marks every 12 in (0.3 m) from the bottom to the top of the cone, in two places, on opposite sides of the tank, in at least 3-inch letters, in a contrasting color to the tank wall paint color.

3.595.3 REPEATER STORAGE AND HANDLING

Racks capable of storing 60 repeaters shall be provided on the Cable Highway. Repeater racks may be arranged such that bodies are stacked a maximum of four high. The repeater racks shall be divided into two or more equal areas corresponding to the number of main cable tanks. For example, if two main cable tanks are provided, then two repeater rack areas capable of holding 30 repeaters each are required.

Each repeater rack area shall be located such that the aft end of the rack is approximately 2 to 10 m forward of the bight slot of the corresponding main cable tank. The overhead above each rack shall contain a means of securing rigging to suspend and secure pigtailed spare repeaters in the racks. Storage for repeaters shall be environmentally controlled within a range of -3 to 30 °C and electrically grounded. For informational purposes only, a 30-repeater rack is approximately 8.5 m long x 6.1 m wide x 1.8 m high and weighs approximately 17 MT when fully populated.

Space and a removable foundation for a 10-repeater rack shall be provided to service spare cable tanks.

A water basin shall be provided in the vicinity of the repeater racks for the main cable tanks for cooling Power Branching Units (PBUs). The water basin shall be approximately 2.5 m long x 1.0 m wide x 0.6 m high and shall have a drain spigot at both ends. Freshwater shall be provided

at a minimum flow rate of 23 lpm (6 gpm).

3.595.4 MISSION SPACES AND ROOMS

The ship shall have the following mission spaces and rooms:

- Mission Control Room
- Mission Conference Room
- Splice Shop
- Test and Transmission Room
- Plow, Projector, and ROV Control Room
- UUV Control Room
- Mission Electronics Storeroom
- CHE Electrical Storeroom
- CHE Mechanical Storeroom
- Test and Transmission Storeroom
- Plow and ROV Storeroom
- Plow and ROV Workshop
- Projector Room
- Lithium Battery Room
- Cable Engineer's Office

3.595.4.1 MISSION CONTROL ROOM

The MCR is the space in which operators supervise and control all mission activities. The MCR shall be a minimum of 100 m² (1,076 ft²) and be located near the bridge.

The MCR shall include the following systems and features:

- Cable Operations Console:
 - Makai cable lay software system workstation
 - WINFROG navigation system workstation
 - DP computer and display
 - Remote CHE Controls (RCC) workstation
 - Three Critical Information Displays (CIDs), one for each CDE and one for the LCE
 - Multiple Mission CCTV displays
 - Communications System (Mission Communications System, Sound Powered Phone, and PBX telephone)
 - Three operator's chairs with arms and adjustability for seat height and back recline

- Survey Console:
 - MBSS-DW Workstation
 - Two MBSS-DW Post Processing Workstations
 - SBSS Workstation
 - ADCP Workstation
 - SBP Workstation
 - Two ANTS Workstations
 - POS-MV Workstation
 - XSVP Workstation

- Communications System Console (at a separate location from the Cable Operations Console):
 - Mission Communications System station
 - Sound powered phone
 - PBX telephone
 - Iridium phone station (GFE)
 - One Unclassified LAN workstation
 - One Classified LAN workstation

- IMU (for AHRS system)
- Mission CCTV control unit
- Approximately eight 19-in racks for various equipment
- Large format color plotter
- Printer
- Two 5-drawer Mosler safes, or equivalent, with individual locking drawers
- Two heavy duty shredders (one for paper and one for CD/media destruction)
- Chart table with drawers under
- Two desks for computer workstations
- Two work tables
- Three Vidmar, or equivalent, cabinets for parts and tools
- Coffee mess including refrigerator, sink with hot and cold water, microwave, supply cabinet, and coffee maker

Resilient mounts shall be used to secure consoles, racks (top and bottom), and equipment.

Lighting in the MCR shall be dimmable from 500 lux at 1 m above the deck to zero.

A head with toilet, urinal, and sink shall be provided external to the MCR.

3.595.4.2 MISSION CONFERENCE ROOM

A secure mission conference room of at least 75 m² (approximately 800 ft²) shall be provided with seating for up to 20 around a conference table.

Conference room furnishings shall include:

- 55 in or larger color monitor, wall mounted such that everyone at the conference table can see it.
- Conference table that seats 20
- 30 padded adjustable height chairs
- Coffee mess including small refrigerator, sink, microwave, coffee maker, supply cabinet
- 4 ft by 8 ft whiteboard
- Large bulletin board
- Multilevel bookshelf
- At least (24 each) 2-blade plus ground 120 VAC, 60 Hz outlets on three 20 amp circuits
- Dimmable lighting with an illuminance range of 0 to 500 lux measured 1 m off the deck
- PBX telephone

The mission conference room shall be adjacent to the MCR and one door shall open into the MCR.

3.595.4.3 SPLICE SHOP

The Splice Shop shall be adjacent to the Cable Highway on the opposite side from the repeater racks and approximately midway between the forward most and after most repeater racks longitudinally.

The space shall be a minimum 10 m long and 4.5 m (45 m²) wide and have access directly into the Cable Highway.

The space shall include:

- A means to simultaneously:
 - Allow a bight of cable from the Cable Highway to enter and exit the space without violating the cable's minimum bend radius. Options include, but are not limited to, a large door, a roll-up door, a slot, etc. sufficient to provide for a fair cable entry and exit from the space.
 - Preserve the environmental characteristics of the space to the maximum extent possible while a bight of cable is within the space. Options could include a curtain of overlapping plastic sheets (used terrestrially in some commercial refrigerated spaces), permanent and temporary covers, temporary seals and materials.

- Provide personnel and equipment access of at least 1.5m wide between the Splice Shop and the Cable Highway. Personnel and equipment access may be the same.
- A central part of the floor in the space, 5 m long x 3 m wide, covered with a resilient cushioning material
- Heating and air conditioning to maintain ambient temperature between 66-74F (19-23 °C) and a relative humidity of less than 65%
- A sink, hot and cold potable water, and an Emergency Eye Wash station
- Illuminance level of 500 lux measured at 1 m from the floor
- Communications systems (Mission Communications System, Sound Powered Phone, and PBX Telephone System)
- A 38 L (10 gal) ventilated chemical storage cabinet with a secure lock
- An overhead lifting device, rated for 3 MT, for the movement of repeaters in and out of the Splice Shop
- A Cable Termination Enclosure (CTE) and a Fiber Junction Box (FJB). Cables shall connect the CTE and the FJB to equipment in the Test and Transition Room.
- Miscellaneous small power tools, 6 circuits, 120 VAC, 20 amps, 60 Hz with 3 straight-blade with ground duplex receptacles

Provide clean power and receptacles for equipment:

- Brazing: 3.6 KVA, single phase, 120 V, 60 Hz
- Molding: 3.6 kVA, single phase, 120 V, 60 Hz, two circuits
- X-ray: 1.8 kVA, single phase, 120 V, 60 Hz
- Chiller: 1 circuit, 220 VAC, 30 amps minimum, NEMA configuration, L6-30R, wall receptacle

3.595.4.4 TEST AND TRANSMISSION ROOM

The TTR shall be at least 56 m². The room shall be located near the Cable Highway to provide electrical and optical power to cables and to monitor the electrical and optical characteristics of cables.

The room shall include:

- Equipment racks:
 - Four 24 in wide racks: two racks for the HVPS, one rack for the Test Load equipment, and one rack for the Shore Terminus Equipment (STE) processor suite
 - Eight 19 in wide racks for equipment such as auxiliary test equipment, data logger, mega-Ohmmeters (“megger”), optical transceivers, digital oscilloscopes,

electrical and optical spectrum analyzers, System Management Terminal, etc.

- Two desks with chairs and PC workstations
- Two workbenches
- Four Vidmar, or equivalent, cabinets for parts and tools
- Printer
- Communications System (Mission Communications System, sound powered phone, PBX telephone)
- Dimmable lighting with an illuminance range of 0 to 500 lux

Resilient mounts shall be used to secure the racks at the top and bottom.

A grounding lug shall be provided on each rack consisting of a 3/8-16 collar stud that is connected to ship's ground.

Power and fiber optic cabling shall be provided that connects equipment in the TTR to each CTE Junction Box and each Fiber Termination Junction Box. Electrical cables shall be rated for 7,000 VDC. Fiber cables shall contain single mode fibers with angle polished connectors at all connections.

The three racks containing the HVPS and the Test Load equipment shall be supplied with two circuits each of 208 V, 3-phase, 60 amp service. The rack containing the STE equipment shall be supplied with two circuits of 120 V, 30 amp service. The rack containing the UPS shall be supplied with 30 kVA at 208, 3-phase, VAC. All other racks shall be supplied with two circuits of 120 V, 30 amp service.

Test and Transmission equipment generates more heat than typical rack-mounted electronics. The estimated heat load for the TTR is approximately 84,000 BTU/hr. Sufficient HVAC shall be provided to maintain the temperature in the TTR between 18.3 °C (65 F) and 26 °C (80 F) with relative humidity between 30% and 65%. The TTR shall be equipped with a thermostat dedicated to the TTR.

3.595.4.5 PLOW, PROJECTOR, AND ROV CONTROL ROOM

The Plow, Projector, and ROV Control Room shall have a footprint of at least 56 m² and shall contain the Plow Control Console, the ROV Control Console, the ROV Power Distribution Unit equipment, and the Projector Control Station.

The Projector Control Station shall support the GFE Projector topside control units. Cabling shall be provided between the Projector Control Station and the Projector Winch. The GFE Projector topside control units are not permanently mounted. They will be installed prior to a Projector Tow mission and removed upon mission completion. The Projector topside control units consist of:

- Four case-mounted electronics boxes of approximately 2 ft long x 2 ft wide x 3 ft deep. The cases can be placed side by side on a tabletop and secured or mounted by other means.
- One power distribution transformer panel of approximately 4 ft long x 4 ft wide x 2 ft high
- Two operator's chairs

The Plow and ROV Control Consoles shall each be equipped with Mission Communications System, a sound powered phone, and a PBX telephone and shall be configured such that the operators do not have to move from their normal operating position to use the various communications systems.

The Plow Control Consoles shall include:

- All the controls, displays, gauges, etc. needed to operate the Sea Plow
- Three CID displays
- Two Mission CCTV displays
- Two operator's chairs

The ROV Control Consoles shall include:

- All the controls, displays, gauges, etc. needed to operate the ROV
- Two Mission CCTV displays
- Two operator's chairs

Dimmable lighting shall be provided with an illuminance range of 0 to 500 lux.

3.595.4.6 UUV CONTROL ROOM

The UUV Control Room shall be located near the Moonpool Staging Bay. The room shall be at least 15 m².

Dimmable lighting shall be provided with an illuminance range of 0 to 500 lux.

3.595.4.7 MISSION ELECTRONICS STOREROOM

The Mission Electronics Storeroom shall be at least 60 m².

The room shall be equipped with:

- heavy duty shelving and cabinets
- aisle between rows of shelving/cabinets that is at least 1.2 m wide
- lighting fixtures arranged to maximize utility and minimize blockage from shelves and items on the shelves and from cabinets

3.595.4.8 CHE ELECTRICAL STOREROOM

The CHE electrical storeroom shall be at least 15 m². The space shall include shelves, Vidmar, or equivalent, cabinets, and racks.

3.595.4.9 CHE MECHANICAL STOREROOM

The CHE Mechanical Storeroom shall be at least 40 m² be located near the Cable Highway and have a double door for access. Space shall include shelves, Vidmar, or equivalent, cabinets, and racks as well as bulkhead and floor fixed tiedown points on a grid pattern. The space shall have tire racks for spare tires for the DOHBs and the LCE. A means shall be provided to move items up to 0.5 MT between the storeroom and the CHE on the Cable Highway.

3.595.4.10 TEST AND TRANSMISSION STOREROOM

The Test and Transmission storeroom shall be at least 20 m².

The room shall be equipped with:

- heavy duty shelving and cabinets
- aisle between rows of shelving/cabinets at least 1.2 m wide
- lighting fixtures arranged to maximize utility and minimize blockage from shelves and cabinets

3.595.4.11 PLOW AND ROV STOREROOM

The Plow and ROV Storeroom shall be at least 130 m² and shall have a double door.

A means shall be provided to move hardware of up to 0.5 MT among the Plow and ROV Storeroom, the Plow and ROV Workshop, the Plow stowage location at the Stern Frame, and the Plow and ROV LARS locations.

The room shall be equipped with:

- heavy duty shelving and cabinets
- aisle between rows of shelving/cabinets at least 1.2m wide
- lighting fixtures arranged to maximize utility and minimize blockage from shelves and

cabinets

3.595.4.12 PLOW AND ROV WORKSHOP

The Plow and ROV Workshop shall be at least 100 m² and shall have a double door.

A means shall be provided to move hardware of up to 0.5 MT between the Plow and ROV Workshop, the Plow stowage location at the Stern Frame, and the Plow and ROV LARS locations.

The Workshop shall be located adjacent to the Plow and ROV Storeroom. A double door shall be provided between the Plow and ROV Storeroom and the Plow and ROV Workshop.

The Workshop shall be provided with the following:

- Workbench with vise
- Vidmar, or equivalent, cabinets
- Heavy duty shelving
- Soldering station
- Tungsten Inert Gas (TIG) welding machine capable of welding steel or aluminum
- Plasma cutter
- Welders grid table at least 4 ft by 6 ft
- Welding curtain
- Exhaust fan venting to weather
- Drill Press 16"
- Milling Machine
- Lathe
- Hydraulic hose crimping machine
- Desk with swivel chair adjustable for seat height

3.595.4.13 PROJECTOR ROOM

The Projector Room shall be at least 22 m².

The Projector Room shall include:

- Stowage and cradles or tiedowns for two large and two small Projector transducers with

characteristics as provided below

- Stowage for two large and two small fins
- Vidmar, or equivalent, cabinet
- Shelving
- Tool cabinet
- Workbench with vice
- Multiple 110V outlets for power tools
- 220V outlet for portable welding machine
- Compressed air

The Projectors shall be GFE.

The characteristics of the large Projector are:

- Transducer: 8 ft long x 2.5 ft wide x 6 ft high
- Fins (approximately): 6 ft long x 26 in wide x 24 in high
- Assembled dimensions: 14.1 ft long x 2.5 ft wide x 8 ft high
- Assembled weight: 5,000 lbs in air

The characteristics of the small Projector are:

- Transducer (approximately): 6 ft long x 2.5 ft wide x 5.2 ft high
- Fins (approximately): 5 ft long x 26 in wide x 24 in high
- Assembled dimensions: 14.6 ft long x 2.5 ft wide x 7.5 ft high
- Assembled weight: 3,950 lbs in air

3.595.4.14 LITHIUM BATTERY ROOM

A Lithium Battery Room shall be provided and shall be at least 22 m² and located in the vicinity of the Moonpool Staging Bay such that UUV battery modules may be transported between the Staging Bay and the Battery Room. The space shall be used for charging, monitoring, and maintaining battery modules.

3.595.4.15 CABLE ENGINEER'S OFFICE

A Cable Engineer's Office shall be provided on the Cable Highway and shall be at least 13 m². The office shall contain a desk and chair with a PC workstation, printer, file cabinet, bookshelf, mission communications system master station, and PBX telephone.

3.595.5 CABLE HANDLING EQUIPMENT

3.595.5.1 CABLE DRUM ENGINES

Two CDEs shall be provided. Each CDE shall have an overall diameter of at least 4.6 m. The width of the CDE shall be a minimum of 1.2 m. The CDE shall be installed with minimum 1 m clearance from the surface of the drum.

The cable drums shall be capable of working simultaneously and independently. CDEs shall provide automatic fleeting without the use of fleeting knives.

The CDEs shall be capable of withstanding the forces imposed by the cable system with overboarding tensions up to 50 MT. The CDEs shall be capable of holding two cable ends simultaneously with overboarding tensions up to 40 MT each. The CDEs shall be equipped with a static brake system that can hold the drum for extended periods with overboarding tensions up to 50 MT. The static brake system shall be a fail-safe design such that the loss of electrical power does not allow the brake to slip.

3.595.5.2 DRAW-OFF HOLDBACK MACHINES

Two DOHBs shall be provided, one for each CDE, to supply the necessary back tension. The DOHBs shall be tire-type and capable of maintaining constant tension on lines or cables up to a maximum of 4,000 lb. The DOHBs shall maintain dynamic tension excursions within 200 lbs of the control set point tension. Static tension excursions shall be maintained within 300 lbs of the control set point tension. DOHBs shall be capable of applying and maintaining a squeeze force of 0 to 2,000 lbs. Each DOHB shall accommodate cables, lines, or repeaters with diameters ranging from 0.525 in to 13.5 in. Each DOHB shall be equipped with manually controlled guides or drag boards such that lines or cables can be centered within the machine.

Each DOHB shall be equipped with a static brake system that can hold a line or cable for extended periods with tensions up to 2,000 lb. The static brake system shall be a fail-safe design such that the loss of electrical power does not allow brakes to slip.

A means shall be provided to maintain cable landing position on the drum and keep the cable centered in the DOHB tires.

3.595.5.3 LINEAR CABLE ENGINE

An LCE shall be provided that shall have sufficient tire pairs to generate 25,000 lbs of overboarding tension. The LCE shall be equipped with a static brake system that can hold a line or cable for extended periods with overboarding tensions up to 30,000 lbs. The LCE minimum squeeze force shall be adjustable from 0 to 2,000 lbs. The LCE shall be capable of maintaining the set-point squeeze pressure for each tire pair within $\pm 5\%$. The LCE shall accommodate cables, lines, or repeaters with diameters ranging from 0.525 in to 13.5 in. The LCE shall be equipped with manually controlled guides or drag boards such that lines or cables can be

centered within the machine. The static brake system shall be a fail-safe design such that the loss of electrical power does not allow the brake to slip.

The LCE shall prevent individual tire pairs from "spinning out", which causes cable damage.

3.595.5.4 ROTOMETER (ROTO) SYSTEMS

Each of the three cable paths shall have a ROTO system, each with two ROTO rollers to measure linear cable speed and cable count. System accuracy shall be at least 0.2%.

3.595.5.5 DYNAMOMETER FAIRLEAD ASSEMBLY

Each overboard cable path shall have a dynamometer fairlead assembly to measure the tension in cables or lines passing from the cable drum or LCE to the sheave or roller. The dynamometer shall be capable of sensing tensions within a range of 0.01 to 45.4 MT (100 to 100,000 lbs). The dynamometer shall be capable of withstanding overboarding tensions up to 50 MT. The dynamometer should have a full-scale accuracy of $\pm 0.5\%$ under static conditions. All tension displays shall be accurate within 0.5% of actual tension and are required for the LCE and CDE.

3.595.5.6 STONKER

A manually actuated stonker (cable arresting device) shall be provided directly aft of the LCE for the purpose of preventing cable runaway. It is preferred the Stonker be located within the Cable Highway, but it may be located on the Aft Working Deck as close to the LCE as possible. If the Stonker is located on the Aft Working Deck, then the Stonker and its foundation shall be removeable and portable such that it may be stored when not in use.

3.595.5.7 CABLE HAULERS

Four identical Cable Haulers shall be provided to safely load and unload cable and rope between the vessel and ashore, and to support tank-to-tank transfers. The Cable Haulers shall be:

- Of the opposing tire-pair type
- Electrically powered
- Rated for 4000 lbf tension
- Capable of providing a squeeze force of 0-2000 lbf
- Capable of linear cable speeds of 12.9 km/hr
- Capable of passing repeaters of 13.5 in diameter

Cable Hauler positions shall be provided at the following locations:

- (1) Just forward of each cable tank in line with each cable pathway leading to/from the tank
- (2) Just aft of each cable tank in line with each cable pathway leading to/from the tank
- (3) At each of the four cable loading locations inboard of the overboarding chute and in line with the cable pathway from the cable loading location to each cable tank

Each Cable Hauler position shall be equipped with a receptacle for electrical power to the Cable Hauler and communications connections for use by the operator. Cable Hauler positions at the cable tanks shall have doubler plates, if needed.

3.595.5.8 CABLE HANDLING EQUIPMENT CONTROLS

Cable handling equipment features shall include:

- Closed Loop Control: The CHE shall have a control system that provides closed loop control of the CHE components.
- Modes of Control: The CHE control system shall have manual mode and three modes of closed loop control:
 - Manual: Control of the CHE is performed by human operators manipulating various electro-mechanical or Human-Machine Interface (HMI) (i.e. touch screen) controls on the control console(s).
 - Constant Speed: Cable speed is automatically maintained at a constant value via a closed loop feedback system.
 - Constant Slack: Cable surface slack percentage is automatically maintained at a constant value via a closed loop feedback system.
 - Constant Tension: Cable tension is automatically maintained at a constant value via a closed loop feedback system.
- Cable Path Independence: The control system shall independently control the LCE, two CDEs, DOHBs, etc.
- Control Mode Availability: All modes of control shall be available at the main Control Console on the Cable Highway. The Remote Control Console (RCC) in the MCR shall have Constant Speed and Constant Slack modes of control, but not Constant Tension or Manual modes.
- Transfer of Control:
 - Transfer of control from the Control Console on the Cable Highway to the RCC in Mission Control shall require the Control Console operator to grant permission for transfer of control and the operators in MCR to accept control.
 - Transfer of control shall be allowed only in the Constant Speed mode of control.
 - A capability shall be provided such that when control resides in MCR, operators at the Control Console on the Cable Highway can quickly take back control without permission at any time for safety reasons. When operators at the Control Console take back control, the system shall automatically be placed in Constant Speed mode regardless of what mode of control the system was in at the RCC.

- Whenever control resides in MCR, control of all functions other than the commanded linear cable speed or commanded surface slack percentage shall remain at the Control Console.
- Cable-Lay Software Control Prohibition: Even though it may be technically feasible, allowing cable lay software to control the CHE shall not be permitted.
- Control Indicators: There shall be clear indication on the Control Console, the RCC, and all CIDs showing which station has control of the CHE.
- Mode of Operation Indication: There shall be clear indication on the Control Console, the RCC, and all CIDs showing the mode of control in which the CHE control system is operating.
- CHE Speed Control: The control system shall be capable of controlling the cable handling system sufficiently to maintain a linear cable speed of ± 0.01 m/sec. This requirement applies to the Manual, Constant Speed, Constant Slack, and Constant Tension modes of control.
- Interlocks and Limits: The control system shall include interlocks and limits to prevent damage to equipment and increase safety of personnel.
- Processing System Architecture: The processing system architecture used in the control system shall be configured such that loss of any single processor or communications path will not prevent control, monitoring, and operation of the CHE system.
- CHE Control Console:
A single Control Console shall be provided.
 - Control Console Location: The CHE control console shall be located on the Cable Highway such that operators have a clear view of all CHE and as much of the entire cable path as practical.
 - Control Console Layout: The Control Console shall have all the controls, switches, gauges, indicator lights, displays, data entry devices, etc. needed to operator the CHE. The layout shall be arranged in a logical manner such that controls for a particular CHE component are grouped together as much as possible.
 - CIDs: The Control Console shall incorporate one CID for each group of CHE that constitutes a cable path.
 - CID Information: Each CID shall display critical information including Linear Cable Speed, Cable Count, Cable Tension, Distance to Go, a cable tension graph, alarms, etc.
 - CID Locations: CID displays shall be located at the following locations - Control Console on the Cable Highway, on or near the RCC in MCR, Stern Work Platforms, Bridge, aft weather deck, mid Cable Highway, Master's office, Chief Engineer's office, SDR office.
 - CID Viewability: All CIDs shall be viewable in daylight, artificial white light and in darkness.
 - CID Dimming: All CIDs shall be dimmable to zero.
 - Emergency Stop Button: The Control Console shall have an E-stop button that cuts power to the CHE and stops all CHE functions (except brakes) abruptly.

- Cable Emergency Button: The Control Console shall have a cable emergency button that causes the CHE to come to a controlled stop and placed in a known state.
- Human-Machine Interfaces: The Control Console shall incorporate HMI devices for the purpose of navigating menus, entering and changing data, and displaying information. All HMIs shall be ruggedized and intended for industrial applications. HMIs shall be such that no special computer or IT skills are needed for their operation. Menus shall be intuitive and easy to navigate. Data entry shall be quick and not prone to error.
- Un-Interruptible Power Supply: The control system and Control Console shall receive electrical power from a UPS. The UPS shall be capable of supporting operations at full power consumption for at least 30 minutes.
- Number of Operators: The Control Console shall be designed such that a single operator can control the CHE. Two operator chairs shall be provided.
- Viewability: All gauges, HMIs, displays, indicator lights, keypads, and other components on the Control Console shall be viewable in daylight and artificial white light.
- Test Port: The Control Console shall have at least one test port into which operators and technicians may plug test equipment or laptops for the purpose of troubleshooting, routine maintenance, or testing of the system.
- RCC: An RCC shall be provided in the MCR.
 - RCC Functionality: The RCC shall have active and stand-by modes. In the active mode, control of the CHE is performed via the RCC and is restricted to the Constant Speed and Constant Slack modes of control only. In the standby mode, control of the CHE is performed via the Control Console on the Cable Highway.
 - RCC Cable Emergency Button: The RCC shall have a Cable Emergency button, but not an E-Stop button. The Cable Emergency button causes the CHE to come to a safe controlled stop, transfers control from the RCC to the Control Console on the Cable Highway, places the system in a constant speed mode at zero speed, and applies brakes.
 - RCC Connectivity: The RCC shall not be connected to any classified systems or process or store any classified information.
- Data Logging: The Control System shall incorporate the ability to log unclassified data.
- Passwords: The system shall allow passwords to be changed at any time, shall not have a password expiration date, and shall not require strong passwords.

3.595.6 SEA PLOW

A Soil Machine Dynamics (SMD) MD3 Sea Plow, or equivalent, shall be provided.

The Sea Plow shall be capable of burying cable and repeaters 3 m deep in cohesive and non-cohesive soils in water depths up to 1,500 m. The Sea Plow shall have burial speeds of at least 1.5 km/h (0.8 knots) in cohesive and non-cohesive soils. The Sea Plow shall be capable of

sustaining a tow force resulting from a tow wire tension of 120 MT at the ship. The Sea Plow shall be capable of passing repeaters of 0.34 m diameter x 3 m long.

The Sea Plow shall have the following additional features and subsystems:

- The ability to steer the plow at $\pm 15^\circ$
- The ability to load and unload the plow with product cable on deck from the side (rather than having to thread the product cable through the plow)
- The ability to remove the cable from the plow while the plow is on the seafloor (i.e. a “spitter” mechanism)

Multiple sensors shall be provided such as forward-looking sonar, cameras and lights, load cells, altimeter, fluxgate compasses, inclinometers, responders compatible with the ANTS, pressure transducers, etc.

3.595.7 REMOTELY OPERATED VEHICLE

One SMD Q-Trencher 400 ROV, or equivalent, shall be provided.

The ROV shall be of the “free-flying” type with no cage or top hat. The ROV shall be capable of burying cable and repeaters to depths of 1 m in cohesive and non-cohesive soils at water depths up to 3,000 m at a minimum of 400 m/h using jetting swords. The cable burial system may be integrated into the vehicle or provided as a detachable work package, as long as all other capabilities and features are not degraded.

Jetting swords shall be independently adjustable and used. The jetting swords shall have a minimum separation distance between swords of 0.1 m and a maximum ID between swords of 0.5 m.

The ROV shall be capable of performing the following additional tasks:

- Finding and tracking proud and buried cables
- Cutting cables and lines
- Attaching cut-and-hold devices and cable gripping devices
- Connecting and disconnecting underwater wet-mateable connectors
- Manipulating control actuators mounted on Packages on the seafloor up to 3,000 m water depth
- Attaching and releasing lift hooks and other lift mechanisms from Packages
- Recording video of all underwater operations

The ROV system shall be equipped with the following:

- Two 7-function manipulators. Both manipulators shall be of the type that allow both rate and spatially correspondent control. The reach envelope of the manipulators shall overlap.
- A Removeable TSS, or equivalent, cable tracking system
- Removeable cable cutters and softline cutters
- Multiple sensors such as cameras and lights, forward look sonar, altimeter, fluxgate compasses, inclinometers, responders compatible with the ANTS system, battery powered beacon in case of vehicle loss, pressure transducers, umbilical rotation counter, etc.

3.595.8 CABLE GEAR

3.595.8.1 ROPE STOWAGE

Stowage for various sizes and lengths of rope shall be provided in at least 20 bins in one or more compartments. Bins shall be approximately 3.7 m long x 3.7 m wide x 1.5 m high and provide a total rope volume of approximately 380 m³. Total rope weight required is approximately 12.5 MT.

Each bin requires provisions for installing a cone in the middle of the bin. Fifteen cones made of pipe grid or similar construction with a base diameter of 1 m shall be provided along with any needed attachment hardware.

Each rope compartment shall have a path for rope between each rope bin and the cable pathways on the Cable Highway.

The rope stowage compartment(s) shall have forced air ventilation. Rope bins shall have drainage. Each compartment(s) shall have a low-point drain.

3.595.8.2 BUOY STOWAGE

Six buoys shall be provided for use during cable repairs. A notional buoy is approximately 3.7 m³ in volume and weighs approximately 1 MT in air.

Each buoy shall include:

- Strobe light
- Radar reflector
- Light reflecting tape or paint on a portion of the buoy above the buoy waterline that is visible from any direction
- Lifting bales with floating pendant

Stowage shall be provided for six buoys. Four of the buoys shall be mounted in buoy-launch cradles at the deck edge and within reach of the main crane. Two of the buoys can be stowed topside or below decks, provided they can be moved to the buoy launch cradles.

Interior stowage space(s), if used, shall have drainage and forced air ventilation.

3.595.8.3 QUADRANTS STOREROOM(S)

The following items used for loading and unloading cable, and stowage for these items, shall be provided in up to three compartments:

- Two Overboarding Chutes with dimensions of approximately 5 ft long x 4 ft wide x 4 ft high. One overboarding chute shall be designed for use on the vessel's port side at both the port forward and port aft cable loading locations. One overboarding chute shall be designed for use on the vessel's starboard side at both the starboard forward and starboard aft cable loading locations. If a single Overboarding Chute can be used at all four cable loading locations, that is acceptable. The Overboarding Chute(s) shall be capable of loading and offloading two cables simultaneously to support dual load line operations.
- At least one Large Turning Quadrant and at least one Small Turning Quadrant. The turning quadrants shall have a minimum 1.5 m bend radius and shall provide a 90 degree turn and be temporarily bolted to the deck at a location that aligns with the Overboarding Chute and a cable path to a cable tank. The turning quadrants shall be invertible such that they can be used for cable loads from both the port and starboard sides of the vessel. They shall be designed such that Small Turning Quadrant(s) can "nest" inside the Large Turning Quadrant(s) for stowage. The Large Turning Quadrant(s) are expected to be approximately 10 ft long x 10 ft wide x 4 ft high and the Small Turning Quadrant(s) are expected to be approximately 7 ft long x 7 ft wide x 4 ft high. The final geometry, number, and dimensions of the quadrants will be determined by the cable route from the Landing Table to the permanent cable paths on the Cable Highway.
- Landing Table (approximately 5 ft long x 5 ft wide x 4 ft high) to be located inboard and adjacent to the Overboarding Chute(s). The Landing Table shall be capable of loading and offloading two cables simultaneously to support dual load line operations.
- Portable Load Troughing - approximately 14 items:
 - Four items approximately 10 ft long x 2.5 ft wide x 4 ft high each
 - Four items approximately 8 ft long x 2.5 ft wide x 4 ft high each
 - Four items approximately 6 ft long x 2.5 ft wide x 4 ft high each
 - Two items approximately 4 ft long x 2.5 ft wide x 4 ft high each
 - Over CDE troughing (if needed): 2 items 12 ft long x 2.5 ft wide x 1 ft high each
 - Two Hanging Quadrants approximately 6 ft long x 2.5 ft wide x 6 ft high. Hanging

Quadrants are used to assist cable loading from the pier by suspending them from a crane.

- Portable Fairings: Two items approximately 5 ft long x 5 ft wide x 4 ft high each

The total weight of equipment is approximately 2.6 MT.

A means shall be provided to move the above gear between Storerooms, loading/unloading locations, and the Cable Highway.

3.595.8.4 CABLE GEAR STOREROOM

Stowage shall be provided for:

- 26 DorMor anchors in three sizes (10 x 500 lb, 10 x 1000 lb, 6 x 2000 lb). The anchors shall be stored on the deck of the storeroom. A means shall be provided to secure the anchors. Total anchor volume is approximately 15 m³ and total weight is approximately 12 MT.
- 26 grapnels of various types and sizes. Grapnels shall be stowed in 13 bins (2 per bin) that are approximately 2.0 m long x 2.0 m wide x 1.2 m high. The total bin volume is approximately 62 m³ and the total grapnel weight is approximately 5.6 MT.
- 20 swivels of various sizes and ratings. The total volume required is approximately 2.0 m³ and the total swivel weight is approximately 1.0 MT.
- Preformed stoppers of various sizes and ratings. Stoppers are to be stored on racks or heavy-duty shelves assorted by size and rating. Stopper lengths range from 6 ft to 14 ft. Total stopper volume is approximately 34 m³ and total weight is approximately 6 MT.
- Large shackles stored on racks or shelves such that they can be assorted by size and rating.
- Chain of various sizes and rating. Chain shall be stored in 4 bins of approximately 2 m long x 2 m wide x 1.2 m high. Each bin shall be sub-dividable in half using removable wood planks dropped into steel channels welded to the bin walls or other means.

The stowage space(s) shall have drainage and forced air ventilation.

A means shall be provided to move cable gear between stowage areas and the aft working deck at sea.

3.595.8.5 CABLE RIGGING LOCKER

A Cable Rigging Locker shall be provided to stow small cable rigging items and tools. This locker is separate from the ship's bosun's locker.

The Cable Rigging Locker shall be located adjacent to the Cable Highway as close to the Aft Working Deck as possible.

The Cable Rigging Locker shall have a footprint of approximately 18 m² and shall include racks, shelves, and cabinets.

The space shall have drainage and forced air ventilation.

3.595.9 MOONPOOL

A moonpool shall be provided with a clear opening of at least 27 ft long x 14 ft wide to accommodate the following payloads:

- A 23 ft long x 5 ft diameter UUV weighing 13.6 MT
- A 20 ft long x 8 ft wide x 8.5 ft high Package weighing 9 MT.

The clear opening includes a minimum clearance on each side of 2 ft longitudinal and 3 ft transverse.

A baffle system outside the clear opening shall be provided that meets the deck wetness (overtopping) criteria of Table 3.079-1. The baffle design shall include access to maintain the coatings on all sides of the baffles and moonpool structure. The baffle design shall provide access to the moonpool hydraulics components and systems.

There shall be a means for divers or swimmers to climb safely out of the water from the top of the lower doors to the moonpool deck. This may be incorporated into the baffle design.

The moonpool shall be constructed using double continuous welds.

There will be waterline markings in two places in opposite corners of the moonpool, with graduations at least every 6 in (0.15 m), in clear bold numbers, readable from the Moonpool Staging Bay deck. These markings shall be in a contrasting color to the paint color in the moonpool for maximum visibility. The markings shall extend from the keel to the Staging Bay deck.

3.595.9.1 MOONPOOL LOWER DOORS

The moonpool shall have one or two lower doors that open inwards against the sides of the moonpool. The door(s) shall conform to the shape of the hull when closed. The hinge pins on each door shall not be continuous along the length of the door, to facilitate periodic maintenance.

The doors shall maintain their structural integrity in sea state 8 and be operable through sea state 5.

All hydraulic cylinders shall be in the fully retracted position when the doors are closed. All hydraulic cylinders shall be mounted above the still water line.

BERPs shall be provided to remove moonpool hydraulics.

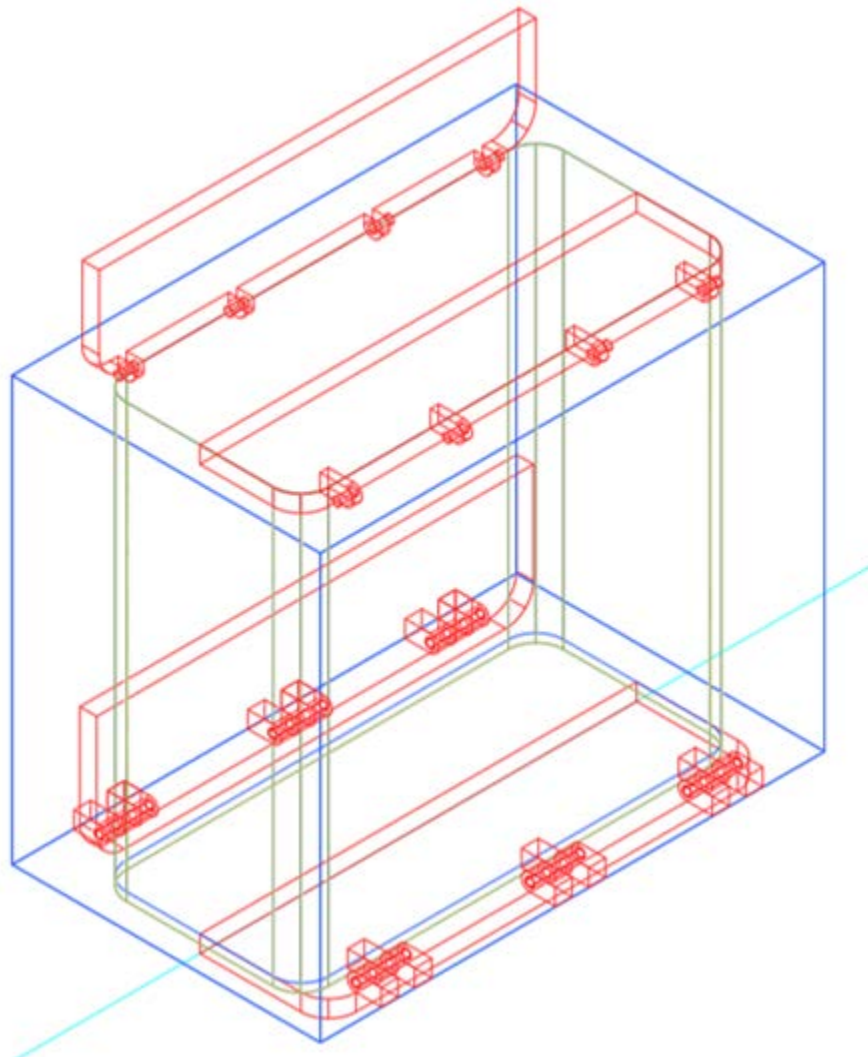


Figure 1: [3.595.9.1-1] Concept Sketch of Moonpool Door Openings

Figure 3.595.9.1-1 shows a notional door concept with the port side doors shown open and the starboard side shown closed. The blue box shown represents the watertight boundary of the moonpool. The green rounded rectangle is the clear opening. The baffle structure is not shown.

3.595.9.2 MOONPOOL UPPER DOORS

The moonpool shall be equipped with upper door(s). The door(s) shall be weight bearing at the load rating of the surrounding deck or the weight of the payload, whichever is greater.

3.595.9.3 MOONPOOL BAY VENTING AND DRAINAGE

Pressure fluctuations in the moonpool bay shall not exceed 2 millibar (0.029 psi) when the lower doors are open through sea state 3 as defined herein.

The moonpool bay shall drain any water that comes in due to overtopping and from retrieved payloads. Gravity drains back into the moonpool are suggested.

3.595.9.4 MOONPOOL STAGING BAY

A staging bay adjacent to the moonpool shall be provided. The staging bay area shall be large enough to set down and maintain one of each payload, not simultaneously. A walkable space with 1 m clearance around the payloads shall be provided.

The following services shall be supplied to the staging bay:

- Ten 120 V, 20 amp, corrosion-resistant, watertight duplex receptacles fed from GFCI circuit breakers equally spaced around the staging bay perimeter
- Sink with hot and cold potable water
- Eyewash station
- Compressed air
- Freshwater and seawater for washdown
- Workbench with vice
- Ships Dial Telephone
- Sound Powered Phone (4 Jacks)
- Ship's PA System

Floor strength in the staging bay shall be 1,024 lbs/ft² (5 MT/m²).

3.595.10 ACOUSTIC PROJECTOR HANDLING SYSTEM

GFE will include:

- A Projector winch with cable and cable fairings (222-in length x 102-in width x 120-in height, 22,150 lbs)
- A Projector winch HPU (54-in length x 54-in width x 49-in height, 2750 lbs) with 440V 3-phase service
- A tow sheave (36-in diameter, 350 lbs)
- Controls: four half-racks in Pelican cases weighing 400 lbs total and two half-rack spares in Pelican cases weighing 200 lbs
- Miscellaneous spares: two 48-in x 48-in pallets weighing a total of approximately 2,000

lbs

A means for launching, towing, and recovering the Projectors shall be provided. The stern frame can be used for launch and recovery utilizing the GFE sheave.

A means shall be provided to move the Projectors between the Acoustic Projector Storeroom and the LARS location.

Projector fin assemblies can be mounted onto the transducer frame in the Acoustic Projector Storeroom or on the aft working deck.

Projector controls shall be located in the Plow, Projector, and ROV Control Room. Signal cabling shall be run between the Plow, Projector, and ROV Control Room and the Projector Winch. A Mission Communications station shall be provided at the same location as the Projector Winch Controls.

3.600 GENERAL REQUIREMENTS FOR OUTFIT AND FURNISHINGS

Living spaces shall be in accordance with MSC QMS N0720-110.00-P, Habitability Standards for New Construction Large Ships.

Food service shall be in accordance with MSC QMS N0720-111.00-P, Steward Department and Food Service Standards for New Construction Large Ships.

Engine department and shops shall be in accordance with MSC QMS N0720-112.00-P, Engine Department and Shop Standards for New Construction Large Ships.

Deck departments and the pilot house shall be in accordance with MSC QMS N0720-113.00-P, Deck Department and Pilot House Standards for New Construction Large Ships.

Medical spaces shall be in accordance with MSC QMS N0720-114.00-P, Medical Space Standards for New Construction Large Ships.

The compartment arrangement drawings and the outfitting tables in the above five MSC QMS Standards are notional. Details will be provided in a future revision.

The colors and number of each color scheme shall be in accordance with Appendix H. Patterns and textures for coverings, sheathing, decks, paints, tabletops, upholstery, curtains, bedspreads, furniture finish, framed artwork, planters, and other accessories shall be coordinated for each color scheme.

Living, food service, and working spaces shall be separately grouped. Living spaces shall not be located forward of the collision bulkhead or abaft of the aft peak bulkhead. Living spaces,

except for the Engineer's Change Room and the deck head in the vicinity of the EOS, shall not be located below the bulkhead deck unless otherwise approved.

Merchant mariner's certification display boards shall be provided in the passageway adjacent to the Master's Office and in the passageway adjacent to the Chief Engineer's Office. The boards shall have aluminum frames and lockable windows. Each board shall accommodate displaying all merchant mariner certificates required by minimum manning certificate.

3.602 DESIGNATING AND MARKING

Identification, display markings, label plates, placards, signs, posters, holders, and frames shall be provided in accordance with MSC QMS N0720-006.00-AQ, Appendix H, and as specified herein. Compartment numbering shall be in accordance with MSC QMS N0720-006.00-AQ.

The anchor chains shall be painted and wire marked in accordance with Appendix H.

A ship historical data plate shall be provided on the forward exterior bulkhead of the deckhouse. The ship historical data plate shall be installed at the main deck on centerline. The ship historical data plate shall be of polished brass or architectural bronze in high relief. The ship historical data plate shall include the builder's name, year delivered, builders' hull number, and ship hull number for identification.

The ship's name shall be located directly on the stern at the centerline in a location below the main deck. Where the ship includes a sharp stern or interferences in stern area, the name shall also appear on each quarter. Numerals and letters shall be sized in accordance with Appendix H.

Weld beads in accordance with MSC QMS N0720-006.00-AQ shall be installed to define upper and lower limits of the boot topping.

3.602.1 LABELS, MARKINGS, AND PLACARDS

Hazard identification, system operating, and system maintenance instruction labels, charts, plates, and placards shall be provided and installed in accordance with ASTM F1166, with the exception of warning labels, which are to be yellow. Danger, warning, and caution labels shall be in accordance with ANSI/NEMA Z535.2. Photo-luminescent and retro-reflective materials shall not be applied to surfaces visible from the weather.

Label plates located in the weather and areas exposed to seawater shall be sealed to exclude moisture between the plate and mounting surface. Non-corrosive label plates affixed to equipment by manufacturers are acceptable where they contain the required information or are augmented by Contractor provided label plates.

Type 316 stainless-steel or photosensitive anodized aluminum type label plates showing safe working load, test load, and last date tested shall be attached to the structure adjacent to the load carrying fittings.

3.604 LOCKS AND KEYS

3.604.1 DOOR LOCKS

Doors shall be provided with a means for positive closure.

Exterior doors shall have a means of locking or pinning for intrusion prevention.

Locks, hasps, latches, and associated hardware shall be corrosion resistant. Locks, hasps, latches, and associated hardware for exterior doors shall be Type 316 stainless-steel. Lock types and function numbers shall be provided as follows. Locks not specifically identified shall be comparable in type and function to those described below for similar applications:

- ANSI/BHMA A156.2, F75 for passageways, access trunks, fire doors, and other doors where locking is not permitted or required
- ANSI/BHMA A156.2, F76 for semi-private Toilet and Shower (T&S) spaces. The lock enable/disable button shall be on the T&S side of the door
- ANSI/BHMA A156.5, E2191 dead bolt for semi-private T&S spaces with the turn piece on the Stateroom side
- ANSI/BHMA A156.2, F81 for storerooms, the solid waste processing facility, laundry spaces and unassigned spaces
- ANSI/BHMA A156.2, F90 for doors to the weather, food service spaces, offices, lounges, medical facility, workshops, Pilot House, Mission Control Room, Naval Communications Center, permanent Quarterdeck Stations, and machinery spaces

The Ship Store and the Ship Store Storeroom shall be provided with both a dead bolt door lock and a hasp for a high security padlock.

Dutch doors shall have a lock set on the bottom half of the door as required for the type of space being served, and a thumb knob operated dropbolt on the inside surface of the top half of the door for securing to the bottom half.

Closures not otherwise provided with built in locks, shall be provided with hasps, staples, and padlocks. Hasps and staples shall be arranged to prevent the lock or hasp being caught between the door and the frame when the door is closed. Hasps and staples shall be installed to prevent removal.

Padlocks shall be cylinder type with solid laminated bronze casings and hardened brass or bronze shackles. Padlocks shall have brass or bronze pin tumblers, and brass or bronze keep chains. Padlocks for exterior use shall be provided with non-corroding keyhole spring covers.

Wardrobes shall be provided with a closure mechanism that permits use of a padlock.

Stateroom and office doors shall be provided with electronic keycard type locks. An electronic key management system shall be provided that encodes, cancels, and duplicates keycards and allows different master keycard access levels.

A manual key override shall be provided for all electronic keyed doors.

3.604.2 KEYS

Door locks of the same type shall be master keyed/encoded for each group. Three master keys shall be provided for each group, and three grand master keys for entrance to all groups of locks.

Padlocks shall be similarly grouped and master keyed. Each mechanical lock and padlock shall be provided with three keys. Groups/departments shall be:

- Deck department
- Engineering department
- Supply department
- Communications department
- Mission
- Medical
- Purser

Common types of spaces shall be keyed the same. When there is more than one door to a space or cabinet, the locks to that space or cabinet shall be keyed the same. Spaces listed under multiple space types shall be master keyed such that they can be opened by each group's key. Hazardous Material Lockers shall be keyed the same as the space in which they are located.

Mechanical keys, including duplicates, shall be numbered with engraved numbers and have a tag of heavy fiber or plastic with the name of the group designator, space, and ship inscribed thereon.

Departmental key lockers shall be provided and sized to accommodate the keys for the deck, engineering, supply, and medical departments.

3.612 RAILS, STANCHIONS, LIFELINES, AND SAFETY NETS

Interior and exterior rails and guards shall be provided. Hand (i.e. storm) rails shall be provided around all accessible deckhouse peripheries. Removable guardlines shall be provided at access openings in lifelines, liferails, and bulwarks. Portable guardlines and stanchions shall be provided around hatchway openings and around the moonpool. Handrails shall return to the bulkhead or adjacent railing. Ends of exterior handrails shall be seal welded.

Handrails shall be seal welded, closed pipe, through-bolted to double padeyes to mitigate water entrainment and corrosion.

Lifelines and removable lifeline stanchions shall be provided around areas where removal or set up is necessary for crane operations including the deck edge or hatch openings.

Guardlines shall be provided at access openings in lifelines, liferails, and bulwarks. The chain shall be retractable to allow access to such places as the accommodation ladder and vertical ladders.

Temporary guardlines and stanchions shall be provided around hatchway openings. Stowage for temporary guardlines shall be provided near the area of use in the interior of the ship.

3.613 FLAG HOISTS

Signal yardarms shall be provided port and starboard. Three signal flag hoists and retrievers shall be provided on each yardarm. Hoists shall be spaced a minimum of 760 mm apart, and the inboard hoist shall be not less than 760 mm from any adjacent structure. The hoists shall accommodate five Size Six flags. Flag hoist halyards shall be 13 mm diameter rope. Signal flag hoists shall be visible from a location in the vicinity of the Bridge Wings. Hoists shall be provided for day shapes in accordance with COLREGS 1972.

Flag hoists for the national ensign and special purpose flags shall be provided on the after part of the mast(s).

Jack and ensign staffs with flag hoists shall be provided. The height of the jack staff shall be no less than 2.5 m between top block and cleat or supports. The height of the ensign staff shall be no less than 3.7 m between top block and cleat or supports.

3.621 JOINER WORK

3.621.1 GENERAL

The Pilot House, Naval communications spaces, living spaces, and stairtowers in living spaces shall be provided with joiner bulkheads, linings, and ceilings. Protuberances in these spaces shall be recessed to present a flush surface to the maximum extent practical. Where protuberances extend into the space, the area occupied by the protuberance shall not be counted

towards meeting the minimum area requirement for that space. The protuberance shall not interfere with the routine functioning of that space. The required clear width and height requirements for that space (e.g. passageways) in way of the protuberance shall be maintained.

Heavy items up to manufacturer's allowable weight attached to joiner bulkheads or ceilings shall be reinforced by members independent of the bulkhead or ceiling.

Individual joiner panels shall be capable of being removed without affecting adjacent panels. Bulkhead and ceiling panels in way of concealed items requiring periodic operation, maintenance, and inspection shall be provided with hinged access panels. The hinged access panels shall permit operation, servicing, and removal/replacement of concealed items. Hinged access panels shall have quick-acting, flush catches. Access panels shall be labeled to identify the concealed items.

3.621.2 JOINER BULKHEADS

Joiner bulkheads shall be faced with decorative Polyvinyl Chloride (PVC) foil covered galvanized steel sheets. Exposed metal surfaces shall have a baked enamel finish compatible with adjacent finished surfaces. Sharp edges shall not be permitted. Outside corners shall have a rounded corner profile with a minimum radius of 19 mm.

Panels shall be lightweight, removable, and supported by a system of profiles at top, bottom, corners, tees, and door frames. Joiner panel bottom edges, corners, and tee joints in wet spaces shall be fitted with a 150 mm x 6 mm stainless-steel watertight coaming and a sealed waterproof stainless-steel bottom channel. Additional backing structure may be required in way of handrails.

3.621.3 JOINER LINERS

Panels shall be lightweight, removable, and supported by a system of profiles at top, bottom, corners, tees, and door frames. Linings shall be capable of being removed from the space and reinstalled without special tools or degradation of the panels, trim, hangers, or fasteners. Arrangement of linings shall minimize disruption of permanently installed outfitting items during lining removal and reinstallation.

3.621.4 JOINER CEILINGS

Ceiling systems shall be of self-supporting or suspended type. Ceiling panels shall consist of vinyl coated galvanized steel panels (or cassettes) or aluminum panels with baked enamel finish. Ceiling panels shall be compatible with the installed bulkhead system. Ceiling panels shall be removable. Ceiling panels shall not be loose, rattle, or vibrate. Ceiling hangers and framework shall be supported against racking forces due to ship motions.

Pilot House ceilings shall be of a flat, dark color to reduce reflectance and glare. Local flat black ceiling matting shall be provided above large displays (e.g. radars, ECDIS, workstations) to reduce reflection and glare.

3.623 LADDERS AND STAIRS

3.623.1 GENERAL

Stairs shall be provided in the accommodation levels. Stairs shall have solid risers. Inclined ladders shall have open risers. Interior inclined ladders located in spaces where personnel may traverse beneath them shall be fitted with a protective shield on the underside of the ladder. Exterior inclined ladders shall have diamond plate or non-metallic open grate style treads.

Inclined ladders and stairs shall have a maximum inclination of 50°. Inclined ladders and stairs shall have a minimum vertical clearance of 2.1 m from the treads and landings to overhead obstructions. Inclined ladders and stairs shall have non-slip stair treads and landings. Stairs shall have a minimum tread width of 1.2 m. Inclined ladders shall have a minimum tread width of 760 mm. Inclined ladders shall be arranged in a longitudinal, vice transverse orientation to the greatest extent possible.

Vertical ladders shall be constructed of steel. Vertical ladders in trunks shall be removable. Where vertical ladders cannot be installed, ladder rungs shall be provided. Ladder rungs shall be welded to the structure. Chain lockers and swash bulkheads shall be provided with foot holes in lieu of ladders and rungs. Tank and void access ladder shall be at least 508 mm (20 in) in width.

The deckhouse shall be provided with at least two enclosed stairtowers. Where practical, they shall be located in diagonally opposite portions of the deckhouse.

3.623.2 ACCOMMODATION LADDERS

Dedicated port and starboard accommodation ladders shall be provided. The accommodation ladders lower platform walking surface shall reach to 600 mm above the ballast arrival water line at a maximum angle of 55° relative to the ship's baseline.

The accommodation ladders shall each be provided with an upper platform capable of rotating 180°. The accommodation ladders shall each have 750 mm-wide curved non-skid treads, two course railing, lower platform, dockside roller, a bridle and associated handling rigging, and stowage rotation and securing features utilizing guidance from Naval Ship Systems Command (NAVSHIPS) Drawing No. 804-2255403. The stowed ladders shall not protrude outboard of the ship's hull while not in use. Safety nets shall be provided for the gap between the hull and the accommodation ladder when the ladders are in their deployed position.

The accommodation ladders shall each be provided with detachable boat landing fenders on the outboard side of the lower platform, and extendable shell fenders on the inboard side. Accommodation ladders and boat landing platforms shall be sized to withstand the impact of boats contacting the platform.

The ship shall be capable of slewing the accommodation ladders out from the side of the ship to a minimum angle of 45° relative to the ship's centerline by means of an onboard crane.

Each accommodation ladder shall have a dedicated davit for handling the ladder along the side shell. The davit shall have a safe working load capacity to handle 1.25 times the weight of the accommodation ladder including boat landing fenders. The hoisting and lowering system shall be electrically or electro hydraulically powered. The hoisting and lowering system shall hoist and lower the accommodation ladder with boat landing fenders at a minimum rate of 300 mm per second.

The accommodation ladders and boat landing platforms shall be stowed adjacent to their deployment locations or installed in a recessed pocket in the side shell at the bulkhead deck level. The stowed accommodation ladder shall be accessible for maintenance.

3.624 ACCESS CLOSURES

3.624.1 INTERIOR DOORS

Interior joiner doors and frames shall be hollow steel in accordance with ASTM F821.

Watertight doors shall be quick acting. Roller type watertight doors with remote indication are permitted in main subdivision bulkheads.

The minimum door clear height above the finished deck shall be 1980 mm. Interior doors shall have a minimum clear opening width of 660 mm except as follows. Main Machinery Room (MMR) and combustion air ventilation intakes shall have weathertight interior access doors with a minimum clear opening width of 610 mm. Stateroom sanitary spaces shall have doors with a minimum clear opening width of 610 mm. The following spaces shall have doors with a minimum clear opening width of 760 mm:

- Staterooms
- Ship Store
- Conference Room(s)
- Ship's Library
- Food service spaces
- Offices, except for the Master's Office and Chief Engineer's Office
- Pilot House
- EOS

- EDG Room
- Steering Gear Compartment(s)
- Storerooms
- Laundry spaces
- DC Lockers, if separate entrance and exit doors are provided

Thaw and refrigerated food service provision storerooms shall have doors with a minimum clear opening width of 940 mm.

The following spaces shall have double doors with a minimum clear opening width of 1,500 mm:

- Medical Treatment Room (MTR) (access to passageways and to the Hospital Room)
- Hospital Room (access to passageways and to the MTR)
- Mission Electronics Storeroom
- Cable Rigging Locker
- Sea Plow Workshop
- ROV Workshop
- Machine Shop
- Diesel Repair Shop
- Electrical Workshop
- AMR Workshops
- Engineer Storeroom
- Breathing Air Compressor Room
- Solid waste processing facility spaces.
- DC Lockers, if double doors are provided.

Interior doors shall open into rooms from passageways, except for small storerooms where outward opening doors are acceptable.

Automatic door closers shall be fitted to doors as follows:

- A/C boundary doors
- Stairtower doors
- Vestibule doors
- Deck head doors
- Office doors
- Naval Communications Center door
- Master's Stateroom door
- Chief Engineer's Stateroom door

Interior doors shall be fitted with bumper stops. Interior doors, except fire doors and doors fitted with automatic closers, shall be fitted with hook type holdbacks. Magnetic holdbacks on fire doors, when provided, shall be controlled from the Pilot House.

The following interior doors shall be fitted with fixed portlights:

- Food service space doors
- Leisure space doors
- Sewage treatment plant space doors
- Decontamination station doors
- Cargo handling area doors
- Self-serve laundry doors
- Vestibule doors
- Stairtower doors
- Doors between passageways

Fixed portlights in interior watertight doors shall be a minimum of 150 mm in diameter. Fixed portlights in other interior doors shall be 250 mm in diameter.

Interior doors to Staterooms shall be provided with kick out panels.

Interior doors opening into rooms from passageways shall not be undercut more than 12 mm.

Interior doors installed in way of sloping decks and serving wet spaces shall have sills, except double doors serving solid waste processing spaces, double doors serving the Hospital Room, and double doors serving the MTR. Interior door sills in wet spaces shall be a minimum of 100 mm above the finished deck. Interior doors installed in structural bulkheads shall have sills as necessary to satisfy ship strength and fatigue requirements.

Walk-in refrigerator doors shall be fire retardant lightweight fiberglass, sheathed in stainless-steel. Walk-in refrigerator doors shall be thermally equivalent to the insulated bulkhead to which they are attached. Walk-in refrigerator doors shall be capable of being opened from inside and outside and are to be fitted with exterior padlock hasp (with inside emergency release) and self-engaging holdbacks. Refrigerated space doors shall open outward. The minimum clear height of walk-in refrigerator doors shall be 1,830 mm.

Doors for escape trunks from the machinery spaces, if used, shall be provided with two dogs opposite the hinge.

3.624.2 EXTERIOR DOORS

Exterior doors shall be weathertight or watertight. Exterior doors shall be constructed of Type 316L stainless-steel. Exterior personnel doors on the weather deck and below shall be quick-acting watertight.

Exterior doors shall be fitted with automatic door closers. No holdback devices are permitted on exterior self-closing doors for spaces protected by fixed gas firefighting systems.

Exterior watertight doors shall be fitted with minimum 150 mm diameter fixed portlights. Other exterior doors shall be fitted with 250 mm diameter fixed portlights.

Exterior door openings shall have a minimum clear height above the deck of 1980 mm and a minimum clear width of 760 mm.

Exterior doors in longitudinal bulkheads shall open outward and forward, and those installed in transverse bulkheads shall open outward and outboard.

Where an exterior door opens to an exterior passageway, the passageway shall have a minimum clearance of 760 mm outside of the door swing.

Exterior doors shall be provided with water brows.

Pilot House exterior doors shall be either sliding or hinged. The Pilot House exterior doors shall meet following additional requirements:

- Hinged doors shall be provided with holdbacks.
- Sliding doors shall have the ability to remain partially or fully open without sudden closure due to ship motion.
- Doors shall be at least 915 mm in width.

Exterior doors on the aft face of the deckhouse shall withstand a wind load of 2 kPa.

3.624.3 HATCHES AND SCUTTLES

Means for undogging each hatch and scuttle closure shall be stowed adjacent to the hatch. Weather hatches and scuttles shall be lockable from the interior.

Grab handles shall be provided on hatches and scuttles. Grab handles installed on flush hatches and scuttles shall be hinged and recessed within the closure.

Deck mounted hatches shall be provided a mechanical holdback to hold the hatch in the open position.

Deck mounted hatches weighing in excess of 20 kg shall be provided with a mechanism to allow a single person to open and close the hatch.

3.624.4 MANHOLES

Manholes shall be fitted with gaskets. Manhole covers shall be secured with corrosion resistant fasteners. Manhole covers and manhole cover fasteners located in walking or working areas in the weather shall be flush or semi-flush. Manhole covers shall be secured with corrosion resistant fasteners.

Manhole covers and manhole cover fasteners located in other walking or working areas shall be flush. Manhole covers shall be provided with jacking bolt holes. Manholes located in the machinery space bilges shall be located a minimum of 150 mm above the deck.

3.624.5 BOLTED EQUIPMENT REMOVAL PLATES

BERPs shall have the same strength and tightness as the structure in which they are installed. BERPs weighing more than 20 kg shall be provided with dedicated lifting padeyes in the overhead, unless equipment handling padeyes can be utilized.

3.625 WINDOWS AND PORTLIGHTS

Windows shall afford the same degree of tightness as the structure to which they are attached. Watertight portlights and windows shall have weld-in steel frames. Glass shall be tempered and replaceable.

Living spaces having an exterior bulkhead shall be provided with windows. Windows shall be rectangular and be centered 1.6 m above the finished deck, with the exception of the Pilot House. Stateroom and office space windows shall be at least 460 mm x 610 mm. Messroom and lounge windows shall be at least 500 mm x 1,000 mm.

Living space windows and portlights shall be provided with curtains. The curtains shall be lined and weighted. Curtains shall be hand traversed on extruded anodized aluminum rods. Curtains shall be provided with snaps or hook-and-loop fasteners to retain them in open and closed positions.

Pilot House windows shall be provided with wiper-equipped windows and a window washing system. Window wiper blade material shall be suitable for operation at the minimum exterior operating temperature. 50% of the windows shall be provided heaters for de-icing. The heated windows shall be located to allow maximum visibility. Catwalks with guardrails shall be provided for exterior cleaning of Pilot House windows. Pilot House windows shall be fitted with interior, pull-down screen sunshades.

The Pilot House shall be provided with at least one opening window on the port and starboard sides. If the Bridge Wings are totally enclosed, the opening windows shall be side-hinged and provide visibility to the waterline along the length of the ship. Partially open Bridge Wings shall not have windows on the outboard sides.

3.631 CORROSION PREVENTION AND CONTROL

The ship, except as noted below, shall be protected from corrosion. Coating system materials shall be selected from either a Navy Qualified Products List (QPL) approved for the application or Appendix H, except where addressed herein. The coating shall be applied in accordance with Appendix H, except as modified herein. Each individual coat for a given coating system shall be from the same manufacturer. Materials for coating systems shall be applied in accordance with ASTM F718 data sheet supplied by the manufacturer of that product.

Seawater ballast tank coatings shall comply with IMO Prevention of Corrosion on Board Ships.

Type 316 stainless-steel fasteners and composite outfitting materials shall be used in all weather-exposed applications.

3.631.1 LIMITATIONS

The following shall not be painted or coated:

- Cathodic protection reference cells and anodes
- Heat exchange surfaces
- Gasket seats
- Lubricating fittings
- Nameplates, labels, and signs
- Threads and working surfaces
- Rubber and other elastomers
- Firefighting system nozzle
- Decorative and finished parts of furnishings and equipment
- Windows and portlights
- Stainless-steel material
- Internal surfaces of waster pieces
- Electrical and electronic cables which:
 - Have not been successfully tested per the ABS requirements and received USCG

- approval
 - Are on OEM's equipment
 - Are subject to repeated flexing from equipment movement
 - Are intrinsically safe cables
 - Are high voltage electrical cables
 - Are Interior wireless communications cables such as Radiax and Heliac systems
- Ordnance grounding point

3.631.2 SURFACE PREPARATION

Underwater hull, freeboard, superstructure (including masts and kingposts), exterior decks, ramps, bilges, voids, air plenums, tanks surfaces, decks of other wet areas, and up to 300 mm above the decks of other wet areas shall:

- Be prepared to a near white blast in accordance with SSPC SP 10 and primed with an approved inorganic zinc silicate type shop pre-construction primer except as specified in Table 3.631.2-1
- Have edges radiused to a minimum of 2 mm
- Have welds prepared to NACE SP0178 Grade D
- Have pre-construction primers removed and the surfaces cleaned at time of final coating system application in accordance with SSPC SP 10, except as specified in Table 3.631.2-1

Stainless-steel that is painted shall be prepared in accordance with SSPC SP 2 with a surface profile of 1.5 mils.

Pre-construction primers, where compatible with the paint system, uncontaminated, clean, sound and intact, are not required to be removed in interior dry spaces and as specified below, but shall not be considered as one coat of primer. Pre-construction primers shall be removed in all other instances.

Table 18: [3.631.2-1] Surface Preparation Standards (per SSPC)

Area	Secondary Surface Preparation				
	Intact Pre-Construction Primer	Blast and Paint Facility		Erection or Grand Block	
		Damaged Areas	Butts/Seams	Damaged Areas	Butts/Seams
Bilges, Decks of Wet Areas, and Voids	SP 1	SP 3	SP 11	SP 3	SP 11
Sanitary and Waste Oil Tanks	SP 7	SP 10	SP 10	SP 11 (Note 2)	SP 10

Area	Secondary Surface Preparation				
	Intact Pre-Construction Primer	Blast and Paint Facility		Erection or Grand Block	
		Damaged Areas	Butts/Seams	Damaged Areas	Butts/Seams
Underwater Hull, Boottopping	SP 1	SP 3	SP 11 with 2 mil Profile	SP 3	SP 11 with 2 mil Profile
Exterior Decks with and without Personnel Non-Skid	SP 1	SP 3	SP 10	SP 3	SP 10
Ballast Tanks	SP 7	SP 11 (Notes 1 and 2)	SP 10	SP 11 (Notes 1 and 2)	SP 10
Fuel Oil Tanks	SP 10	SP 10	SP 10	SP 11 (Note 2)	SP 10
Lube Oil Tanks	SP 10	SP 10	SP 10	SP 10	SP 10
Freeboard, Superstructure, and Air Plenums	SP 1	SP 3	SP 10	SP 3	SP 11 with 2 Mil Profile

Notes:

1. In accordance with IMO Annex I, Resolution MSC.215(82): SSPC SP 11 may be used in areas of neighboring damage which are up to 25 m² and up to 2% of the total block area to be coated. SSPC SP 10 is required in the areas of neighboring damage which are either greater than 25 m² or greater than 2% of the total block area to be coated.
2. Damages prior to coating where profile is lost shall be blasted to SSPC SP 10. Damages after final paint of the tanks shall be completed with SSPC SP 11. If contiguous damaged area exceeds 25 m², damaged area shall be prepared to SSPC SP 10 (similar to IMO resolution for Ballast Tanks).

3.631.3 STRIPE COATING

A “stripe” coat shall be applied to edges, welds, cutouts, crevices, rivets, and bolts between spray coats in the following locations:

- Underwater hull
- Freeboard
- Superstructure (including masts and kingposts)
- Decks, ramps, bilges, voids, air plenums, and tanks
- Wet areas up to 300 mm above the decks of wet areas

The “stripe” coat shall be unthinned of a contrasting color and the same product as the previous coat. “Stripe” coats in tanks shall be applied by brush.

Welds in way of non-skid shall be stripe coated.

3.631.4 ENGINE EXHAUST TREATMENT SYSTEM REDUCING AGENT SERVICE AND STORAGE TANKS

The coating system for the engine exhaust treatment reducing agent service and storage tanks shall be in accordance with the engine exhaust treatment system manufacturer’s recommendations.

3.633 CATHODIC PROTECTION

An automatic impressed current system shall be provided to protect areas of the underwater hull with damaged coatings. The system shall provide protection with up to 15% of the underwater surface area uncoated.

Anode currents and power supply functions shall be centrally regulated and balanced. Alarm conditions shall be annunciated, and system status logged via the MCCS. The system shall be adjustable and include low level protection settings.

Anodes and reference cells shall be permanently installed on the exterior hull a minimum of 1.5 m below the waterline in the lightest loading condition. Anodes and reference cells shall be located in areas most protected against physical damage from chain, bottom scraping, lighterage, and fenders.

Voltage drop at maximum current for anode to power supply cables shall be less than 4 V. Anode leads from the same power supply shall be maintained at less than a 2 V differential. Anodes shall be in accordance with Table 3.633-1.

Table 19: [3.633-1]: Requirements for Impressed Current Cathodic Protection Anodes

Underwater Wetted Surface Area of Hull and Appendages, m²	Design Current of System, amps	Number of Reference Cells	Number of Controllers, min.	Number of Type I Anodes, min.	Number of Type II Anodes (optional)	Current Available Using Min. Type I and II Anodes

	min.					
5,580 – 7,430	875	2	2	8	2	900
7,430 – 9,300	1100	4	2	8	4	1200
9,300 – 9,760	1200	4	2	8	4	1200
9,760 – 10,690	1300	4	2	10	4	1350
10,690 – 11,620	1400	4	2	12	4	1500
11,620 – 12,550	1500	4	2	8	6	1500

Notes:

1. ASTM B418 Type I anode - designed to operate at currents up to a maximum of 75 amps
2. ASTM B418 Type II anode - designed to operate at currents up to a maximum of 150 amps

Dielectric shields shall be installed around and beneath anodes.

Anodes shall:

- Be located no closer than 5 m from the main seawater intakes and outlets
- Be located a minimum of 12 m from speed log positions, reference cell positions, and transducers
- Have their shape and location, and that of their reference cells, forward of and in the vicinity of the sonars specified by the noise consultant
- Be located ahead of the propeller plane. Where azimuthing propulsors are provided, the propeller plane shall be with the propulsor oriented in the ahead thrust position.
- Be located a minimum of 12 m apart
- Be evenly distributed in the remaining underwater hull area
- Be located so as not to interfere with the drydock arrangement
- Be located in an area where turbulent flow of water is minimal
- Not be installed on the flat bottom

Where practical, pairs of anodes shall be located symmetrically port and starboard. When ASTM B418 Type II anodes are provided, they shall be located in the area of greatest current demand. Where this area is in the stern near the propellers, ASTM B418 Type II anodes shall be located a minimum of 3 m and a maximum of 15 m from the propellers. Where podded propulsors are provided, measurements shall be with the propulsors oriented in the ahead thrust position.

The center of each anode and reference electrode outer hull penetration shall be a minimum of 250 mm from a vertical butt weld.

The electrical connections to the anodes and reference cells shall be accessible from inside the hull for maintenance and repair. Through-hull penetration stuffing glands for anodes and

reference electrodes located in spaces where they may be subject to physical damage shall be protected.

A means of centralized control shall be provided to coordinate and balance the performance of multiple controller, power supply, anode, and reference electrode systems.

Supplemental sacrificial anodes shall be provided in accordance with ASTM F1182. The anodes shall be installed in accordance with NAVSEA Drawing No. 803-921865 for rudders, skeg(s), shaft seals, thruster(s), propulsors, bilge wells, seawater ballast tanks, VCHT, gray water holding tank, intermediate gray water holding tanks, OWHT, seawater intakes to machinery, seawater shell and tube heat exchangers, sea chests, and seawater floodable voids. Sacrificial anodes are not required for titanium plate type heat exchangers.

Oscillating and reciprocating appendages shall be bonded to ground by brazing a flexible copper cable between the appendage and the hull. The length of the bonding cable shall accommodate the full range of the appendage rotation. Rudder posts shall be grounded on the inboard side. The grounding connections shall be accessible for inspection.

3.634 DECK COVERING

Deck coverings requirements shall be in accordance with Appendix I.

Where deck coverings do not require application of a deck leveling compound, deck weld profiles shall be ground to a maximum of 1.6 mm (0.06 in). Resilient deck coverings and quarry tile shall have a smooth underlayment fitted before installation.

Deck weld profiles in living spaces shall be ground to a maximum height of 1.6 mm.

A smooth underlayment shall be fitted before installation of deck coverings except paint. Water-soluble underlayments and water-absorbent epoxy-based underlayments are prohibited. Underlayments shall be sloped to drains in wet spaces.

The Pilot House steering station and other control stations in the Pilot House shall be provided with a cushioned, rubber standing mat. A 915 mm wide rubber sheet runner shall be provided athwartship across the Pilot House along the forward bulkhead.

Slip resistant (non-skid), painted deck covering shall be applied to all deck areas exposed to the weather, in the Moonpool Staging Bay, and the Cable Highway from the Cable Highway Aft Door sill to 10 m forward of the forwardmost CHE.

3.635 COMPARTMENT TREATMENTS

3.635.1 GENERAL

Thermal insulation at compartment boundaries shall be fiberglass faced insulation board. Acoustic and structural fire protection insulation at compartment boundaries shall be as specified herein.

The surfaces to which insulating material is applied shall be cleaned and given a protective coating. Insulating materials shall not come loose due to ship's movement or vibrations.

Insulation installation shall prevent standing liquids from wicking up into the material.

Edges of insulation shall be sealed with adhesive. Seams shall be covered with a minimum 50 mm wide fibrous glass cloth tape. Board and block shall be provided in multiple layers with staggered joints. Board and block shall be joined with adhesives.

Insulated surfaces that may be exposed to damage or wear during normal ship operations shall be sheathed with #16 USSG galvanized sheet steel, linings, or sanitary sheathing to protect the insulation.

Where both thermal and acoustic insulation are required, if the acoustic insulation provides a U-factor no greater than the maximum U-factor specified herein and condensation will not occur under the acoustic insulation, only the acoustic insulation shall be applied. Where the resulting acoustic insulation U-factor is greater than that specified herein, or where condensation can occur, thermal insulation with vapor sealing shall be provided under the acoustic insulation to reduce the U-factor to no more than the maximum U-factor specified herein.

3.635.2 INSULATION, THERMAL

SNAME T&R Bulletin No. 4-7 shall be used for determination of insulation requirements and U-factors (heat transmission factors) unless otherwise specified.

Boundaries requiring insulation shall be fitted with insulation on plane surfaces and around webs and flanges of structural members. Uninsulated boundaries that abut insulated boundaries shall be insulated out to a distance of 300 mm from the insulated boundary.

Thermal insulation providing the performance specified herein shall be installed on boundaries between air-conditioned and non-air-conditioned areas. Where spaces gain heat from adjoining compartments and require insulation, the common boundary shall be insulated on the high temperature side with the exception that decks shall be insulated on the underside.

Refrigerated spaces shall be insulated to maintain required temperatures and prevent sweating on the warm side of decks, bulkheads, and shell over the required range of outside air temperature and humidity. Boundaries shall be insulated on the low temperature side.

3.635.3 INSULATION, ACOUSTIC

Acoustic absorptive treatment shall be provided to meet the airborne noise criteria specified herein. Acoustic absorptive treatment shall be applied to plane surfaces only. Acoustic treatment of machinery spaces and fuel handling areas shall not absorb oil and oil vapors. Perforated hardfaced insulation shall be used in areas where high grade finishes are not required except in machinery spaces and fuel handling areas.

Where acoustic absorptive treatment is required for a deck head and a suspended ceiling is provided, acoustic ceiling panels shall be provided. Installation of acoustic treatment for suspended ceilings does not negate thermal insulation requirements for deck heads.

3.635.4 VAPOR BARRIERS

Insulation within the following spaces shall have either a vapor barrier applied to the insulation or have insulation facing with a vapor barrier:

- Laundries
- Scullery
- Galley
- Refrigerated spaces, on the high temperature side
- Spaces where the dew point temperature of the space is more than 15 °C higher than the temperature of the insulated surface in the adjacent space during cooling and heating seasons

3.637 SHEATHING

Bulkheads and overheads in galleys and sculleries shall be sheathed with stainless-steel sheet having No. 4 finish in accordance with ASTM A480. Ceiling panels shall be removable.

Bulkheads in refrigerated spaces and solid waste processing facility shall be sheathed with stainless-steel sheet having No. 4 finish in accordance with ASTM A480.

Bulkheads and overheads in the MTR and Hospital shall be sheathed with stainless-steel sheet having No. 4 finish in accordance with ASTM A480 or fiberglass reinforced polyester resin laminate. Ceiling panels shall be removable.

Joints and corners in stainless-steel sheathing shall be covered with stainless-steel strips and shapes respectively. Stainless-steel strips and shapes shall be secured with stainless-steel fasteners.

3.640 LIVING SPACES

Accommodations, sanitary spaces, office spaces, laundry rooms, lounges, and leisure spaces shall be in accordance with MSC QMS N0720-110.00-P, Habitability Standards for New Construction Large Ships.

3.641 STATEROOMS

3.641.1 LOCATION AND SIZE

Staterooms shall be located on an exterior bulkhead, except EST staterooms may be interior. Staterooms for officers shall be separated from and, in multi-decked accommodations, located above CPO and crew staterooms, or, if located on the same deck, shall be separated by a passageway door. Similarly, staterooms for CPOs shall be separated from and, in multi-decked accommodations, located above crew staterooms, or, if located on the same deck, shall be separated by a passageway door. Stateroom spaces shall be grouped by department to the maximum extent possible. Stateroom spaces shall be grouped by watch standers to the maximum extent possible. The Master, Chief Engineer, SDR, and Mission Director (MD) staterooms shall be located forward of other staterooms. When deck and engine personnel are mixed on the same deck, deck personnel shall be grouped to starboard and engine personnel to port.

Staterooms shall not share a common boundary with fan rooms, laundry spaces, lounges, and machinery spaces.

The total accommodations and other complement related facilities, services, stores, and functions shall be based on Table 3.641-1. Staterooms shall have the minimum areas in accordance with Table 3.641-1. The required area in Table 3.641-1 shall be the gross area inside the joiner bulkheads without deductions for furniture.

Table 20: [3.641-1] Number and Size of Staterooms

Room Classification	Number of Rooms	Number of Personnel	Minimum Stateroom Size, m²	Personnel Type
Senior Licensed	4	4	19	Master, Chief Engineer, SDR, MD
Department Head	7	7	16	1 st Officer, 1 st Assistant Engineer, Supply Officer, Ship's Communication Officer (SCO), Purser, MSO, EST Officer
Licensed	36	36	13	MSC licensed personnel and mission personnel
CPO	15	15	13	MSC CPOs, EST CPO
Unlicensed	42	42	10	Unlicensed personnel

2 Person	1	2	11	EST/Surge
4 Person	2	8	20	EST/Surge

3.641.2 ARRANGEMENTS AND CLEARANCES

The arrangement of fixed furnishings shall permit use of the full range of drawers, doors, and writing surfaces. When open, drawers shall not block entry and egress from the space. Berths shall be oriented fore and aft.

3.641.3 FURNISHINGS AND MATERIALS

Furniture shall be commercially available marine grade of steel or aluminum construction. Steel surface finishes shall be baked enamel, fluidized epoxy, resin laminate, or chrome plated. Aluminum surfaces shall have an anodized clear satin finish. Working surfaces of tables, desks, dressers, bookcases, cabinets, and sideboards shall have resin laminate tops.

Fixed furniture and decorative lighting fixtures shall be secured to decks or bulkheads. Portable furniture shall be fitted with securing devices and flush deck sockets. The sockets shall not compromise deck integrity.

Furniture drawers and doors shall be provided with individual latches to prevent them opening due to ship motion.

3.644 SANITARY SPACES AND FIXTURES

A refrigerated, plug-in drinking fountain shall be provided in the passageway on each accommodation level.

3.644.1 STATEROOM SANITARY SPACES

Private baths shall be provided for Senior Licensed, Department Head, Licensed, and CPO staterooms. Private baths shall be contiguous with one stateroom. Private baths shall have a minimum area of 2.8 m². Semi-private T&S shall be provided for unlicensed staterooms. Semi-private T&S spaces shall be contiguous with two staterooms. Private T&S shall be provided for two person and four person staterooms. Private T&S spaces shall be contiguous with one stateroom. T&S spaces shall have a minimum area of 2 m².

Shower enclosures shall have a minimum clear area of 915 mm x 915 mm. Shower heads shall be located a minimum of 1.9 m above the finished deck. Shower heads shall be directionally adjustable.

Exposed supply piping and drains shall have a non-corroding surface finish.

Lavatories shall be vitreous china, in accordance with ASME A112.19.2, with back, rectangular sink, splash lip, overflow, and soap depressions.

Faucets shall have knob handles. Faucet knobs shall be clearly and permanently marked 'H' for hot water on the left side control and 'C' for cold water on the right side control.

3.644.2 DECK HEADS

Deck heads shall be provided at the following locations:

- In the vicinity of each permanent Quarterdeck Station
- Contiguous with the Pilot House
- In the vicinity of the EOS
- In the vicinity of the Mission Control Room
- In the vicinity of the Conference Rooms
- In the vicinity of the Gymnasium
- Near amidships on the cable highway
- In the vicinity of each department office
- On each accommodation level

Where these locations are collocated, dedicated deck heads are not required.

Access to deck heads shall not open to Galley, Scullery, serving line queuing area, or messrooms.

3.644.3 CLEANING GEAR LOCKERS

Cleaning gear lockers with a minimum area of 2.3 m² shall be provided on each deckhouse level. The Galley shall be provided with a dedicated cleaning gear locker.

Cleaning gear lockers shall be furnished with a hot and cold hose bibb faucet located 600 mm above the deck, a deck pan or deck coaming with drain, a stainless-steel deep sink, a 900 mm x 300 mm shelf, and a mop and broom rack. A 1.8 m length of water hose adaptable to hose bibb shall be provided.

3.644.4 EMERGENCY WASH FACILITIES

Permanently plumbed emergency combination shower and eye/face wash units and emergency eye/face units shall be provided in accordance with ANSI/ISEA Z358.1, Office of the Chief of Naval Operations Instruction (OPNAVINST) 5100.19, and as described below.

Emergency combination shower and eye/face wash units shall be provided as a minimum in the following locations:

- Compartments that employ or store caustic, corrosive, or toxic agents
- Moonpool Staging Bay
- Near the aft end of the cable highway

Emergency eye/face wash units shall be provided as a minimum in the following spaces:

- Machinery spaces adjacent to the purifier workbench basins
- Splice Shop
- MTR
- Plow and ROV Shop
- Sewage treatment plant space
- Flammable Liquids Storeroom
- Incinerator Room
- Lithium Battery Room
- Workshops and laboratories

Emergency wash facilities shall be provided with audible alarms in accordance with OPNAVINST 5100.19. The alarms shall be located in the passageway outside the compartment containing the emergency wash facility. The alarms shall sound remotely via the MCCS.

3.644.5 ENGINEER'S CHANGE ROOM

An Engineer's Change Room with a minimum area of 20 m² shall be provided. The Engineer's Change Room shall be adjacent to the EOS.

The washer and dryer shall be installed with their rotating axis oriented fore and aft.

3.645 LEISURE SPACES

Leisure spaces, including lounges and gymnasiums, shall be provided in accordance with MSC QMS N0720-110.00-P, Habitability Standards for New Construction Large Ships. Lounges shall be in the vicinity of staterooms of the same rank. Physical fitness equipment shall be commercial grade quality.

Each space shall be provided with a Miscellaneous Equipment Storeroom. The storeroom shall be contiguous with the leisure space served unless otherwise approved. Miscellaneous Equipment Storerooms shall have a minimum area of 2.5 m².

3.651 FOOD SERVICE SPACES

Food service and ship's store shall be in accordance with MSC QMS N0720-111.00-P, Steward Department and Food Service Standards for New Construction Large Ships.

The food service spaces shall be on the same deck as the solid waste processing facility. Traffic flow from the serving line to the messrooms, and from the messrooms to the scullery, shall provide ease of personnel movement without doubling back. The access to the scullery passing window shall not interfere with the serving line, serving line queuing area, and the paths from the serving line to the messrooms.

3.651.1 EQUIPMENT AND INSTALLATION

Food service equipment shall be commercially available equipment complying with the requirements of NSF/ANSI 2. Furnishings, counter mounted appliances, and installed equipment shall withstand the effects of ship motions. Furnishings that come into contact with food and drink (except mess tables) shall be constructed of stainless-steel. Furnishings shall be free of sharp edges, sharp corners, and burrs. Corners shall have a minimum 13 mm radius. Furnishings shall be easy to clean and maintain, with no cracks, crevices, or voids that may harbor vermin, food waste, and other extraneous matter. Expanded or perforated metal shall not be permitted.

Portable and mobile equipment shall be provided with quick-release securing mechanisms at both service and storage locations. Dresser and counter mounted electrical equipment shall be plug-in type.

Food service equipment shall be hatchable.

Appliances shall be electric with automatic front-mounted controls. Hot cooking appliances, hot sanitizing equipment, and cold storage equipment shall be provided with built in thermometers. Deck mounted equipment and dressers shall be supported by 150 mm to 200 mm high stainless-steel legs secured to the deck. Fixed, dresser, or counter mounted equipment shall be installed on 100 mm high stainless-steel leg supports secured to the dresser or counter.

Griddle(s), range(s), and deep fat fryer(s) shall be installed with top surfaces 915 mm above the finished deck. A stainless-steel shield, extending to 300 mm above the top surface shall be installed on the back and both sides of the griddle(s), range(s), and deep fat fryer(s). The shield may be omitted where this equipment protection is provided by bulkhead sheathing, the vent hood end plate, or where a dresser is installed adjacent to the unit. Deep fat fryer(s) shall be arranged so that the operator position is forward or aft of the unit.

Galley exhaust shall be steel. Galley ventilation hoods shall have washdown capability and automatic fire dampers that exhaust directly to the weather. Galley ventilation hoods shall be provided with an emergency shutdown switch located outside each entrance to the Galley.

Sinks shall be located a minimum of 1.2 m from equipment having an external cooking surface. Sinks of size 530 mm x 610 mm and larger shall be 14-gauge metal. Sinks smaller than 530 mm x 610 mm shall be 16 gauge. Sinks shall have dresser or counter space on both sides. Dressers and counters adjacent to sinks shall slope to the sinks or be fitted with drains piped to deck drains. Sinks shall be provided with flush, portable, stainless-steel covers with finger holes.

A minimum of 610 mm x 610 mm of dresser top workspace shall be provided adjacent to both sides of installed pieces of Galley equipment. Dresser tops shall be reinforced to support dresser mounted equipment and prevent vibration when equipment is operated.

Dressers, cabinets, and shelves shall be stainless-steel Type 304 with a No. 4 finish in accordance with ASTM A480. Dressers and counters shall have an 18-gauge body with a 12-gauge top. Shelving shall be 18-gauge. Cabinets shall have an 18-gauge body with 20-gauge doors and shelves. Dressers and counters shall be installed with working surfaces 915 mm above the finished deck. Dressers and counters shall have a minimum depth of 530 mm.

Unless otherwise specified, the space under dresser tops and under drawer units installed within dressers shall be fitted with two removable stainless-steel Type 304 shelves. The bottom shelf shall be located a minimum of 200 mm above the finished deck. The shelving shall be removable without using tools and shall have portable battens on the front and fixed battens on the sides and back.

Splashboards shall be provided at the backs and ends of dressers and counters where they adjoin bulkheads, vent hoods, and food service equipment. Splashboards shall be formed from the dresser top material and extend 150 mm above the working surface. The space between the splash back and adjoined bulkhead, sheathing, or equipment shall be fitted with stainless-steel Type 304 flashing and sealed with seam filler.

The edges of dressers or counters, when not fitted with splashboards, shall be formed to provide a retainer edge and an apron integral with the dresser or countertop. The top of the retainer edge shall be approximately 20 mm above the working surface and have a 10 mm radius. The apron shall cover the top horizontal frame member.

Dressers and counters shall:

- Be parallel to the ship baseline
- Have a minimum of 150 mm of clearance between bulkheads, and adjacent equipment, or be butt fitted and sealed
- Be mounted with front toe space
- Have welds ground smoothed to a No. 4 finish in accordance with ASTM A480 with no

discoloration

- Not have solder or riveted joints
- Have closed ends and sides or butted to form a continuous piece
- Have butt welded and finished sinks, drains, and other inserts as an integral part of the top
- Be fitted with drains, piped to deck drains, where tops can collect water

Cabinets installed above dressers shall have a minimum clearance of 450 mm above the working surface with the fronts of the cabinets set back 300 mm from the working face of the dressers. Cabinets shall be fitted with removable shelving.

Shelving installed above dressers shall have a minimum clearance of 450 mm above the working surface with the fronts of the shelving set back 300 mm from the working face of the dressers. Shelving shall be fitted with portable battens in front and fixed flat battens on the sides.

3.651.2 GALLEY

General and task areas of the Galley shall be segregated. The Galley shall provide passage and working areas to facilitate ease of movement of Galley workers.

One side of the Galley shall open to an adjacent passageway to form a serving line. The serving line queuing area shall be separated from the serving dressers by a bulkhead fitted with a pass-through window extending the full length of the serving dressers. The window shall be fitted with a lockable roller curtain door with positive means to prevent closing when in the open position. The serving line queuing area shall be a minimum of 6 m long (not including the tray rail). The path from the Galley tray rail to the messrooms shall be a minimum of 1.7 m wide.

3.651.3 SCULLERY

Adequate personnel passage shall be provided for working areas and equipment.

The scullery shall be fitted with a pass-through window with a direct opening into an adjacent passageway. An area shall be designated to accommodate trash receptacles adjacent to the pass-through window.

Final rinse water shall be provided at a minimum temperature of 82 °C. The dishwashers shall be fitted with thermometers for wash, rinse, and final rinse. Thermometers shall be installed on the final rinse supply line as close as practical to the point where the supply enters the machine. Thermometers shall be visible and accessible from the front of the dishwasher.

Counters shall be installed in way of the pass-through window and before and after the dishwasher.

3.651.4 MESSROOMS

Separate Licensed, CPO, and Unlicensed Messrooms shall be provided. Messrooms shall be located on an exterior bulkhead and have a minimum of two windows.

The back-to-back clearance between personnel seated at adjacent tables and between the backs of seated personnel and adjacent bulkheads shall be a minimum of 610 mm. Minimum clearance outboard from the tray rail to other equipment, seating, or bulkheads shall be 1200 mm.

Coffee makers shall be connected to a cold potable water supply. Coffee messes shall be provided with stainless-steel CRES Type 304 decanters. Coffee messes shall be provided with storage for ingredients and accessories.

3.652 MEDICAL FACILITIES

Medical spaces shall be in accordance with MSC QMS Design Standard N0720-114.00-P-Medical Space Standards for New Construction Large Ships.

The medical facility shall be located above the freeboard deck. The medical facility shall not be located adjacent to the machinery casing, food service spaces, lounges, Ship Store, Conference Room, Ship's Library, control spaces, EDG Room, and Steering Gear Compartment(s). Ship's medical spaces shall be located to permit unobstructed movement of a loaded stretcher to the Medical Evacuation (MEDEVAC) area without carrying it up or down a ladder or otherwise tilting the stretcher. The Medical Treatment Room and the Hospital shall be contiguous and have direct access to each other and to the hospital bath.

3.652.1 DISTRIBUTED MEDICAL SUPPORT EQUIPMENT

Bulkhead mounted first aid boxes to stow the inventory of the approved Authorized Medical Allowance List (AMAL) shall be provided in the following locations:

- In passageway adjacent to the Galley
- Pilot House
- EOS
- Naval Communications Center
- Mission Control Center
- In passageway adjacent to the Ship's Laundry
- Workshops
- Moonpool Staging Bay
- Cable Highway
- Machinery spaces
- Enclosed Materials Handling Equipment (MHE) passage

Mounts for stowing Stokes type litters shall be provided in the following locations:

- In the passageway adjacent to the medical facility
- Adjacent to the Galley
- Adjacent to the main machinery space access
- Moonpool Staging Bay
- Cable highway

Mounts for Reeves Sleeve II Litter(s) (NSN 6530-01-477-8524) shall be provided as follows:

- In the passageway adjacent to the medical facility
- Adjacent to the top of each access trunk spanning more than two levels

3.654 SHIP STORE

A Ship Store shall be provided in the vicinity of the food service spaces. The Ship Store shall be a minimum of 15 m². The Ship Store shall be arranged to accommodate a minimum of three patrons at the same time.

3.655 LAUNDRY SPACES

Laundry spaces shall be in accordance with MSC QMS N0720-110.00-P, Habitability Standards for New Construction Large Ships.

Separate self-serve laundries shall be provided on each deck level with staterooms for Licensed, and Unlicensed personnel. Self-serve laundry spaces shall be located in the vicinity of the staterooms served.

Washers and dryers shall be installed with their rotating axis oriented fore and aft. A 100 mm high watertight coaming shall be provided around the washer(s) with a deck drain installed within the coaming area. Self-serve laundry equipment shall be hatchable. Washers shall have individual potable water connections.

Dryer exhaust ventilation shall be a dedicated exhaust system, separate from the ship recirculation system and shall include accessible cleanout ports for each leg of the exhaust from the dryer to the weather. A horizontally installed secondary lint filter or lint arrester shall be provided on the dryer exhausts. Lint filter mesh size shall be approximately 40-mesh.

3.661 ADMINISTRATIVE SPACES

Administrative spaces shall be in accordance with MSC QMS N0720-110.00-P, Habitability Standards for New Construction Large Ships.

3.661.1 LOCATIONS

The Master's, Chief Engineer's, SDR's, and MD's Offices shall be contiguous to their staterooms. They shall have access to the adjoining passageway and be located on an exterior bulkhead.

The Purser's Office, Chief Steward's Office, Supply Office, food service spaces, and Ship Store shall be grouped in the vicinity of each other.

The Deck Office and Bosun Office shall be grouped in the vicinity of each other and have convenient access to the weather deck.

The Engineering Log Office and Technical Library shall have convenient access to the EOS.

3.661.3 FURNISHINGS AND MATERIALS

Furniture shall be commercially available marine grade furniture of steel or aluminum construction. Steel surface finishes shall be baked enamel, fluidized epoxy, resin laminate, or chrome plated. Aluminum surfaces shall have an anodized clear satin finish. Working surfaces of tables, desks, dressers, bookcases, cabinets, and sideboards shall have resin laminate tops.

Fixed furniture and decorative lighting fixtures shall be secured to decks or bulkheads. Portable furniture shall be fitted with securing devices and flush deck sockets. Sockets shall not compromise deck integrity. Furniture drawers and doors shall be provided with individual latches to prevent them opening due to ship motion.

3.662 CONTROL SPACES

3.662.1 PILOT HOUSE

3.662.1.1 GENERAL

The Pilot House shall be in accordance with MSC QMS N0720-113.00-P, Deck Department and Pilot House Standards for New Construction Large Ships.

The Pilot House arrangement shall be in accordance with the ABS Guide for Bridge Design and Navigational Equipment/Systems and ISO 8468. The Pilot House shall be arranged into individual functional areas, to facilitate management by two or more bridge operating personnel. These functional areas include:

- Primary Conning
- Manual Steering
- Secondary Conning
- Central Monitoring and Control
- Bridge Wings
- Route Planning
- Damage Control Central
- Weather Planning
- Communication

The Pilot House shall have a minimum clear height of 2.25 m from the deck to the lowest overhead obstruction. Portable slip-resistant electric grade mats shall be installed in front of electronics equipment and behind electronics equipment when rear access is provided. Bridge Wings shall extend to the full breadth of the ship to allow visibility of the ship's sides and waterline. If Bridge Wings are not fully enclosed, then they shall be fitted with the following:

- Overhead weather protection
- Windows forward
- Deck drains
- Access to catwalks

Light traps shall be provided on accesses between the Pilot House and other interior spaces. The light trap shall be either a vestibule or stairtower with a door at the deck level below the Pilot House. Cover plates shall be provided on light trap doors.

3.662.1.2 CONSOLES, CONTROL, AND DISPLAYS

Consoles shall be configured and designed for operation by standing personnel. Indicator lights on consoles and local panels shall be the LED type. Software programs running on Pilot House

displays shall have the capability to switch from “daytime” to “nighttime” color graphics to optimize user ability to see display data in the respective ambient light conditions.

The following overhead displays shall be located above the front conning window. The overhead displays shall be clearly visible from the Manual Steering Station, Primary Conning, Secondary Conning, the SCC, and Central Monitoring and Control:

- Ship’s Heading
- Rudder Angle Indicator
- Shaft Speed (revolutions per minute)
- Propeller Pitch (if CP)
- Wind Speed and Direction (graphic/analog)
- Ship’s Speed Log
- Rate of Turn Indicator
- LEFT and RIGHT helm direction signs
- Clock, digital display

PBX telephones shall be provided at the following positions: SCC, DPS Control, Central Monitoring and Control, DCC, Route Planning Workstation, and adjacent to the Captain’s starboard chair in the Pilot House.

3.662.1.3 PILOT HOUSE FURNISHINGS

There shall be a total of 24 chart table drawers split between the various chart tables. Chart table drawers shall be provided with the following features:

- Arranged six high per table
- A minimum height of 76 mm
- Individual positive locking mechanisms for both the fully open and fully closed positions
- Open in the fore and aft direction
- Open fully and allow drawer removal without disassembling or moving the chart table

3.662.2 ENGINEER’S OPERATING STATION

The EOS shall be in accordance with MSC QMS N0720-112.00-P, Engine Department and Ship Standards for New Construction Large Ships. EOS shall be located on a single level and shall be adjacent to the Engineer’s Change Room. Fixed windows shall be provided in the EOS that permit visibility of the machinery plant(s).

3.662.3 QUARTERDECK STATIONS

Quarterdeck Stations shall be in accordance with MSC QMS N0720-113.00-P, Deck Department and Pilot House Standards for New Construction Large Ships.

Permanent enclosed Quarterdeck Stations shall be provided at the accommodation ladders. The Quarterdeck Stations shall be equipped with window(s) to provide an unobstructed view of the deployed accommodation ladder and surrounding boarding area for operational security surveillance of any visitor approaching.

Each permanent Quarterdeck Station shall have a minimum area of 3.25 m². The permanent Quarterdeck Stations shall have either a Dutch door with direct access to the boarding area or a sliding window facing the boarding area.

3.663 NAVAL COMMUNICATIONS CENTER

The Naval Communications Center shall be provided for the government furnished communications suite and network equipment identified via the Naval Communications System Turnkey Approach to be provided for DD&C. Identified space dimensions shall be the gross area inside the joiner bulkheads without deductions for furniture. The arrangement of C4I equipment, electronics, and furnishing shall be in accordance with the Naval Communications System Turnkey Approach to be provided for DD&C.

The space shall be located as close to the topside antennas as possible. The space shall not have windows.

A heavy duty raised floor with removable tiles suitable for use over electrical cables shall be provided in the Naval Communications Center. The space shall have a minimum clear height of 2.25 m from the top of the raised floor to the lowest overhead obstruction. Portable slip-resistant electric grade mats shall be installed in front of electronics equipment and behind electronics equipment when rear access is provided.

The Naval Communications Center shall have a minimum area of 49 m². The Naval Communications Center shall measure approximately 7.0 m x 7.0 m.

Approximately 4.5 MT of GFE equipment shall be installed in the Naval Communications Center in accordance with the Naval Communications Systems Turnkey Approach to be provided for DD&C. GFE power requirements are approximately 35 kW (115 VAC, 60 Hz, single phase) and 10 kW (460 VAC, 60 Hz, 3 phase). GFE HVAC load is approximately 50 kW.

3.664 DAMAGE CONTROL SPACES

Decontamination station(s) shall be located to permit access to the ship via the decontamination station(s) from any place in the weather and shall provide for personnel decontamination and isolation of contaminated clothing. MSC Drawing No. 802-4844759 may be used as guidance. Stowage for one Emergency Escape Breathing Device (EEBD) shall be provided along each escape route from and at the foot of all ladders within:

- Machinery spaces
- Storerooms below the bulkhead deck

Stowage for one EEBD shall be provided in each hard-to-exit space. Hard-to-exit spaces are those spaces for which the distance between the exit of that space to weather is greater than 60 m, calculated using the following procedure:

- Horizontal passageways, 1 m per meter length traversed
- Ladders and stairtowers, 1 m per meter length traversed
- Hatches and scuttles, 15 m per hatch and scuttle traversed
- Doors, 15 m per door traversed
- Air and pressure locks, 15 m

EEBDs shall be provided and stowed in accordance with MSC QMS N0732-221.00-AQ Emergency Escape Breathing Devices.

EEBDs shall be outfitted in Damage Control Lockers in accordance with the Damage Control Allowance Equipage Lists (AEL).

3.664.1 DAMAGE CONTROL CENTRAL

DCC shall be a designated area within the Pilot House. The DCC shall provide a central display area for fire and smoke detection, flooding detection, watertight and fire door position indication, damage control communications, and security alarm data.

3.664.2 DAMAGE CONTROL LOCKERS AND SECONDARY DAMAGE CONTROL CENTRAL

Two DC Lockers shall be provided on the bulkhead deck, one forward and one aft. The lockers shall be located between the forward and aft collision bulkheads. MSC Drawing No. 664-8393510 may be used as guidance for the arrangements. Each locker shall have a minimum area of 25 m². AEL equipment locations within the DC Lockers shall be labeled. Access shall be provided by either separate entrance and exit doors, or a single double door. Both DC Lockers shall have access convenient to the weather. Dedicated open areas shall be provided adjacent to the DC Lockers to facilitate response party dress-out.

Stowage aids shall be provided in each locker to stow the equipment listed in the approved allowance documentation.

The DC Lockers shall be labeled in accordance with COMSCINST 3541.2 and N0732-227.00-AQ Damage Control Markings.

A secondary DCC shall be located in the DC Locker farthest from the primary DCC. The secondary DCC shall be equipped to take over the functions of the DCC as specified herein.

3.664.3 BREATHING AIR COMPRESSOR ROOM

A Breathing Air Compressor Room shall be provided adjacent to the aft DC Locker. MSC Drawing No. 664-8393515 may be used as guidance for the arrangements. The Breathing Air Compressor Room shall have a minimum area of 20 m².

3.665 WORKSHOPS, LABORATORIES, AND MAINTENANCE AREAS

The following spaces at a minimum shall be provided:

- Machine Shop
- Main Machinery/Diesel Repair Shop
- Auxiliary Machinery Room Workshop
- Electrical Workshop
- Electronics Test Shop
- Machinery Space Fuel Oil, Lube Oil, and Water Sampling Test Lab
- Bosun's Workshop

Requirements for selected spaces are described in MSC QMS N0720-112.00-P Engine Department and Shop Standards for New Construction Large Ships and MSC QMS N0720-113.00-P Deck Department and Pilot House Standards for New Construction Large Ships.

The workshop and laboratory arrangements shall accommodate movement of personnel and materials in the course of routine workshop and laboratory operations. Workshop and laboratory equipment and furnishings shall be capable of being secured and shall be designed to fit through typical ship hatches with minimal additional equipment disassembly.

Ovens and tanks containing flammable solvents shall be provided with fire protection systems in accordance with NFPA Codes 30 and 86.

Welding areas shall be painted flat black and enclosed by a welding curtain. The area above the welding curtain rail shall be enclosed between the curtain rail and the overhead. The welding curtain shall be constructed of a black, flame resistant material. Welding areas shall be provided with a separate portable, flexible exhaust trunk to remove welding fumes separately to weather. Electrical and electronics workbenches shall be provided with safety shorting probes. Any metal adjacent to the workbench, which could be contacted by the person working at the workbench, shall be insulated. Workbenches shall be insulated in accordance with NAVSEA S9086-KC-STM-010/CH-300 Subchapter H. The deck area, 1.5 m on both sides, and

front of electrical and electronic workbenches, shall be insulated with a non-conductive insulating material. The work surface, front surfaces, knee surfaces under auxiliary tables, back panels, and exposed end surfaces of metallic workbenches shall be insulated. Surfaces above the work surface do not require insulation. Switchboard testers and Type 2 workbenches shall be equipped with emergency cutoff switches located at the workshop door or within sight of the workbench.

Stowage shall be provided for workshop tools.

3.665.1 MACHINE SHOP

The Machine Shop shall provide a space to perform preventive and corrective maintenance on the ship's machinery and components. The Machine Shop shall be contiguous to the main machinery space. The lifting gear serving the main machinery space shall extend into the Machine Shop and serve the welding area and the shop laydown area.

3.665.2 DIESEL REPAIR SHOP

The Diesel Repair Shop shall provide a space with special tools, spare engine components, and test equipment to support the disassembly of an entire top end component. The Diesel Repair Shop shall be contiguous with the main machinery space and the Machine Shop. The lifting gear serving the main machinery space shall extend into the Diesel Repair Shop and serve the cylinder head mounting and turning device and the shop laydown area.

3.665.3 ELECTRICAL WORKSHOP

The Electrical Workshop shall provide a space to maintain and repair the ship's electrical systems and components. The Electrical Workshop shall be contiguous to the main machinery space.

3.665.4 MACHINERY SPACE FUEL OIL, LUBE OIL, AND WATER SAMPLING TEST LABORATORY

The Machinery Space Fuel Oil, Lube Oil, and Water Sampling Test Laboratory shall provide a space for oil testing, water treatment testing, and fuel oil sample storage in accordance with IMO requirements. The Machinery Space Fuel Oil, Lube Oil, and Water Sampling Test Laboratory shall be adjacent to the EOS. The oil test sink shall drain to the OWHT.

3.665.5 ELECTRONICS TEST SHOP

The Electronics Test Shop shall provide a space to maintain and repair the ship's electronic systems and components. The Electronics Test Shop shall be located convenient to the EOS.

3.665.6 AUXILIARY MACHINERY ROOM WORKSHOP

An AMR Workshop shall be provided contiguous with each AMR. The AMR Workshop(s) shall provide a space to perform preventive and corrective maintenance on the AMR space machinery and components. The lifting gear serving the AMR shall extend into the AMR Workshop and serve the shop laydown area.

3.665.7 BOSUN WORKSHOP

The Bosun Workshop shall provide a space to maintain and repair the ship's deck machinery and components. The Bosun Workshop shall be located convenient to the forward mooring area.

3.670 STOWAGE SPACES

Stowage shall be provided for outfitting items in the approved allowance documentation (including consumables, spares, repair parts, portable equipment, tools, test equipment, and other items stowed onboard). Spares will be identified as OSI or SRI. OSI consists of breakbulk material as well as items stowed in racks, bins, and shelving. OSI shall be stowed in the maintenance work area where they will be used. SRI shall be stowed in storerooms as specified herein.

Stowage for items shall provide protection from direct sunlight, precipitation, temperature, humidity, sea spray, and other conditions that may cause degradation of the items. Stowage aids shall be provided to support and secure stowed items from shifting, tipping, spilling, and other effects caused by ship motion. Materials and devices provided to secure and protect the items shall not loosen under the effects of ship motion and vibration. Stowage shall be provided for portable stowage aids when they are not in use. Stowage aids shall facilitate cleaning and maintaining stowage spaces in a sanitary condition.

Storerooms designated for breakbulk stowage shall be fitted with a system of portable non-ferrous stanchions with deck and overhead grating. The perimeter of bulk stowage spaces shall either use rows of portable stanchion or fixed battens attached to the structural boundaries to permit circulation of air and protect remote operating mechanisms, insulation, piping, and cables. The ends of the battens shall be closed. The system of stanchions and grating shall secure breakbulk items. Usable area shall be determined based on the face of the portable stanchions or the fixed battens that form the perimeter of the bulk stowage space.

Modular Drawer Storage (MDS) cabinets shall conform to General Services Administration (GSA) Commercial Item Description A-A-59470 with lock-in/lock-out drawers. The MDS pallet base shall be removed and the cabinets mechanically attached to a welded sub-base, approximately 50 mm high. The MDS cabinets shall be arranged to permit full extension and removal of the drawers. The MDS cabinets shall be provided with factory-provided partitions and dividers. For drawers greater than 100 mm in height, the configuration shall be two

partitions with three dividers in each section. For drawers 100 mm or less in height, the configuration shall be three partitions with five dividers in each section.

Bins, racks, and shelving shall be provided with removable horizontal angle battens with pins and lanyards. Front flanges of lower shelves of bins, racks, and shelving shall be stiffened to prevent damage from a person stepping on them. Stops shall be provided on fronts and backs of shelving and bins. Bins, racks, and shelving may be installed between bulkhead and shell stiffeners. Built in shelving, racks, and bins may be installed to augment modular shelving, bins, and racks in order to make efficient use of the available space. Bins installed above cabinets shall be of similar depth and width as the cabinets over which they are installed. Bins installed above cabinets shall extend a maximum of 2 m above the deck. Bins installed above cabinets shall be permanently secured to the bulkhead or overhead.

3.671 LOCKERS AND SPECIAL STOWAGE

Lockers are free-standing storage units for supplies in the location of their intended use. Lockers shall be provided with hasps and staples for use with padlocks. Special stowage consists of stowage aids and locations provided in non-dedicated spaces for the materials identified. The location and arrangement of special stowage, including the stowed materials, shall not interfere with other operations within that space. Special stowage locations shall be designated for the specific items being stowed. Lockers and special stowage shall be provided as follows.

3.671.1 WATERLINE SECURITY LIGHTING SYSTEM STOWAGE

Interior special stowage shall be provided for portable waterline security floodlights in the vicinity of their deployed locations.

3.671.2 POTABLE WATER TREATMENT STORAGE LOCKER

A non-metallic potable water treatment storage locker with shelving shall be provided in an air-conditioned space in the vicinity of the water treatment system. The locker shall be capable of storing a minimum of a 6-month supply of treatment system consumables.

3.671.3 POTABLE WATER HOSE STOWAGE

A stowage reel for 30 m of 20 mm potable water hose shall be provided adjacent to each hose bibb within machinery spaces and in the vicinity of the solid waste processing facility.

A weather tight potable water hose storage locker with shelving shall be provided central to the shore connections. The locker shall provide stowage for 90 m of 64 mm potable water hose, fittings, and tools for rigging the potable water shore connection. The lowest point in the locker shall be a minimum of 450 mm above the deck.

3.671.4 GAS FREE PORTABLE SENSOR STOWAGE

A storage location with shelving shall be provided for stowage of handheld Carbon Monoxide (CO), Nitric Oxide (NO), and Nitric Dioxide (NO₂) sensors and associated calibration gasses.

3.671.5 MOORING LINE STOWAGE

Stowage reels shall be provided for stowage of mooring lines. Each mooring line shall be stowed individually on separate reels. Special stowage shall be provided to store the mooring line reels in a location protected from the weather. If mooring line stowage is not located in an interior space, covers shall be provided for the reels. Interior mooring line stowage spaces shall be ventilated. Mooring line stowage shall be located to permit convenient movement of the reels to the locations where the lines will be used. A low point drain shall be provided.

3.671.6 SEWAGE TREATMENT CHEMICAL STOWAGE

A sewage treatment chemical locker with shelving shall be provided in the sewage treatment plant space. The locker shall be capable of storing a minimum of a 1-month supply of treatment system consumables. The locker shall be constructed of a non-ferrous material.

3.671.7 SEWAGE SPILL RESPONSE LOCKER

A sewage spill response locker with shelving shall be provided in the vicinity of the sewage treatment plant space. The locker shall provide stowage for the sewage system spill kit specified in the applicable approved allowance documentation.

3.671.8 GUARDLINE STOWAGE

Interior stowage for removable guardlines shall be provided in the vicinity of their area of use.

3.671.9 PYROTECHNIC LOCKER

A weathertight pyrotechnic locker with shelving sized to accommodate line throwing apparatus, flares, etc. shall be provided in the weather adjacent to the Pilot House. Sun shielding shall be provided for the locker.

3.671.10 FLAG STOWAGE

A flag stowage “pigeon hole” type shelving with dedicated stowage for the ship’s allowance of flags shall be provided in the Pilot House.

3.671.11 SHORING STOWAGE

Special stowage shall be provided in two locations for the damage control shoring allowance as listed in the applicable approved allowance documentation. Stowage locations shall be in the vicinity of the damage control lockers.

3.671.12 COMPRESSED GAS CYLINDER STOWAGE

Special stowage shall be provided for compressed gas cylinders as specified herein. Stowage for oxygen bottles in the Medical Facility shall provide the means to restrain the bottles in the horizontal and vertical planes. Other compressed gas cylinders shall be stored in racks in accordance with NAVSEA Dwg. No. 803-5184287. Compliance with MIL-S-901 is not required. Strap assemblies as allowed by General Note 2 of NAVSEA Dwg. No. 803-5184287 shall not be used as the method of vertical restraint.

3.671.13 ACCOMMODATION LADDER EQUIPMENT LOCKER

An Accommodation Ladder Equipment Locker shall be provided central to both accommodation ladders for stowing nets and other rigging. The Accommodation Ladder Equipment Locker shall be provided with bins, shelving, and hooks.

3.672 STOREROOMS

Requirements for selected spaces are described in MSC QMS N0720-112.00-P Engine Department and Shop Standards for New Construction Large Ships and MSC QMS N0720-113.00-P Deck Department and Pilot House Standards for New Construction Large Ships.

Storerooms are spaces that are provided for stowage of consumables, SRI, repair parts, portable equipment, and other items specified herein. Stowage spaces specified within this section, as well as the Cleaning Gear Lockers and DC Lockers, shall be storerooms even when their space nomenclature uses the term "locker." Storerooms shall be provided as follows.

3.672.1 GENERAL STORES STOREROOM

A General Stores Storeroom shall be provided for stowage of general use consumables. The General Stores Storeroom shall be accessible by pallet jacks. The storeroom shall be provided with bulk stowage, bins, racks, and shelving. The bins, racks, and shelving shall provide a service life growth margin equal to 15% of the ship's initial inventory.

3.672.2 SHIP SPARE PARTS STOREROOM

A Ship Spare Parts Storeroom(s) shall be provided for ship spares. The Ship Spare Parts Storeroom(s) shall be located to provide practical and convenient movement of spares to the main machinery space. The Ship Spare Parts Storeroom(s) shall be accessible by pallet jacks.

The Ship Spare Parts Storeroom(s) shall have a combined minimum area of 55 m² with a minimum clear height of 2.5 m. The Ship Spare Parts Storeroom(s) shall be provided with bulk stowage, MDS cabinets, bins, racks, and shelving. The MDS cabinets, bins, racks, and shelving shall provide a service life growth margin equal to 15% of the ship's initial inventory.

3.672.3 ENGINEER STOREROOM(S)

An Engineer Storeroom(s) shall be provided. The Engineer Storeroom(s) shall be in the vicinity of the Machine Shop. The Engineer Storeroom(s) shall have a total minimum area of 95 m² with a minimum clear height of 2.1 m. If multiple Engineer Storerooms are provided, each Engineer Storeroom shall have a minimum area of 20 m². The Engineer Storeroom(s) shall be provided with bulk stowage, MDS cabinets, storage cabinets, shelving, and miscellaneous hooks, hangers, rods, and tool boards.

3.672.4 ELECTRICAL STOREROOM

An Electrical Storeroom shall be provided. The Electrical Storeroom shall be contiguous with the Electrical Shop. The Electrical Storeroom shall have a minimum area of 25 m² with a minimum clear height of 2.5 m. The Electrical Storeroom shall be provided with MDS cabinets, storage cabinets, shelving, and miscellaneous hooks, hangers, rods, and tool boards. The MDS cabinets, storage cabinets, shelving and miscellaneous hooks, hangers, rods, and tool boards shall provide a service life growth margin equal to 15% of the ship's initial inventory.

3.672.5 SHORE POWER CABLE STOREROOM

A storeroom for shore power cables and portable shore power cable tray system shall be provided adjacent to the shore power connections. Stowage racks shall be provided for securing the shore power cables and the portable shore power cable tray system.

3.672.6 BOSUN STOREROOM

A Bosun Storeroom shall be provided adjacent to the Bosun Workshop and be a minimum of 60 m². The Bosun Storeroom shall be accessible by pallet jacks. Where the Bosun Storeroom is not located on the same deck as the mooring fittings, inclined ladders and hatches fitted with davits shall be provided for personnel and stores handling access to the mooring deck. A scuttle shall be provided to the Bosun Storeroom that allows direct access for passing of rope and fittings. A stowage rack shall be provided for the Suez Canal light in the forward Bosun

Storeroom. The Bosun Storeroom shall be equipped with a hatch sized for loading and unloading of items stored in that space. The Bosun Storeroom shall be furnished as follows:

- Hawser and wire rope shelving
- Rope and small line reels stowage
- Cabinet, MDS
- Cabinet, storage
- Hawser bins and rat guards
- Miscellaneous hooks, hangers, rods, and tool boards

The stowage aids shall provide a service life growth margin equal to 15% of the ship's initial inventory.

3.672.7 BOAT GEAR LOCKER

A Boat Gear Locker with a minimum area of 10 m² shall be provided adjacent to each group of lifeboats. A Boat Gear Locker with a minimum area of 2.5 m² shall be provided adjacent to each RHIB. Boat Gear Lockers shall be provided with bins and shelving.

3.672.8 FOUL WEATHER GEAR LOCKERS

Two crew Foul Weather Gear Lockers shall be provided in the deckhouse, one aft and one forward. The Foul Weather Gear Lockers shall be located adjacent to a vestibule. Each Foul Weather Gear Locker shall be a minimum of 5 m². The Foul Weather Gear Lockers shall be provided with shelving, hooks, and racks.

3.672.9 PAINT LOCKER

A Paint Locker with a minimum area of 12 m² shall be provided. The Paint Locker shall be provided with storage cabinets and shelving.

3.672.10 BAGGAGE STOREROOM

A Baggage Storeroom shall be provided on each accommodation level. Each Baggage Storeroom shall have a minimum area of 5 m². The Baggage Storerooms shall be provided with shelving.

3.672.11 MORALE, WELFARE, AND RECREATION STOREROOM

A storeroom shall be provided in the vicinity of the messrooms for the storage of Morale, Welfare, and Recreation (MWR) gear. The MWR Storeroom shall have a minimum area of 9 m². The MWR Storeroom shall be provided with adjustable shelving.

3.672.12 FOOD SERVICE PROVISION STOREROOM

Dedicated food service provision storerooms shall be provided in accordance with MSC QMS N0720-111.00-P Steward Department and Food Service Standards. The storerooms shall be co-located with and on the same deck level as the Galley. The Daily Provision Storeroom shall be provided contiguous to the Galley. The Dry and Daily Provision storerooms shall be accessible by pallet jacks. Access to the refrigerated storerooms shall be via a thaw area(s).

The storerooms shall be provided with perforated shelving and grating. The Daily Provision Storeroom shall be equipped with deck-to-overhead shelving on all sides.

Thirty percent of the dry, chill, and freeze storerooms shall be reserved for bulk stowage.

3.672.13 MEDICAL STORES LOCKER

A Medical Stores Locker shall be provided contiguous to the Medical Office or MTR. The Medical Stores Locker shall have a minimum area of 7 m².

The Medical Stores Locker shall be provided with storage cabinets and shelving. The storage cabinets and shelving shall provide a service life growth margin equal to 15% of the ship's initial inventory.

3.672.14 SHIP'S STORE STOREROOM

A Ship Store Storeroom shall be provided and shall be contiguous with the Ship's Store. The Ship's Store Storeroom shall be a minimum area of 10 m².

3.672.15 LINEN LOCKERS

Linen Lockers shall be provided on each accommodation level. Each Linen Locker shall have a minimum area of 2.3 m². The Linen Lockers shall be provided with adjustable shelving.

3.672.16 CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL DEFENSE EQUIPMENT STOREROOM

Storeroom(s) shall be provided for stowage of CBR-D personal protective equipment (PPE) and shall be located adjacent to each decontamination station and be accessible from the interior of the ship.

3.672.17 FLAMMABLE LIQUIDS STOREROOM

A Flammable Liquids Storeroom that meets the requirements of NFPA 30 shall be provided. The Flammable Liquids Storeroom shall be a minimum area of 15 m² and a minimum clear

height of 2.5 m. The Flammable Liquids Storeroom shall be accessible by pallet jacks. The Flammable Liquids Storeroom shall be provided with the following stowage aids:

- Hazardous Materials (HAZMAT) locker with lock and four shelves
- Shelving and battens for stowage of lube oil provided in 20 L cans
- Bulkhead mounted D rings for securing 200 L drums

3.672.18 NON-FLAMMABLE HAZARDOUS MATERIALS STOREROOM

Hazardous material lockers, each with a minimum capacity of 110 L, shall be provided as specified herein. The lockers shall be configured to permit segregation of incompatible hazardous materials. Hazardous material lockers shall be outfitted with self-closing doors.

A Non-flammable Hazardous Materials Storeroom that meets the requirements of NFPA 400 shall be provided. The Non-flammable Hazardous Materials Storeroom shall be a minimum area of 15 m² and a minimum clear height of 3 m. The Non-flammable Hazardous Materials Storeroom shall be accessible by pallet jacks. The Non-flammable Hazardous Materials Storeroom shall be provided with the following stowage aids:

- HAZMAT locker with lock and four shelves
- Epoxy coated chemical-resistant shelving with battens, for stowage of chemicals provided in 20 L cans
- Bulkhead mounted D rings for securing 200 L drums

3.672.19 USED HAZARDOUS MATERIALS STOREROOM

A Used Hazardous Materials Storeroom that meets the requirements of NFPA 400 shall be provided. The Used Hazardous Materials Storeroom shall be a minimum area of 7 m² and a minimum clear height of 2.5 m. The Used Hazardous Materials Storeroom shall be accessible by pallet jacks. The Used Hazardous Materials Storeroom shall be provided with the following stowage aids:

- Epoxy coated chemical-resistant shelving with battens, for stowage of chemicals provided in 20 L cans
- Bulkhead mounted D rings for securing 200 L drums

3.700 GENERAL REQUIREMENTS FOR ARMAMENT SYSTEMS

Magazines, ready service lockers, ordnance movement routes, and ordnance handling equipment shall conform to NAVSEA OP 4, COMSCINST 5530.3, and OPNAVINST 5530.13 requirements, except as specified herein. The shock and vibration requirements of NAVSEA OP 4 are not required.

3.711 ANTITERRORISM/FORCE PROTECTION (AT/FP) WEAPONS MOUNTS AND READY SERVICE LOCKERS

The ship shall have permanently installed 50 cal. machine gun mounts with ballistic shield mounting pads and ready service lockers. Type, numbers, and locations for AT/FP weapons mounts will be provided in accordance with the GFI, Schedule C provided with the DD&C RFP. Ready service locker stowage in accordance with NAVSEA OP 4 shall be provided for AT/FP ammunition near the mounts. Ready service lockers shall be in accordance with NAVSEA Drawing No. 804-1360106 and shall be provided with sunshields.

3.763 AT/FP SMALL ARMS MAGAZINE

A Small Arms Magazine shall be provided. The Small Arms Magazine shall provide stowage for the ship's and AT/FP allowance of small arms ammunition. The type and quantity of ship and AT/FP ammunition will be provided in accordance with the GFI, Schedule C provided with the DD&C RFP. Bin and rack type stowage in accordance with NAVSHIPS Drawing Nos. 804-4563098 and 804-4563099 respectively, shall be provided for stowing small arms ammunition in their shipping containers.

The Small Arms Magazine shall not share a common bulkhead with hazardous material storerooms.

The access door, if watertight, shall be in accordance with NAVSEA Drawing No. 803-6397261.

3.764 SHIP'S ARMORY

A Ship Armory shall be provided for the stowage of AT/FP weapons and ship small arms. The type and quantity of AT/FP weapons will be provided in accordance with the GFI, Schedule C, Attachment J-8, to be provided in Phase 2.

Rifle stowage shall be provided in lockers in accordance with NAVSHIPS Dwg. No. 804-4444648. Pistol stowage shall be provided in lockers in accordance with NAVSEA Dwg. No. 804-4444649. Lockers for stowage of other weapons shall be provided in accordance with NAVSHIPS Dwg. No. 804-4444648.

A GSA certified Class 5 locker shall be provided for stowage for ship small arms and other ordnance material in accordance with the applicable approved allowance documentation and COMSCINST 5530.3.

One 1.8 m long metal workbench with latch type drawers, cabinet pedestals, and shelving above the bench shall be provided. Bins in accordance with NAVSHIPS Dwg. No. 804-860159,

Type D-3, shall be provided. A log desk in accordance with Chief, Bureau of Ships (BUSHIPS) Dwg. No. S3209-866181 and a stool shall be provided.

The Ship Armory access door shall be in accordance with BUSHIPS Dwg. No. 803-1400075 for non-tight construction or NAVSEA Dwg. No. 803-6397261 for watertight construction.

4 VERIFICATION

The requirements of Section 3 shall be verified as having been met. Verification shall be in accordance with the requirements specified herein, regulatory and classification requirements, SNAME T&R Bulletin No. 3-39, SNAME T&R Bulletin No. 3-47, and Contractor defined and Government reviewed procedures that provide assurance that the performance requirements have been satisfied. Trials shall include Propulsion Plant Trials, Maneuvering and Special Tests, Standardization Trials, “First of Class” and “All Ship” items, thruster(s), and other auxiliary systems tests in accordance with SNAME T&R Bulletin No. 3-47.

Verification shall be accomplished by analysis, inspection, and testing using the definitions below:

- Analysis - This method utilizes established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that the stated requirements have been met. Analysis consists of using these methods on physical items as well as with construction drawings and other design documentation to verify that performance requirements are met. Simulations shall be validated and verified by a generally recognized industry standard.
- Inspection - Inspection consists of investigation, without the use of special laboratory appliance or procedures, of items to determine conformance with those specified requirements that can be determined by such investigation. Inspection is generally non-destructive and typically includes the use of sight, hearing, smell, touch, taste, simple physical manipulation, and other forms of investigation. Inspection consists of using these methods on physical items as well as with construction drawings and other design documentation to verify that required features, clearances, and other spatial and performance requirements are met.
- Test - A test generally denotes the determination, by technical means, of the properties or elements of items, including functional operation, and involves the application of established scientific principles and procedures. Testing may include the actual operation, adjustment, or re-configuration of items to provide evidence that the designed functions have been accomplished under specific scenarios. The items may be outfitted with instruments and quantitative limits of performance monitored.

Unless otherwise specified, inspections and tests shall be performed in accordance with the test conditions specified in regulatory body requirements or the applicable paragraphs in this specification.

Model tests shall be in accordance with Appendix B.

Diesel engines shall be tested in accordance with Appendix F.

APPENDIX A ACRONYM LIST

1MC	General Announcing Circuit
6MC	Intership Announcing Circuit
18MC	Bridge Announcing Circuit
ABS	American Bureau of Shipping
ABT	Automatic Bus Transfer
AC	Alternating Current
A/C	Air Conditioning
ACCU	Automated Centralized Control Unmanned
ACP	Alternate Compliance Program
ACP	Panama Canal Authority
ADCP	Acoustic Doppler Current Profiler
AEL	Allowance Equipage Lists
AFFF	Aqueous Film Forming Foam
AFN	Armed Forces Network
AGMA	American Gear Manufacturers Association
AHRS	Attitude Heading Reference System
AIS	Automatic Identification System
AM	Amplitude Modulation
AMAL	Authorized Medical Allowance List
AMR	Auxiliary Machinery Room
AMS	Acoustic Monitoring System
ANSI	American National Standards Institute
ANTS	Acoustic Navigation and Tracking System
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASTM	American Society for Testing and Materials
AT/FP	Antiterrorism/Force Protection
AWE	Accepted Weight Estimate
AWG	American Wire Gauge
BERP	Bolted Equipment Removal Plate
BEP	Best Efficiency Point
BLII	Base Level Information Infrastructure
BPVC	Boiler and Pressure Vessel Code
BT	Builder's Trials
BUSHIPS	Chief, Bureau of Ships
BWT	Ballast Water Treatment
CBM	Condition Based Monitoring
CBR-D	Chemical, Biological, and Radiological Defense
CCTV	Closed Circuit Television
CDC	Center for Disease Control and Prevention
CDE	Cable Drum Engine

CFR	Code of Federal Regulations
CG	Center of Gravity
CHE	Cable Handling Equipment
CID	Critical Information Display
CNSS	Committee on National Security Systems
COLREGS	International Regulations for Avoiding Collisions at Sea
COMSCINST	Commander Military Sealift Command Instruction
CONOPS	Concept of Operations
CP	Controllable Pitch
CPO	Chief Petty Officer
CPU	Central Processing Unit
CRC	Crane Register Certificate
CTE	Cable Termination Enclosure
DAI	Data Acquisition Interface
DAU	Data Acquisition Units
DC	Damage Control
DC	Direct Current
DCC	Damage Control Central
DCCC	Damage Control Central Console
DD&C	Detail Design and Construction
DFM	Diesel Fuel, Marine
DGPS	Differential Global Positioning System
DISA	Defense Information Systems Agency
DM	Distillate Marine
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOHB	Draw-Off Hold Back
DPS	Dynamic Positioning System
ECA	Emission Control Area
ECDIS	Electronic Chart Display and Information System
EDG	Emergency Diesel Generator
EEBD	Emergency Escape Breathing Device
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
EMCON	Emissions Control
EME	External Electromagnetic Environment
EOS	Engineer Operating Station
EPA	Environmental Protection Agency
EPLA	Electric Plant Load Analysis
EROW	Priority Calling
ESDV	Explosives Safety Design Validation
EST	Embarked Security Team
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FIPS	Federal Information Processing Standards

FM	Frequency Modulation
FOD	Foreign Object Damage
FP	Forward Perpendicular
FTE	Fiber Termination Enclosure
FTJ	Fiber Termination Junction (Box)
GFE	Government Furnished Equipment
GFCI	Ground Fault Circuit Interrupter
GFI	Government Furnished Information
GFM	Government Furnished Materials
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
GPT	General Purpose Transceiver
GSA	General Services Administration
GUI	Graphical User Interface
HAZMAT	Hazardous Materials
HERF	Hazards of Electromagnetic Radiation to Fuels
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HF	High Frequency
HiPAP	High Precision Acoustic Positioning
HIPS	Host Instruction Prevention
HM	Hazardous Material
HMI	Human-Machine Interface
HPU	Hydraulic Power Unit
HTFW	High Temperature Freshwater
HVAC	Heating, Ventilation, Air Conditioning
HVPS	High Voltage Power System
IA	Information Assurance
IAPP	International Air Pollution Prevention Certificate
IATA	Information Assurance Technical Authority
IBS	Integrated Bridge System
ICC	International Code Council
ICD	Intelligence Community Directive
IDS	Intrusion Detection Security
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFF	International Friend or Foe
IGPP	International Garbage Pollution Prevention Certificate
IMDG	International Maritime Dangerous Goods Code
IMU	Inertial Measurement Unit
IMO	International Maritime Organization
INMARSAT	International Mobile Satellite Organization
IOPP	International Oil Pollution Prevention Certificate
IPC	International Plumbing Code
ISPP	International Sewage Pollution Prevention Certificate

ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LARS	Launch and Recovery System
LBP	Length Between Perpendiculars
LCE	Linear Cable Engine
LED	Light Emitting Diode
LP	Low Pressure
LPI	Low Probability of Intercept
LRIT	Long-Range Identification and Tracking
LSC	Local Session Controller
LTFW	Low Temperature Freshwater
MAF	Mechanically Attached Fitting
MARPOL	Marine Pollution from Ships
MBSS-DW	Multibeam Survey System – Deep Water
MCC	Main Control Console
MCCS	Machinery Centralized Control System
MCR	Mission Control Room
MD	Mission Director
MDS	Modular Drawer Storage
MEDEVAC	Medical Evacuation
MES	Mission Electronic System
MHE	Materials Handling Equipment
MKD	Minimum Keyboard Display
MMR	Main Machinery Room
MOCOMP	Motion Compensation
MRB	Master Reference Block
MSC	Military Sealift Command
MSO	Medical Services Officer
MSS	Manufacturers Standardization Society
MSS	Mission Sonar System
MTR	Medical Treatment Room
MVR	Marine Vessel Rules
MWR	Morale, Welfare, and Recreation
NACE	National Association of Corrosion Engineers
NATO	North Atlantic Treaty Organization
NAVSEA	Naval Sea Systems Command
NAVSEAINST	Naval Sea Systems Command Instruction
NAVSHIPS	Naval Ship Systems Command
NCSC	National Counterintelligence and Security Center
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NH	National Hose
NIBS	Navigational Bridge Layout and Equipment/Systems

NIST SP	National Institute of Standards and Technology Special Publication
NOSSA	Naval Ordnance Safety and Security Activity
NPSHR	Net Positive Suction Head Required
NPT	National Pipe Thread
NTRP	Navy Tactical Reference Publication
NSTISSAM	National Security Telecommunications and Information Systems Security Advisory/Information Memorandum
NTTP	Navy Tactics, Techniques, and Procedures
NVIC	Navigation and Vessel Inspection
OC	Optical Carrier
OCM	Oil Content Monitor
OEM	Original Equipment Manufacturer
OPAS	Oil Pollution Abatement System
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	Office of the Chief of Naval Operations Instruction
O/S	Operating Stations
OSI	Operating Space Items
OWHT	Oily Waste Holding Tank
OWS	Oily Water Separator
PA	Public Address
PBU	Power Branching Unit
PBX	Private Branch Exchange
PCCL	Prohibited and Controlled Chemicals List
PDU	Power Distribution Unit
PEL	Permissible Exposure Limits
PMS	Power Management System
PPE	Personal Protective Equipment
PSTN	Public Switched Telephone Network
PVC	Polyvinyl Chloride
PTZ	Pan-Tilt-Zoom
QPL	Qualified Products List
RAA	Restricted Access Area
RCC	Remote Control Console
RF	Radio Frequency
RFP	Request for Proposals
RFT	Ready for Tasking
RHIB	Rigid Hull Inflatable Boat
RMS	Root Mean Squared
RMF	Risk Management Framework
ROTO	Rotometer
ROV	Remotely Operated Vehicle
RPM	Rotations per Minute
RSL	Remote Source Lighting
RTD	Remote Temperature Detector
SAMM	Shipboard Automated Maintenance Management

SAWE	Society of Allied Weight Engineers
SBP	Sub Bottom Profiler
SBSS	Single Beam Survey System
SCA	Suez Canal Authority
SCBA	Self-Contained Breathing Apparatus
SCC	Ship Control Console
SCO	Ship's Communications Officer
SDR	Sponsor's Designated Representative
SECNAV	Secretary of the Navy
ShipCLIP	Ship's Configuration and Logistics Information Program
SI	International System of Units
SIP	Session Initiation Protocol
SLC	Safety Construction Certificate
SLE	Safety Equipment Certificate
SLR	Safety Radio Certificate
SMD	Soil Machine Dynamics
SNAME	Society of Naval Architects and Marine Engineers
SOF	Statements of Fact
SOLAS	Safety of Life at Sea
SOVC	Statement of Voluntary Compliance
SR	Secure Room
SRI	Materials Storeroom Items
SSAS	Ship Security Alert System
SSPC	Society for Protective Coatings
SSVS	Surface Sound Velocimeter System
STANAG	Standardization Agreement
STE	Shore Terminus Equipment
STP	Sewage Treatment Plant
SWL	Safe Working Load
T&S	Toilet and Shower
THD	Total Harmonic Distortion
TIG	Tungsten Inert Gas
TLI	Tank Level Indicator
TTR	Test and Transmission Room
TV	Television
TV-DTS	Television – Direct to Sailor
UAA	Uncontrolled Access Area
UFC	Unified Facilities Criteria
UHMW	Ultra-High Molecular Weight
UHMWP	Ultra-High Molecular Weight Polyethylene
UL	Underwriters Laboratories
ULFSO	Ultra Low Sulfur Fuel Oils
UPS	Uninterruptable Power Supply
USCG	United States Coast Guard
USPHS	United States Public Health Service

USSG	United States Steel Gauge
UUV	Unmanned Underwater Vehicle
UV	Ultraviolet
UWILD	Underwater Inspection in Lieu of Drydocking
VAC	Voltage Alternating Current
VCG	Vertical Center of Gravity
VCHT	Vacuum Collection and Holding Tank
VDC	Voltage Direct Current
VHF	Very High Frequency
VLFSO	Very Low Sulfur Fuel Oils
VoIP	Voice over Internet Protocol
VSD	Variable Speed Drive
WDCM	Washdown Countermeasure
WERP	Welded Equipment Removal Plate
WO/ST	Waste Oil/Sludge Tank
XSVP	Expendable Sound Velocity Profiler

APPENDIX B MOBILITY PERFORMANCE CALCULATIONS

B1. Performance Prediction

B1.1 Pre-model testing - Initial speed-power estimates shall be in accordance with DDS 051-1. Bare hull resistance shall be estimated before model testing using model test data for similar hull forms, with adjustments as necessary, or series data (e.g. Taylor Standard Series) with appropriate adjustments. Appendage resistance estimates shall be based on appropriate model test results or other generally recognized sources of appendage drag data. Hull-propeller interaction coefficient estimates shall be based on model test data for generally similar hull-propeller configurations. Propeller open water efficiency estimates shall be based on series data (e.g. MARIN B-Series) or appropriate blade design prediction methods (e.g. lifting line program).

B1.2 Model testing - Except as noted below, model tests shall be performed at model speeds covering the range 7 knots to sustained speed full scale.

B1.2.1 Bare hull resistance tests - Tests shall be performed with the model representing the ship in the following loading conditions:

- a. Full Load Departure
- b. Mid-Voyage
- c. Ballast Arrival

B1.2.2 Appendage alignment flow tests

B1.2.3 Appended hull resistance tests - Appended hull resistance tests shall be performed with the model representing the ship in the following loading conditions:

- a. Full Load Departure
- b. Mid-Voyage
- c. Ballast Arrival

B1.2.4 Bubble Sweepdown tests - Bubble sweepdown flow visualization tests shall be performed with the model representing the ship in the Full Load Departure and Mid-Voyage conditions at a speed of 10 knots. Tests shall use water soluble dye to visualize streamlines with flow streamline initiation points in accordance with Section 3.073.3 of the System Specification.

B1.2.5 Wake Survey tests - Wake survey tests shall be performed with the model representing Full Load Departure at sustained speed.

B1.2.6 Stock propulsor Self-Propulsion tests - Stock propulsor self-propulsion tests shall be performed with the model representing the ship in the following loading conditions:

- a. Full Load Departure
- b. Ballast Arrival

B1.2.7 Propulsor Open Water Model testing - Design propulsor open water model testing shall be performed at a sufficient number of pitch or RPM settings to permit matching engine power and RPM in each normal operating mode. Open water tests shall include astern pitch settings or reverse RPM values and idle settings as required to simulate a crash stop.

Design propulsor self-propulsion testing shall be performed with the model representing the ship in the following loading conditions:

- a. Full Load Departure
- b. Mid-Voyage
- c. Ballast Arrival

B1.2.8 Cavitation tests - Model scale cavitation tests with the design propulsor(s) shall be performed in a simulated or scaled wake in a cavitation tunnel or depressurized towing tank. Cavitation tests shall be performed with the model representing the following loading conditions:

- a. Full Departure
- b. Ballast Arrival

Cavitation tests shall be performed to model the flow on the full-scale ship at sustained speed and the speed corresponding to full power.

Propulsor Cavitation Erosion Tests shall be performed as simulated conditions corresponding to 100% MCR with the ship at its minimum operating draft.

B1.3 Speed/Power Estimates - Speed/power estimates shall be developed based on model test data as follows:

- a. Model resistance data shall be extrapolated to full scale as follows:
 - Appendage resistance of rudders, bilge keels, thruster tunnels, propeller shafts and struts, etc., shall be included as separate elements of speed/power estimates as determined from model tests or by proven computational means. Scale corrections shall not be applied to appendage resistance. Twin skegs, if used, shall not be considered appendages and their resistance shall be included with the bare hull. Rudders, if used, shall be excluded from the bare hull tests.
 - Still-air resistance shall be included. Still-air resistance shall be determined either from wind tunnel testing, were available, or computed analytically using the projected, above-waterline area of the hull and superstructure in a bow view at the appropriate draft. Overlapping areas shall be counted only once, applying them to the surface furthest forward on the ship. Masts and kingposts shall be omitted. The drag coefficients used shall be 0.36 for the hull and 0.91 for the superstructure, as defined in NAVSEA

Memo 55W3/JJK Ser. 53 of 23 Apr 1984, "Still Air Drag Estimation Technique."

- Use ITTC frictional resistance coefficients (C_f) and seawater temperature equal to 15 °C.
- Resistance coefficient shall be determined as follows:

$$C_R = C_{tm} - C_{fm}(1 + k)$$

Where:

C_R is the resistance coefficient

C_{tm} is the model total resistance coefficient

k is the form factor and shall be 0

C_{fm} is the model friction resistance coefficient.

- Use a correlation allowance (C_a) value of 0.00015.
 - Use a design power margin per DDS 051-1.
- a. Model self-propulsion data shall be extrapolated to full scale as follows:
1. Use extrapolated resistance data, as defined above.
 2. Use model hull-propulsor interaction factors such as the thrust deduction (t), wake fraction (w), and relative rotative efficiency (η_R) values as determined from model tests (including tests with the propeller model representing the final propeller design). Scale corrections shall not be applied.
 3. Use model propeller open-water thrust coefficient (K_t) vs advance coefficient (J) and torque coefficient (K_q) vs J values. Scale corrections shall not be applied.

B1.4 Post-trials - Post-trials speed/power estimates shall be developed by correcting the standardization trials speed/power estimates as follows:

- a. Where trials were run at full load displacement and trim, the estimates shall be corrected for seawater temperature, wind and current. Application of margin is not required.
- b. Where trials were run at a displacement which is not more than $\pm 5\%$ from the full load departure displacement and at a trim which is not more than ± 500 mm from Full Load Departure condition, corrections for seawater temperature, wind, and current shall be applied, and then the Admiralty-Coefficient method for correcting speed shall be applied as follows. Application of margin is not required.

$$\frac{V_{FL}}{V_T} = \left(\frac{\Delta_T}{\Delta_{FL}} \right)^{0.2222}$$

Where:

V_{FL} is the speed at Full Load Departure condition

V_T is the corrected speed on trials

Δ_T is the displacement on trials

Δ_{FL} is the Full Load Departure condition displacement

- c. Where trials were run at a displacement more than plus or minus 5% different from the full load departure displacement or at a trim greater than plus or minus 500 mm from Full Load Departure condition, corrections for seawater temperature, wind and current shall

be applied, and then the following method for correcting speed shall be applied:

If the actual trials condition or Full Load Departure condition is different than the conditions model tested, resistance and self-propulsion model tests shall be performed at the trials condition and at Full Load Departure condition.

The correlation allowance (C_a) value shall be derived from the correlation of the trials condition model test and the trials speed/power data as specified herein. This C_a shall be applied to the Full Load Departure condition model test data to calculate the speed/power performance. A 2% design power margin shall be applied on the total effective power.

The C_a shall be derived from full-scale and model test measurements as follows:

a. Input:

1. Trials shaft power and propeller RPM, for one or more speeds; corrected for wind, still air, and current; corrected to 15 °C seawater
2. Estimated hull/propeller interaction and propeller thrust and torque coefficients at each speed, based on model test results

b. Calculate/Derive:

1. Trials total effective power
2. Smooth-water/clean-hull resistance (R_{ts})
3. Smooth-water/clean-hull resistance coefficient (C_{uts}), for each Trials draft/speed

$$C_{uts} = \frac{R_{ts}}{\left[\left(\frac{\rho_s}{2}\right) * S * (0.51444V_k)^2\right]}$$

Where:

R_{ts} = ship smooth-water/clean-hull resistance, in N

ρ_s = mass density of seawater at 15 °C, in kg/m³

S = hull wetted surface at the Trial draft, in m²

V_k = ship speed, in knots

4. Ship clean-hull frictional resistance coefficient (C_{fs}) for Trials draft. Use ITTC frictional resistance formula:

$$C_{fs} = \frac{0.075}{[\text{Log}_{10}(R_n) - 2]^2}$$

Where:

$$R_n = \text{Reynolds Number} = \frac{L_{wl}(V_k * 0.51444)}{v_s}$$

V_k = ship speed, in knots

L_{wl} = ship waterline length, in meters, for Trials draft

v_s = kinematic viscosity of seawater at Trials seawater temperature, in m²/sec

c. Input:

C_r value at trials draft, for each speed (Determined by interpolation of model-test-based C_r vs speed vs draft), based on $(1 + k) = 1$

d. Ship/model powering C_a shall be derived from:

$$C_a = C_{ts} - C_r - C_{fs}$$

B2. Endurance Fuel Calculations

The following formula shall be used to calculate the amount of endurance fuel to be carried.

$$Endurance\ fuel = \frac{total\ fuel\ rate\ x\ endurance\ x\ 1.1}{sustained\ speed\ x\ 1000\ x\ 0.98}$$

Where:

- Endurance fuel is in MT
- Endurance is in nm
- Total fuel rate is in kg/hr
- Sustained speed is in knots

The propulsion power shall be at Full Load Departure condition with clean hull, calm water, and include hydrodynamic design margins. The electric load shall be the 24-hour average electric load at ship delivery, defined as follows:

$$EL_{24} = (L_p + L_{se}) + [0.25EL_S + 0.5EL_T + 0.25EL_W]$$

Where:

- EL_{24} = 24-hour average electric load
- L_p = propulsion load
- L_{se} = steering electric load
- EL_S = Summer electric load
- EL_T = temperate electric load
- EL_W = Winter electric load

Summer, Temperate, and Winter Electric Loads do not include Propulsion and Steering Electric Loads and are at transit operation. Electric loads shall be calculated in accordance with DDS 310-1 REV1 “Electric plant load analysis for surface ships.”

Fuel rates for other fuel consumers, such as incinerators, shall be taken at their average expected utilization.

B2.1 Pre-trial endurance fuel calculations - The total fuel rate for the propulsion engines, generator sets, and any other fuel burning equipment shall be calculated using OEM data. The total fuel rate shall be calculated based on a fuel with a lower calorific value of 42,700 kJ/kg. Prime mover fuel rates shall be calculated using external ambient air and seawater temperatures of 38 °C and 32 °C, respectively, and 40% relative humidity. Where prime movers take combustion air directly from the machinery space, prime mover fuel rates shall be calculated using an air temperature of 45 °C.

Where manufacturer correction data is not available, methods described in SNAME T&R Bulletin 3-49 shall be used. Prime mover fuel rates shall include a manufacturer fuel tolerance of plus 5%. Power transmission efficiencies used in the calculation of power at the prime mover shall be based on manufacturer data at the operating load of the machinery. Where manufacturer data is not available, methods described in SNAME T&R Bulletin 3-49 shall be used.

B2.2 Post-trials endurance fuel calculations. The total endurance fuel rate shall be calculated using measured fuel economy trial data applied to K3.2 post-trials annual fuel consumption steps 3.2.2.b through 3.2.2.j. For step 3.2.2.g, the propulsion power estimate for sustained speed at the Full Load Departure condition as determined in post-trials speed/power estimation

procedure K1.3 shall be used. For steps 3.2.2.i and 3.2.2.j, the manufacturer provided fuel consumption-to-BP relationships for each prime mover shall be adjusted to external ambient air and seawater temperatures of 38 °C and 32 °C, respectively, and 40% relative humidity. Where prime movers take combustion air directly from the machinery space, the manufacturer provided fuel consumption-to-BP relationships for each prime mover shall be adjusted to an air temperature of 45 °C.

B3. Annual Fuel Consumption

B3.1 Pre-Trial Annual Fuel Consumption. Annual fuel consumption shall be calculated using the operating profile. Annual fuel consumption shall be summed using Table K-1 based on the calculated total fuel rate at each plant operating point.

The total fuel rate for the propulsion engines, generator sets, and any other fuel burning equipment shall be calculated using OEM guaranteed data. Fuel rates shall be calculated based on a fuel with a lower calorific value of 42,700 kJ/kg. Prime mover fuel rates shall be calculated using external ambient air and seawater temperatures of 25 °C and 30% relative humidity. Where manufacturer correction data is not available, the contractor shall use methods described in SNAME T&R Bulletin 3-49. Power transmission efficiencies shall be based on manufacturer data at the operating load of the machinery. Prime mover fuel rates shall include a manufacturer fuel tolerance of plus 5%. Where manufacturer data is not available, the contractor shall use methods described in SNAME T&R Bulletin 3-49.

For each operating point, the plant operating mode (i.e. the propulsion, generator, and auxiliary plant line-up) shall correspond to the most economical operation. The propulsion power shall be with clean hull, calm water, and include hydrodynamic design margins.

Table B-1: Annual Fuel Consumption Summary

Annual Fuel Consumption - Not Underway						
Operating Condition	Maintenance (Hot)	Maintenance (Cold)	In port (hot)	In port (cold)	Total	
Time, hr/yr	1320	1320	336	1008	3984	
Plant Operating Mode		-		-	-	
Total Fuel Rate, kg/hr		-		-	-	
Fuel Consumption, MT/yr		-		-	-	
Annual Fuel Consumption - Not Underway, MT/yr						
Annual Fuel Consumption – Underway						
Operating Condition (Speed, kt)	Transit (15)	Cable Install with Plow (1)	Cable Install w/out Plow (3.5)	Cable Repair (0.50)	Bathymetric Survey/ Projector Tow (10)	Total
Time, hr/yr	1056	1248	912	1368	192	4776
Plant Operating Mode					-	
Total Fuel Rate, kg/hr					-	
Fuel Consumption, MT/yr						
Total Time, hr/yr						8760
Total Annual Fuel Consumption, MT/yr						

B3.2. Post-Trial Annual Fuel Consumption. Following the fuel economy trials, the annual fuel consumption shall be determined based on trial measurements as follows:

1. Fuel Rate Corrections. The measured fuel rate for each prime mover shall be corrected to account for the measured fuel leak-off and return rates. The fuel rates for each prime mover shall be averaged to obtain the fuel rate for each run. Prime mover fuel rates shall be corrected to external ambient air and seawater temperatures of 25 °C and 30% relative humidity using OEM guaranteed data. Where manufacturer correction data is not available, methods described in SNAME T&R Bulletin 3-49 shall be used.

2. The annual fuel consumption shall be derived from the trials results using the following procedures:

a. For each prime mover contributing power to the propulsion and/or auxiliary electric loads, the average Brake Power (BP) with respect to each ship speed point (i.e. the V_k value derived for each set of reciprocal trial runs) observed during the trial shall be plotted. Manufacturer power conversion and/or transmission loss shall be used to obtain prime mover BP from the measured shaft power or generator electric load output. The individual prime mover BP values shall be summed to get the combined ship propulsion and auxiliary load at each power level evaluated and resulting V_k .

b. For each prime mover, the average measured fuel consumption rate with respect to the BP recorded for each observed V_k shall be identified. Any discrepancy between observed fuel consumption-to-BP relationship and the manufacturer supplied fuel consumption-to-BP relationship curve shall be noted and characterized.

c. For each plotted point from step a (i.e. BP vs. V_k), the BP component that each prime mover contributes to the auxiliary electric load (BP_{Aux}) shall be determined. The remainder is the propulsion load component (BP_{Prop}).

d. For each plot generated in step c, the percentage of power each prime mover contributes to the total ship BP_{Prop} and BP_{Aux} loads shall be noted.

e. Auxiliary Electric Load Ambient Condition Adjustment. Since the trial will likely be conducted over a small range of temperatures (typically near the temperate condition), HVAC loading that is experienced over the span of a year cannot be directly measured during trials, but shall be accounted for in the annual fuel consumption evaluation. Natural ambient condition variations throughout the day (i.e. diurnal effects) are inherently present in sea trial data as periodic fluctuations of the auxiliary load. The following procedure shall be used to correct for ambient condition variations present during the trial and adjust the results to account for ambient condition variations in the operational profile:

i. For each prime mover BP_{Aux} value obtained from step c, proportionally subtract the respective average HVAC electric load value during the respective trial runs. Additional temperature-dependent loads optionally identified and measured during trials may also be subtracted proportionately from the prime mover BP_{Aux} value.

ii. The prime mover BP_{Aux} values resulting from step e.i shall be summed to obtain the total ship electric load for each observed V_k .

iii. If the trial was completed using a single operating mode for all power levels evaluated, the BP_{Aux} values from step e.ii shall be averaged to obtain the Total Ship Temperature-Independent (TI) electric load value, minimizing diurnal effects on the electric load. The total ship electric load may be dependent on operating mode. Therefore, if multiple operating modes were used, only the average of BP_{Aux} values

from step e.ii which correspond to testing completed using the same operating mode shall be used. The results are the mode-dependent TI electric load values.

iv. Using the Summer, Temperate and Winter HVAC load values from the baseline Electric Plant Load Analysis (EPLA), the ambient condition profile shall be applied to obtain the temperature-adjusted HVAC electric load value. If additional temperature-dependent loads are addressed per step e.i, then the identified load shall be obtained from the EPLA and adjusted with respect to the ambient profile in the same manner. All analysis shall be documented.

v. The ambient HVAC load value shall be added to the TI electric load average value found in step e.iii. If applicable, this shall be done for each respective mode. Any additional temperature-adjusted loads shall also be added to the respective TI electric load average value(s). The resulting value is the Temperature-Adjusted BP_{aux} value (i.e. BP_{Aux-TA}), for each mode evaluated.

f. The plots obtained in step a shall be adjusted by replacing each BP_{aux} value with the respective BP_{Aux-TA} value obtained in step e.v, using the load percentages of step d to proportionally distribute the BP_{Aux-TA} load value across each prime mover of a given test point (V_k).

g. Speed-Power Adjustment for Displacement. Post-trials speed/power estimates shall be developed for each displacement associated with the load conditions specified in the operating load profile using the procedure specified in B1.3. Where necessary, adjustments shall be made to account for variation in trim.

h. Brake Power Adjustment for Displacement. For each speed-power plot derived in step g, the corresponding propulsion shaft power shall be identified for each operating condition profile speed point. Manufacturer supplied conversion and/or transmission loss data shall be used where applicable to adjust the resultant power values from Shaft Power to BP for each speed point. Using the BP_{Prop} load percentages of step d for each speed point, the associated propulsion load value shall be distributed accordingly across each prime mover in operation to obtain the Displacement-Adjusted Brake Power ($BP_{Prop-DA}$) for each prime mover.

i. Total Ship Underway Fuel Consumption Adjustment for Displacement. Using the manufacturer supplied equations describing the fuel consumption-to-BP relationships for each prime mover, the fuel consumption rates shall be identified corresponding to each $BP_{Prop-DA}$ value at each operating condition speed point and load condition. Where prime movers of a given mode contribute power to auxiliary and propulsion loads, the sum of the prime mover's BP_{Aux-TA} and $BP_{Prop-DA}$ component values shall be used to obtain the fuel consumption rate value. Where a prime mover only contributes to auxiliary power, only the BP_{Aux-TA} value shall be used to obtain the fuel consumption rate value. For each speed point, sum all of the associated prime mover fuel consumption rate values to obtain the Total Ship Underway fuel consumption rate values for each operating condition speed point and load condition.

j. Other Fuel Consumers. For fuel consuming systems identified and measured during trials, which do not contribute directly to propulsion or ship service electric load, an annual fuel consumption rate shall be defined based on trial measurements. Any fuel consumption adjustments necessary to account for tested and rated ambient conditions shall be made using manufacturer recommended procedures. Where such procedures are not available, the methods in SNAME T&R Bulletin 3-49 shall be used. All analysis

shall be documented. The system fuel consumption rate shall be added to each Total Ship Underway fuel consumption rate obtained in step i.

k. Not Underway Fuel Consumption Rate Determination. Where trial data is unavailable, the Not Underway fuel consumption rate values from pre-trial annual fuel consumption calculation shall be used. Where pierside trial fuel economy data is available, the average fuel consumption values measured during pierside trials shall be adjusted for ambient condition dependencies as specified in steps e and j, as applicable, to obtain the final Not Underway fuel consumption rate value.

l. Total Ship Annual Fuel Consumption Rate Calculation. The Total Ship Underway and Not Underway fuel consumption rate values found in steps i through k shall be entered in Table B-1. The operating profile shall be applied to the fuel consumption rates to obtain the annual fuel consumption value in each state and sum the results to obtain the Total Ship annual fuel consumption value in mt/yr.

APPENDIX C CONCEPT OF OPERATIONS

T-ARC(X) is part of the Integrated Undersea Surveillance System (IUSS) Program. The mission of the IUSS is to provide global maritime acoustic surveillance and timely, accurate antisubmarine warfare (ASW) reporting using persistent, long-range, fixed and mobile systems. The undersea fixed surveillance systems that the T-ARC(X) installs and repairs enable the Navy to conduct wide-area surveillance to detect, classify, localize and track submarines. The ship's primary mission is to transport, install, retrieve, and repair undersea cables and equipment with additional missions of towing projectors, conducting acoustic, hydrographic and bathymetric surveys, and launching and recovering payloads through a moonpool.

The majority of operations consist of underway missions ranging from seven to 60 days in duration at sea without logistics support. Operations at sea are conducted on a 24-hour per day, seven days per week basis. Cable loading or discharge is conducted at locations worldwide. The ship supports loading and offloading operations on a 24-hour per day, 7 days per week basis. The bulk of underway days supports undersea cable installation, maintenance, and repair.

Depending on water depth, seabed conditions, and the threat to the cable from external activities such as bottom fishing or anchor drags, cables may need to be buried. Cable burial is accomplished by using a Sea Plow concurrently with cable installation, or with a Remotely Operated Vehicle (ROV) that performs Post-Lay Inspection and Burial (PLIB) operations after the cable is laid proud on the seafloor.

To conduct cable repair operations, the ship transits to the estimated location of the failure and conducts grapnel drags to cut and hook the cable or deploys an ROV to locate and cut the cable, if required. One end of the cable is raised to the surface and attached to a buoy while the other end is pulled aboard the ship to further localize the problem. The bad section of the cable is cut out and one end of a new section of repair cable is spliced in. Then, a second splice is made to connect the other end of the repair cable to the buoyed section. The bight of repair cable is then lowered to the seafloor and buried via ROV PLIB operations, if required, completing the repair.

The vessel will periodically conduct missions in addition to cable system installation and repair. These missions include:

- Bathymetric Survey - The integrated bathymetric survey system will be used to accurately map the seafloor in areas of interest. The vessel will precisely follow a set of pre-determined tracklines at a speed of about 10 knots to conduct the surveys.
- Projector Tows – The vessel will tow projectors at speeds from 3 to 10 knots along prescribed tracklines.
- UUV Operations – The vessel will deploy and recover UUVs that will perform various underwater tasks. The launch and recovery system in the moonpool will be used to launch and recover the UUVs.
- Package Operations – The vessel will deploy and recover packages to and from the seafloor at up to 3,000 m water depth. The heavy lift system and the launch and

recovery system in the moonpool will be used to deploy and recover the packages.

Table C-1 provides the projected operating profile. The operating tempo and the mix of missions that may be executed in any particular year will vary.

Table C-1: Notional Annual Operating Profile

Operating Condition	Days per Year	Speed³ (knots)	Dynamic Positioning
In-port (hot) ¹	14	-	-
In-port (cold) ²	42	-	-
Maintenance (hot) ¹	55	-	-
Maintenance (cold) ²	55	-	-
Transit	44	15	No
Cable Installation with Sea Plow	52	1	Yes
Cable Installation without Sea Plow	38	3.5	Yes
Cable Repair with ROV and UUV and Package Ops	57	0.50	Yes
Bathymetric Survey and Projector Tow	8	10	Yes
Total	365	-	-

Notes:

1. Hot Condition: On ship's power
2. Cold Condition: On shore power
3. Average speed in operating condition

Operational Vignettes

To understand the unique equipment, capabilities, and operations of a Navy cable ship, two operational vignettes are described: a typical cable installation operation, and a cable repair.

Cable System Installation

Installing a submarine cable system is a slow and expensive operation that involves many sequential steps. To understand this process, it is important to discuss the systems and the environment in which they will operate since both of those factors drive the installation techniques and procedures employed.

Modern state-of-the-art submarine cable systems use fiber-optic technology, supplanting slower and relatively low-bandwidth legacy coaxial systems of the past. Lasers on one end of the fiber-optic cable fire at extremely rapid rates down thin glass fibers roughly the diameter of a human hair to receptors at the other end of the cable. Since the range of optical signals is limited due to attenuation, repeaters are required at intervals along the cable to amplify the signal. When a cable needs to be branched in different directions, a power branching unit (PBU) is used. Repeaters and PBUs are large pieces of equipment that can weight several hundred pounds each.

The cable's fragile glass fibers are sheathed in several layers of insulation and protection making the cable itself about 1.25 inches in diameter and weighing about 2.9 tons per kilometer. Cables

laid in less than 1,500 meters water depth have extra layers of armoring for enhanced protection and are generally 1.5 to 3 inches in diameter and much heavier.

In areas that are greater than 1,500 meters water depth, cables are generally laid proud on the sea floor. In areas shallower than 1,500 meters where fishing and ship anchoring pose potential threats for damage, the cables are buried in the seabed using a Sea Plow or an ROV with high pressure water jets; in certain high-risk areas, burial with an ROV can be conducted in water depths to 3,000 meters. In hard bottom areas where burial is impractical, up armored cable is used for added protection. Finally, at the shoreline, directional drilling is often used to minimize impacts to the beach and nearshore reef.

The cable installation process generally consists of the following five basic steps, each of which will be discussed in further detail:

- Selection of a provisional cable path
- Survey of the route
- Cable ship loading
- Laying the cable, including burial in appropriate areas
- Post-lay inspection and burial, as necessary

Selection of a Provisional Route

The sea floor varies having mountains, hills, valleys, and plateaus. Considerable care is given to ensure cables follow the safest path to avoid fault zones, fishing zones, anchoring areas, and other hazards. Cable route planners will initiate a comprehensive Desktop Study (DTS) that builds on the initial route engineering by providing additional information about landing sites, geology, meteorology, oceanography, hazards, fisheries, and permit requirements. The DTS ultimately identifies a provisional route and all of the risks associated with that route.

Route Survey

The provisional cable route will be surveyed to ensure that hazards are avoided and to maximize cable protection by finding a route that will avoid noted obstacles and ensure the cable will lie without suspension. The route survey will add additional data for a final Route Position List (RPL). The route surveys consist of geophysical surveys using multi-beam bathymetry, environmental and sub-bottom profiling. This is usually done by another ship but can be conducted by the T-ARC(X) if needed. An autonomous underwater vehicle (AUV) may also be used to select suitable sensor locations.

Cable Loading

After the cable has been manufactured and integrated with its components, it is loaded into a cable ship for deployment. The cable is hauled from the factory tanks to the cable ship using cable engines. A cable coiling gang made up of numerous individuals at the factory and on the ship, is required on the ship to coil the cable into the cable tanks. The loading of a system that is thousands of kilometers of cable can take several weeks working 24/7, taking thousands of

personnel-hours. The more armor layers that the cable has, the slower the load rate. After completion of loading, the cable ship transits to its designated installation site.

Laying the Cable

A cable installation typically has two installation missions: a shore landing or shore end, and the install in deeper water. The shore end may require trenching the beach up to the Shore Terminus Equipment (STE), or if horizontal drilling was conducted, the shore end would connect to the cable bore hole where it exits the drilling pipe. Small boats or barges are used when water depths are too shallow for the larger cable ships. Divers may be used to locate the bore hole. If the water depth is less than 1,500 meters, the install vessel would use a Sea Plow to get the cable into the sea floor. When water depths exceed 1,500 meters and survey data did not reveal trawler scars, then plowing would be discontinued and cable would be laid proud on the seabed. In shallow areas (< 1,500 meters), to ensure that the cable route is clear for the cable installation, a pre-lay grapnel run (PLGR) is executed to remove fishing gear, line, anchors and other debris. This process involves the cable vessel dragging a string of metal hooks (grapnels) along the ocean floor, following the planned cable route. Any debris or obstructions detected by an increase in tension on the grapnel, is brought to the surface and cleared prior to continuing. In addition, out of service cable is cut and moved off the cable route.

Post Lay Inspection and Burial (PLIB)

Cable ships will often deploy an ROV to inspect their installation work and bury exposed cable. An ROV can provide cable protection where the Sea Plow skipped areas or was picked up to avoid in-service cables. The ROV uses onboard water jets to push sediment out from under the installed cable which results in getting the cable below sea floor level. A computer system helps engineers onboard the ship operate the ROV, and the vehicle has a variety of sensors as well as HD video cameras to give the engineers a view of how the cable sits on the bottom. PLIB operations are generally slow, on the order of 300m – 500 m per hour. While this is comparable to the lower end of plowing speeds, plowing at rates higher than 1 km/hr are achievable. Coupled with the fact that plowing combines the installation and burial of the cable simultaneously while PLIB operations are done after surface installation, plowing is the preferred method of cable protection.

Cable System Repair

Modern submarine cables are surprisingly resilient despite the fact that they are typically the diameter of a garden hose. Cable faults are caused by many events both man-made and natural. In water depths greater than 1,500 meters faults are usually caused by natural events such as underwater landslides and seismic events including earthquakes and resultant tsunamis. In water depths less than 1,500 meters faults are nearly always caused by man-made activities such as commercial fishing and vessel anchoring. Around 70% of all cable faults are caused by human activity (e.g., fishing and anchoring) while about 14% are caused by natural hazards such as undersea landslides and current scraping abrasion against rocky surfaces. The remaining 16% of faults are caused by various other manmade and environmental activities. It is worth noting that current trends in fishing and trawling activities are pushing the depths at which these activities can disrupt cable operations to depths well in excess of 1,500 meters. Trawler scars have been

detected in surveys at depths as deep as 2,500 meters, necessitating cable protection efforts at greater depths than historically required.

When a cable repair is required, the procedure typically consists of the following basic steps:

- Localization of the cable fault
- Recovery of the cable
- Jointing of the recovered cable with spare cable
- Post-Repair Inspection and Burial

Each of these steps is discussed in further detail below. Note, however, that there can be many variations to this general procedure based on actual conditions such as the number of cable breaks, time of day, weather conditions at sea, and ships around the area. Note too that a repair operation can take many days to complete – nominally four to six under normal conditions, and many more for complex breaks or when in challenging environments.

Fault Localization

The first indication that a cable is broken or faulty is the failure of the receiving equipment to detect incoming signals, alarms and voltage degradation. Cables are considered faulted when the cable is completely separated or when the electrical current is shunted to sea water due to failure of the cable insulation.

When a fault is detected technicians conduct a series of tests to locate and localize the fault. Shore end equipment can usually determine the span that is faulted between two adjacent repeaters. Voltage measurements can help determine where the fault may lie in the span. Some cable systems are designed to be tested using Optical Time Domain Reflectometry. This technique provides a pulse down the fiber which will bounce back from the fault and can be measured for distance. By calculating the time delay from the reflected signal, engineers can zero in on the exact point and area of the fault.

Cable Recovery

Once the faulted span location is determined a cable repair ship is mobilized with appropriate spare cable and hardware. When the ship reaches the area of the fault the MT will bring one end up to the deck to test. The preferred method to recover the cable is by deploying an ROV. However, if water depth precludes use of the ROV or if an ROV is not onboard, the cable will be recovered by use of a grapnel to engage the cable at a predetermined location.

If the ROV is deployed it will transit a segment of the cable while operators observe the video feed to find the fault. Once the fault is located, if the cable is intact, the ROV will cut the cable. Once the cable is cut (or if the cable was already parted), the ROV will grab hold of the cable, attach a gripper arm, and then attach a line to the gripper arm so the cable can be hauled up to the deck and tested.

If the faulted cable is in excessively deep water, or if an ROV is not available, the ship will overboard a heavy steel cut and hold grapnel attached to a line. The ship will stand off then drag the grapnel along the seabed in a direction perpendicular to the cable to engage it. Grapnel

engagement with the cable is indicated on the ship by dynamometer readings which will register a steadily increasing tension on the grapnel line. Once the cable is cut and gripped, the grapnel is recovered and the cable is tested.

If the recovered cable tests good, the cable end is sealed to protect it from seawater intrusion (capped) and the crew then attaches a buoy to the cable and deploys the buoy. If the cable tests bad, the cable will be recovered until the fault is cleared and tests good. The good cable is capped and attached to a buoy.

The other end of the cable will be recovered using the same methods as outlined above. Testing and removal of faulted cable is also the same as above. When the fault is cleared and the cable tests good, then the initial splice to the recovered cable and the spare cable takes place.

Jointing of the Recovered Cable

If a section of cable had to be removed, a new section of spare cable, sufficient in length to replace the damaged section, is electrically and optically jointed (spliced) to the recovered cable. The repair is then tested to ensure the splice was successful, and the joint is carefully sealed with a watertight and anticorrosive covering. This intricate jointing process can take up to 12 hours or more, depending on the amount of armor on the cable.

This cable end and the spare cable is then laid back to the buoyed cable end. The other buoy is recovered back to the cable ship and, following tests to the cable to ensure there are no further faults, a final splice is made. Once the final splice is complete, the cable is overboarded and held in the water column with line until the shore station confirms that system connectivity has been restored. This additional section is typically two-and-a-half times the depth of water in length to permit what was previously a cable lying flat on the sea floor to reach up to the cable ship, provide length for manipulation and repair activities on board, and reach back down to the sea floor.

Post-Repair Inspection and Burial (PRIB)

Once the shore station reports that system connectivity is restored, the cable is released onto the ocean floor. The section of cable being held by the ship, referred to as the final bight, can be laid on the ocean floor using an acoustic release that is triggered either by depth in the water column or by an acoustic command sent from the ship. Alternatively, the lines holding the final bight can be cut away. In general, the acoustic release method is preferred.

Regardless of the method, the repaired cable, which is now longer due to the added spare cable, must be carefully placed back on the seabed in a direction perpendicular to the line of the original cable so that the cable bight lies flat on the seabed. If the bight is in an area of high risk for external damage (i.e. shallow depths with trawler or fishing activity), the ROV will be deployed to perform protection work by jetting the cable back into the seafloor.

APPENDIX D DAMAGE STABILITY CRITERIA

D1. Definitions

D1.1. Equilibrium waterline - The final waterline, after all flooding (through the damage opening, from downflooding, from progressive flooding, crossflooding, and other sources) and run-off, if any, has been completed and the ship has reached its final balance condition.

D1.2. Intermediate stages of flooding - The condition of the ship at any point after damage, and prior to reaching equilibrium. Ship's with crossflooding/counterflooding designs shall review the damage case where flooding on the side of damage is complete, but that crossflooding/counterflooding has not taken affect.

D1.3. Main transverse watertight subdivision bulkheads - A transverse watertight bulkhead extending from shell to shell and from the bottom to the bulkhead deck defining the fore or aft end of a subdivision. Bulkhead longitudinal steps or recesses less than 3 m in length are permissible. These shall be treated in accordance with the guidelines on equivalent plane bulkheads contained in 46 CFR 171.010, Definitions, paragraph (c). It should be emphasized that stepped or recessed bulkheads increase the likelihood that a bulkhead may be damaged, and their use is therefore discouraged.

D1.4. Downflooding - The entering of water into a space through an opening (e.g. vents on the weather deck) that becomes submerged after damage, either by the equilibrium waterline or at some point in a reasonable range of stability after damage.

D1.5. Counterflooding/crossflooding - The deliberate flooding of a space to allow a ship to survive damage by offsetting the effects of the flooding caused by damage. Counterflooding/crossflooding shall be accomplished passively (for example by crossflooding ducts that are always open). Counterflooding/crossflooding shall be completed within 15 minutes after damage.

D2. Loading conditions - The damage stability criteria shall be met in all loading conditions as defined in Section 3.070.9.

D3. Extent of damage - The extent of damage comprises a physical opening of the dimensions given below in the side of the vessel. The required longitudinal length of side damage equals $0.333L^{2/3}$ (L is the length between perpendiculars in meters) for submarine tending, command and control, and hospital mission/payload ships. This length of damage shall be placed anywhere along the vessel. The required longitudinal length of side damage equals $0.333L^{2/3}$ or 14.5 m, whichever is less (L is length between perpendiculars in meters) for all other mission/payload ships. This extent of damage does not apply across main transverse bulkheads unless they are spaced closer than the required length of damage.

Transverse depth of side damage equals $Beam/5$, where the beam equals the maximum beam of the ship on the summer load waterline. Transverse damage is measured horizontally from the shell inboard, perpendicular to the ship's centerline. This depth of damage shall be placed anywhere along the vessel. Vertical height of side damage is unlimited above and below the waterline.

Flooding caused by the required extent of damage shall consist of water entering through the damage opening itself, progressive flooding through non-tight openings or accesses, and downflooding through deck openings. Flooding in accordance with the required extent of damage and the proper permeability's is to be considered to continue until the equilibrium waterline is reached. Note that these are maximum extents of damage. If lesser extents of damage result in worse conditions, then those conditions shall be investigated.

D4. Damaged criteria

D4.1. Final equilibrium - After the equilibrium waterline is reached following the specified damage, the following criteria shall be met (refer to Figure D-1). The criteria below are to be used for both symmetric and unsymmetrical flooding:

- a. Equilibrium heel angle θ_1 is less than or equal to 15° .
- b. Downflooding points shall not be submerged at θ_1 unless fitted with watertight closing appliances.
- c. Margin line, as defined in 46 CFR 171.015, shall not be submerged at θ_1 .
- d. There shall be a range of positive stability of at least 20° beyond the damage equilibrium heel angle:
 1. θ_2 minus θ_1 shall be at least 20° , or
 2. If the angle at which unrestricted downflooding occurs, θ_f , is less than θ_2 , then θ_f minus θ_1 shall be at least 20° .

Downflooding points immersed within the above range shall be fitted with weathertight closing appliances. Note that automatic tank vent check valves are considered weathertight.

- e. The maximum righting arm (RA_{max}) within the above range shall be at least 0.10 m.

For cases of symmetric damage, the vessel shall have a minimum of 0.05 m of positive GM in the upright condition after damage.

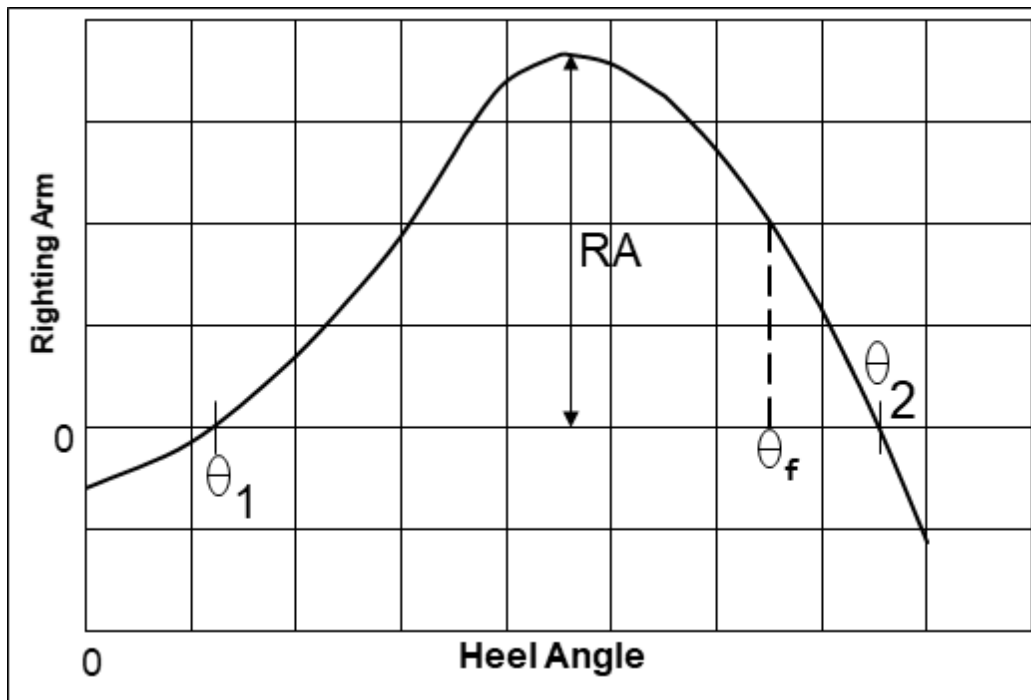


FIGURE D-1: Final Equilibrium

D4.2. Intermediate stages of flooding - Passive counterflooding/crossflooding is permissible. However, if immediate crossflooding is required to prevent capsizing, other solutions shall be required. In any intermediate stage of flooding, the vessel shall have at least a 7° range of positive righting arm beyond equilibrium, and a minimum righting arm of at least 0.05 m within that range. In intermediate stages of flooding, heel angles greater than 25° are not permitted.

In general, survival at intermediate stages of flooding need not be analyzed except as discussed above. However, if due to unusual geometry or combinations of loading conditions, intermediate stages of flooding might result in more severe heel and trim angles than at equilibrium, these intermediate stages of flooding shall be investigated. For example, side damage to a high, pressed up wing tank with only a small penetration through to the hold could result in a large instantaneous run-off and slow flooding to the hold. An intermediate condition might have the vessel capsizing to the opposite side of the damage, whereas an equilibrium condition (assuming the ship were restrained from capsizing until equilibrium were reached) might have only a slight list to the undamaged side.

D5. Permeabilities - In general, permeabilities shall be as shown in Table D-1.

Table D-1. Permeabilities

Space	Permeability
Habitability Spaces	95
Machinery	85
Tanks	As loaded or 95*
Loaded Cargo Holds	60
Empty Cargo Holds	95

NOTE: Whichever leads to a more severe condition. Full or partially filled tanks should be damaged using run-off.

Permeabilities other than those above shall be rationally chosen and documented so as to agree with the actual vessel loading conditions. For example, if the vessel had a cargo hold essentially empty in a light condition, a permeability of 95 shall be used instead of 60.

B6. Free surface - The ship shall meet the damage stability requirements with the actual free surface of all tanks as loaded in the specific loading condition. This shall include the slack free surface of any intermediate tank loads, which occur as the ship's liquid loading is adjusted during the voyage. The effect of free surface shall be included over the full range of heel angles using the moment of transference method. As an alternative, a single correction can be applied at all angles of heel by calculating the free surface assuming the ship is heeled 5°.

B7. Run-off - Where damaged tanks or spaces contain liquids such as fuel oil, lube oil, and water, the entire liquid contents of the tanks or spaces prior to damage is assumed to run-out after damage. Flooding water then refills the space at the appropriate permeability (generally 95) to the equilibrium waterline. Run-off shall be accounted for in each damage case.

approach coordinated with ships' schedules. All available opportunities to perform normal and corrective maintenance are utilized while limiting scheduled repair availabilities and time out of service. When planning for periodic maintenance and voyage repairs, the most efficient means of performing maintenance and repair will be evaluated considering cost and schedule impact of using either ship's force labor or industrial assistance. The high skill level of the career merchant mariners MSC employs provides a level of technical expertise equivalent to a Navy intermediate maintenance. This means that MSC ships will be spared at the "O" and "I" levels, and only "D" level maintenance is accomplished with industrial assistance.

A Memorandum of Understanding (MOU) with PRESINSURV provides for the coordination of different inspection requirements and synchronization of ship inspections with maintenance cycles. MSC will continue to consolidate all required inspections in an effort to minimize impacts on ship schedules. MSC will pursue self inspection initiatives available from ABS and USCG and continue ISM certification.

In summary, MSC will continue to employ efficient and cost effective maintenance approaches that strive to correctly identify work that will be accomplished, determine the most cost effective and schedule efficient way to perform that work and maximize availability to the customer.

APPENDIX F DIESEL ENGINE APPROVAL TEST

This appendix contains requirements for the following:

Diesel Engine Verification Process
Documented Service Record Requirements
Rating Certification Test Requirements
Generator Package Test Requirements
Low Load Testing Requirements
Production Unit Test Requirements

Diesel Engine Verification Process

ABS shall certify the engines. The Government will monitor ABS efforts to certify the engines. The Government shall be the final approving authority for the engines and will issue a qualification letter approving the installed rating upon full receipt of all satisfactory certification data from ABS.

Inspection of on-board technical documentation shall be conducted to verify compliance with the requirements on emissions applicable to marine engines intended for U.S. Flag commercial vessels.

The low load test shall be performed to verify requirements limiting adverse emissions and negative impacts on material condition due to low load operation.

Where the proposed engine drives a generator set, the Generator Package Test described herein shall be performed in addition to any other required testing.

Each production engine shall be tested in accordance with the Production Unit Test.

Proposed engine rating requirements shall be validated by one of the methods cited in Table F-1. If validation testing is required, it shall be performed in accordance with the process described herein.

Table F-1: Test Hours and Cycles for Validation Testing

Engine Category Based on Design and Service History	Endurance Test Hours and (No. of cycles) For 100% Rating	Endurance Test Hours and (No. of cycles) For 1-10% Uprating⁽¹⁾	Endurance Test Hours and (No. of cycles) Beyond 10% Uprating⁽¹⁾
R&D development or commercial engine with no documented service record	1500 (188)	N/A	N/A
Commercial engine with documented service record ⁽³⁾	500 (63)	500 (63)	1000 (125)
Non-U.S. Navy military qualified engines (test and documented service record) ^(4,6)	500 (63)	500 (63)	1000 (125)
U.S. Navy qualified engines/Engines with ABS machinery certificate for naval applications with significant changes ^(2,4,7)	250 (31)	500 (63)	1000 (125)
U.S. Navy qualified engines/Engines with ABS machinery certificate for naval applications with no significant changes with no documented service record ^(2,4,7)	No Testing Required ⁽⁵⁾	500 (63)	1000 (125)
U.S. Navy qualified engines/Engines with ABS machinery certificate for naval	No Testing Required ⁽⁵⁾	No Testing Required ⁽⁵⁾	1000 (125)

Engine Category Based on Design and Service History	Endurance Test Hours and (No. of cycles) For 100% Rating	Endurance Test Hours and (No. of cycles) For 1-10% Uprating⁽¹⁾	Endurance Test Hours and (No. of cycles) Beyond 10% Uprating⁽¹⁾
applications with no significant changes with documented service record ^(2,4,7)			

Notes:

1. The required number of hours of Performance Testing to validate 100% rating shall be satisfactorily completed prior to conducting the uprating test.
2. Significant Changes are modifications made to the engine components or systems required for ABS approval, or changes that affect engine performance, shaft dynamics, and cycle temperatures. The modifications may be major design changes or minor modifications to improve manufacturing processes or service life. Any engine component modified such that it is no longer interchangeable with the component it replaces is considered to have undergone a significant change.
3. When a commercial engine with Documented Service records is proposed, the Documented Service records shall contain cumulative service of at least 25,000 running hours in marine and/or industrial installations using liquid fuels on engines with a rated power equal to or greater than the proposed rating. The Documented Service records shall be in accordance with the requirements herein. At least two of these engines shall have a minimum of 5,000 running hours each with no overhauls except published scheduled maintenance. Consideration will be given to diesel engines of identical make, model, engine family, and cylinder rating, but with different number of cylinders if satisfactory service can be demonstrated.
4. When design and manufacturing changes are made to a previously qualified engine or to a qualified engine currently in production, copies of the revised drawings shall be submitted for review. The engine manufacturer may submit their own Engineering Change Proposal (ECP) indicating drawing number(s), stating the nature of the change, along with a statement indicating the design change has been tested or submitting calculations, and stating the design change has not affected engine performance or has resulted in an improvement to the old part. The certificate shall be signed by the person in charge of engineering.
5. For diesel generator applications, any previous U.S. Navy qualified engine that does not require any testing as indicated in the Table F-1 shall undergo a Generator Package Test.
6. For non-U.S. Navy military qualified engines, the test specification the engine was certified to, including test reports and documented service record shall be submitted for review.
7. A U.S. Navy qualified engine is an engine for which a letter has been issued by the U.S. Navy for a marine application. The performance standard shall be indicated in the letter.

Documented Service Record Requirements

Provide the following information to demonstrate that the proposed prime movers have a history of reliable operation:

1. Previous Applications: Documented service records shall contain cumulative service of at least 25,000 running hours in marine and/or industrial installations using liquid fuels on engines with a maximum continuous power rating equal to or greater than the proposed rating. At least two of these engines shall have a minimum of 5,000 running hours, each with no overhauls except published scheduled maintenance. Consideration will be given to diesel engines of identical make, model, and cylinder rating, but different number of cylinders if equivalent horsepower hours of satisfactory service can be demonstrated.

2. Engine Configuration: The engine configuration of the service applications shall be clearly defined. Any differences with the manufacturer's current production engine shall also be defined. A description of the technical development of the engine including its rating when first used in marine applications, any subsequent upgrades, and major design changes shall be provided.

3. Documentation: The documented service records describing previous marine and/or industrial applications similar to the proposed application shall include the following:

- a. Owner, including point of contact, address, telephone number, telefax number, and e-mail address (if available).
- b. Name of ship or facility containing the engine.
- c. Type of marine application (propulsion, generator, other).
- d. For propulsion service, provide the number of engines per shaft, type of drive (geared, electric, direct), and type of propeller.
- e. Model number, serial numbers, year engine entered service.
- f. Nameplate rating: bhp and RPM or kW (brake power) and RPM.
- g. Operating hours vs power.
- h. Number of starts.
- i. Type of fuel used.
- j. Service and Warranty Records.
- k. Service Bulletins and Certificates.
- l. Any component replacements/repairs, other than normal maintenance that has been done since the engine entered service. Provide background on why this was done.
- m. If failures have occurred, provide detail or description of the failure and provide failure analysis and corrective action taken.
- n. Description of any component improvement programs in progress and their status report.

Rating Certification Test Requirements

1. General. The following general requirements apply to diesel engine testing:

a. The rating established by this approval test shall be based on the test conditions and fuels specified herein.

b. The Government reserves the right to have a representative on site during part or all of the testing. A test procedure, schedule, and agenda shall be provided to the Government and ABS prior to the start of testing.

c. An engine material condition baseline shall be established prior to the start of testing to support the post testing inspection requirements. The material condition baseline shall include measurement of all parts to be presented for inspection following testing, documentation of visual appearance of accessible wearing surfaces, and a record of torques, thrust measurements, hydraulic pressures, and other measurement data to establish the as-assembled condition of the engine. Acceptance criteria for all portions of the material condition baseline shall be established prior to the start of testing.

d. The engine test facility shall be suitable to perform the test providing instrumentation, power absorption, and data recording capability. Data shall be measured and recorded when testing the engine at various load points and shall include all necessary parameters for the engine operation. Readings shall be taken and recorded at a maximum interval of 1 hour with at least one reading taken during each step after the data stabilizes. All data, including written logs, shall be available for inspection by ABS during the full course of the test. Additionally, a written log shall be maintained showing all preventative and corrective maintenance actions performed during the course of the tests.

e. Immediately after completing the Test Profile, the engine shall be disassembled as specified below, each part shall be inspected, and the results shall be documented. The assemblies and parts shall be photographed. Excessive wear or damage that is observed or is suspected on any part or where system test results indicate the component no longer meets design requirements shall be identified and documented.

2. Inspections Before Rating Certification Test. The following inspections shall be performed prior to commencing the rating certification test:

a. Measurement Standards: The wear limits or comparison photographs for all wearing engine components, variability among the parts of the same part number, dimensional acceptance limits, variability limits, limits for all running clearances and adjustments, design tolerances and clearances, engine operating parameters, maximum loads for speeds between idle speed and rated speed, lubricating oil, and jacket water spectrographic trending analysis limits, as applicable, shall be determined and approved prior to the start of testing.

b. Visual and Dimensional Evaluation: Dimensional examinations shall be performed. Visual examinations may be performed, in lieu of dimensional examinations of the parts if approved as part of the test procedure. This visual and measurement examination along with as-built drawings shall establish the configuration baseline for

the component evaluation after endurance tests. Engine parts shall not be replaced or exchanged without prior approval.

c. Documentation: A visual examination checklist shall be prepared and include notations for surface defects on unmachined surfaces, scuff marks, unusual deposits, discoloration, abnormal wear, fretting, beginning of pitting, cavitation, or other signs of distress.

d. Evaluation Criteria: Visual documentation (via photography or videography) shall be conducted and submitted for review of the various engine components and engine areas including piston and rings, cylinder liner, valves and guides, turbocharger inlet and outlet, charge air cooler inlet and outlet, intake and exhaust manifolds, and any other air and exhaust gas passages of the engine. Other engine components and engine areas may be identified during the design assessment to be affected by low load operation and will also be subject to this requirement for visual documentation.

3. Test Method. Diesel engines shall be tested in accordance with the Type Test requirements of ISO 3046-1, and the Test Profile:

a. Test conditions shall be in accordance with Table F-2:

Table F-2: Standard Test Operating Conditions

Test Operating Condition	Value
1. Inlet air temperature ⁽¹⁾ (°C)	45 ⁽²⁾
2. Inlet barometer air pressure dry ⁽¹⁾ (kPa)	101
3. Seawater inlet temperature (°C) (Secondary cooling water system)	32
4. Seawater outlet temperature (°C) (Secondary cooling water system)	54
5. Inlet air system depression after filter for turbocharged engines ^(1, 3) (kPa - total)	2.5
6. Exhaust system restriction ⁽¹⁾ (kPa - total)	4.1 (Note 4)

Notes:

1. Measurement locations for these specified conditions shall be in accordance with ISO 15550 and ISO 3046-3.
2. A means shall be provided to maintain this inlet air temperature during testing.
3. For naturally aspirated engines, use 3.7 kPa.
4. Exhaust system restriction of 4.1 kPa – total is for propulsion engines. Generator engines may be tested at 3.4 kPa – total exhaust system restriction.

Test condition shall be set as close to the standard operating conditions shown in Table F-2 as practical. Where standard operating conditions cannot be duplicated

exactly, the adjustment methods of ISO 3046-1 shall be used to adjust the test conditions to the standard operating conditions listed in Table F-2.

b. Power Correction and Performance Curves: The value corresponding to each specified rated load or torque percentage shall be herein referred to as the target load. The fuel efficiency results shall be presented in the final first article test report. The plotting guideline is as below:

- 1) Both kW vs. RPM and BMEP (or torque) vs. RPM curve.
- 2) Constant BSFC “isometric map” plotted on the BMEP vs. RPM engine load profile curve. The propeller load curve, if applicable, shall also be shown.

c. Intake Depression and Exhaust Back Pressure Restriction Settings: The intake air depression and exhaust back pressure restrictions shall be adjusted to the values specified in Table F-2. The specified restrictions values shall be set at corrected rated load and speed. The settings shall remain unchanged during all specified tests.

d. Test Fluids: The diesel fuel used during the tests shall be Navy distillate fuel as specified herein. Lubricating oil and coolant corrosion inhibitor used during the tests shall be in accordance with the engine manufacturer's recommendations. The jacket water shall be treated with corrosion inhibitor as recommended by the engine manufacturer. The specific brand of lubricating oil and corrosion inhibitor to be used during testing shall be identified.

4. Operation Criteria. Rating certification testing shall be conducted using the following criteria:

a. Commencing and Recommencing: Upon activation and stabilization of the lubricating-oil preheat system, the jacket water keep-warm system, and the lubricating-oil priming system, the engine shall start and attain the first step or operating condition of each 8 hour cycle within the following times given in Table F-3:

Table F-3: Step Change Times

Rated Power	Time to Attain First Step or Operating Condition Stop to 100% Load	Time to Attain Second Step or Operating Condition
≤1000 kW	10 seconds	10 seconds
1000 kW ≤ 3000 kW	20 seconds	20 seconds
3000 kW ≤ 5000 kW	30 seconds	20 seconds
> 5000 kW	40 seconds	20 seconds

Ramp time to attain the first step exceeding the values given above will be specially considered for each application based on technical justification submitted by the manufacturer.

b. Engine Monitoring: Engine operation shall be monitored throughout the test. Specified parameters shall be measured every hour during the test after the engine has been operating at a particular condition for at least 10 minutes and the temperature and

pressures have stabilized. Test events shall be monitored. Charge air cooler performance shall be monitored and verified within limits on both the air and water sides.

c. Engine Maintenance: Preventive maintenance to be conducted during the Test Profile shall be approved prior to conducting the test. The approved preventive maintenance shall be the only allowed maintenance performed on the engine not subject to the test acceptance criteria. No parts shall be modified, replaced, or adjusted, except for scheduled maintenance and to correct permissible shutdowns.

d. Engine Shutdowns: Engine shutdowns shall be defined as either permissible shutdowns or forced shutdowns. The engine shall be shut down if one or more of the following shutdown conditions occur:

- 1) Abnormal operation or failure of an engine component.
- 2) Engine misfire during any test cycle operating condition.
- 3) Engine operation outside of manufacturer's operating parameters
- 4) Test personnel or engine endangered.
- 5) Faulty test cell service systems or other systems extraneous to the engine.

e. Notification at the time of an unscheduled shutdown shall be given to the ABS representative. When a forced shutdown occurs, the test shall be terminated. Recommencement of the entire test shall then be required.

f. A failure report describing the investigation of the shutdown shall be provided by the manufacturer. If the failure is attributable to the design of the component, then the shutdown will be classified as a forced shutdown. Failures attributable to manufacturing or quality defects may require recommencement of the entire test depending upon the results of an investigation of the manufacturer's quality system. Testing may continue at the manufacturer's risk while the failure investigation is ongoing.

g. Permissible Shutdowns: Permissible shutdowns include the minimum 10-minute shutdown period at the end of each cycle, shutdowns due to facility problems, and shutdowns at the end of the test day. Scheduled maintenance shall be performed during this shutdown period, which may be lengthened as desired by the manufacturer to carry out the required maintenance established in the approved first article test procedures. A shutdown shall be classified as permissible only if it cannot be described by any of the forced shutdown criteria.

h. Forced Shutdowns: An engine shutdown shall be classified as a forced shutdown if it can be described by one or more of the following:

- 1) A single failure of an engine component that cannot be corrected or repaired within a 2-hour period (if the engine shutdown occurred during off-hours, initiation of the repair may be delayed until the start of the next workday). The 2-hour period does not include obtaining replacement parts, tools or personnel to perform the repair. The 2-hour period is to include the removal of all interferences, draining of fluids from pipes, etc. that need to be disassembled once the work begins.
- 2) Two failures of the same engine components with the same part number. (The failure of identical components in different locations on the engine is classified as a forced shutdown.)

- 3) Engine repair requires access to the internal crankcase components or gear train; or requires the removal of manifolds, blowers, turbochargers, or cylinder heads.
- 4) Failure to maintain engine operation within the variability limits of the operating parameters, target torque, or target speed; or failure to maintain lubricating oil from exceeding the physical test trending limits.

5. Performance Tests Conducted Before, During, and After the Rating Certification Test. Rating certification testing shall include the following performance tests:

a. Compression and Firing Pressures: Where test connections are installed or provided, compression and firing pressures shall be taken for each cylinder. Compression pressures shall be taken prior to the start of testing and at the completion of testing. Firing pressures shall be taken at the beginning and end of the test. Variables that the manufacturer's standard practice specifies to be controlled shall be measured during each test. Firing pressures shall be taken at no-load and rated speed, and at rated load and speed. Cylinder leakdown tests, blow-by tests, or other tests recommended by the manufacturer to diagnose power train condition may be substituted when specified.

b. Fuel Consumption Test: Fuel mass flow measurements shall be made using Navy distillate fuel at 100, 90, 70, 50, and 30% rated speed and each of the following loads at each speed: 100, 80, 60, 40, 20, and 0% full corrected load (or maximum load at the respective speed). At any test speed where the test load would exceed the specified maximum load, the maximum load shall be substituted for those loads. At each engine operating condition, the engine shall be operated for at least 15 minutes. Once engine temperatures and fuel flow have stabilized at each engine operating condition, three fuel mass flow and other measurements shall be made. The test results shall be used to produce a fuel map. For ship service generators and propulsion engines operating at constant speed, the load point shall be the same except that the speed shall be 100% of rated speed at all load points.

c. Fuel Oil Analysis: Two samples of Navy distillate fuel used for test engine operation shall be collected at initial fueling and then at 250-hour intervals during the endurance test. Samples shall be labeled indicating test cycle number and endurance test hours. Two samples of fuel from each lot of fuel shall be collected. The fuel analysis of one sample shall determine the following characteristics in accordance with each corresponding ASTM test method: lower heating value (ASTM D240), kinematic viscosity (ASTM D445), cetane number (ASTM D613), flashpoint (ASTM D93), sulfur content (ASTM D4294, D2622, or D5453 as appropriate for sulfur level), ash content (ASTM D482), carbon residue (ASTM D189 or D524), total water content (ASTM D6304), weight sediment (ASTM D2276), and appearance (ASTM D4176). The other sample shall be provided to ABS.

d. Lube Oil Analysis: Lubricating oil consumption shall be measured and the oil analyzed:

- 1) All additions and removals of lubricating oil from the engine shall be measured. Lubricating oil consumption rates shall be determined at approximately each 250 hours of testing.

2) Two lube oil samples shall be taken from each lube oil circulating system at the following times during the endurance test:

- a) Prior to the start of the testing.
- b) During the first cycle.
- c) During the last cycle.
- d) After approximately each 250 hours of testing.
- e) During the cycle preceding and after every lube oil change or addition.

3) One of each sample shall be provided to ABS and the other samples shall be analyzed in accordance with Table F-4 and the results provided to ABS. Samples shall be labeled indicating test cycle number and the test hours.

4) Spectrographic analysis of each lubricating-oil sample to be analyzed shall be conducted to measure in ppm the concentration of oil additive elements and wear metal elements of oil-wetted components such as the following: aluminum, calcium, chromium, copper, iron, lead, magnesium, molybdenum, nickel, phosphorous, silicon, silver, tin, and titanium. Condemning limits for wear metal elements of oil wetted components shall be determined prior to testing.

Table F-4: Lube Oil Analysis Requirements

Test	Standard (ASTM No.) (Alternatives)	Condemning Limit
Total Acid Number	D664	Manufacturer's Recommendations
Total base number	D4739, (ASTM D2896, ISO 3771)	Manufacturer's Recommendations min. 50% of fresh-oil value
Viscosity (at 40 °C)	D445 (DIN 51562 including parts DIN 51562-1, DIN 51562-2, DIN 51562-3, and DIN 51562-4)	910 SSU (200 cSt) maximum and 410 SSU (90 cSt) minimum SAE 40
Viscosity at 100 °C maximum mm ² /s		SAE 30, SAE 5W-30, SAE 10W-30 14.0 SAE 40, SAE 10W-40, SAE 15W-40 18.0
Viscosity at 100 °C minimum mm ² /s		SAE 30, SAE 5W-30, SAE 10W-30 9.0 SAE 40, SAE 10W-40, SAE 15W-40 11.5
Fuel dilution determined from flashpoint (if viscosity 130 cSt)	D92	5.0% maximum or manufacturer's published limit, whichever is less.
Water	D6304	Maximum 0.2% by volume or 0.3% (from two sources)

Test	Standard (ASTM No.) (Alternatives)	Condemning Limit
Carbon residue ⁽¹⁾	D189 or D524 (ISO 6615 or ISO 4262)	
Sulfated ash ⁽¹⁾	D874	
Pentane and Benzene Insolubles ⁽²⁾	D893, Procedure B	
Oxidation	Manufacturer's Standard	
Fuel Dilution	Manufacturer's Standard	
Glycol	D2982 (DIN 51375-2)	Maximum 0.1 percent
Soot Index	Manufacturer's Standard	
Wear Metals	Manufacturer's Standard	
Flash point	D92 (ISO 2592)	Minimum 190 °C
Total Contamination	DIN 51365:1988-03	Maximum 2.5% by weight

Notes:

1. This test shall be conducted only on unused oil samples from each lot of oil used.
2. This test shall be conducted only on lubricating oil samples collected during the cycle immediately preceding every lubricating oil change.

f. Cooling Water Analysis: Two samples of cooling water shall be collected from the cooling system, if applicable, at the beginning and end of the endurance test and at intervals of 250 hours of endurance test. Samples shall be labeled. One sample of each pair of samples shall be provided to the attending ABS representative. The other sample of each pair shall be analyzed to determine inhibitor concentration.

g. Exhaust Emissions: Diesel engines shall comply with the emissions requirements applicable to marine engines intended for US Flag commercial vessels. Diesel engines shall be provided with technical documentation for on-board verification and records demonstrating that the engines have been tested by the manufacturer at the proposed rating for gaseous and particulate emissions (NO_x, CO, CO₂, HC, O₂ and PM) and smoke emissions.

h. Overspeed Governor: With the engine governor deactivated or set at an rpm greater than the overspeed protection device activation rpm, increase engine speed from idle to the rpm at which the overspeed protection device is activated. This rpm traverse shall be completed between 30 seconds and 1 minute. A continuous measurement of rpm shall be made during the rpm traverse and for 30 seconds after the overspeed protection device is activated.

i. Emergency Shutdown: This device shall be operated once, preceding the endurance test, without the engine running. Upon completion of the endurance test and before the post endurance test examination, this device shall be actuated twice with the engine operating at no load and at a speed that is 10% greater than rated speed and twice with the engine operating at rated speed and full load. The engine shall be at full operating temperatures before each actuation of the shutdown device. The increase in engine speed prior to activating the shutdown device shall be continuous, and the shutdown device shall be activated immediately upon reaching the required speed. For data collection purposes, a continuous recording/measurement of the engine speed

utilizing a strip recorder or equivalent shall be made for 1 minute before and 1 minute following each actuation.

j. Alarms and Shutdowns: Response to each of the applicable alarms and shutdowns shall be tested. The parameter activating each switch shall be increased or decreased from the acceptable operating range to the alarm activating point. Static tests are acceptable in lieu of testing alarm switches during engine operation. The alarm activation value of each parameter shall be measured for each test. Standard commercial test cells, detached accessories, and instrumentation may be used for these tests.

6. **Test Profile.** The engine shall be subjected to the length of testing required by Table G-1 using the applicable test profile of Table F-5.1 or Table F-5.2. The 10-minute shutdown time between cycles shall not be counted as part of the test qualification time.

Table F-5.1: Standard Test Cycle Profile (for generator engines)

Step	Minutes	Power (Percent)	Speed (Percent)
1 ⁽¹⁾⁽²⁾⁽³⁾	120	100	100
2	60	60	100
3	10	0	Idle ⁽⁴⁾
4	110	100	100
5	10	0	Idle ⁽⁴⁾
6	30	50	75 ⁽⁴⁾
7	10	0	Idle ⁽⁴⁾
8	10	85	100
9 ⁽⁵⁾	120	110	100

Notes:

1. Times to achieve the specified load and speed shall not exceed the values given in Table F-3.
2. Fuel consumption shall be measured at rated power during the first and last Standard Test Profile Cycles. Results shall be corrected to a common calorific value.
3. For each step, with the exception of the idle condition, the load shall be maintained within plus 1% or minus 0% of the specified load value, and the speed shall be maintained within plus or minus 1% or plus or minus 10 RPM (whichever is less) of the specified speed value.
4. Speed shall remain at 100% for generator applications.
5. Upon completion of step 9, the engine shall be shut down for a minimum of 10 minutes before beginning the next cycle.

Table F-5.2: Standard Test Cycle Profile
(for propulsion engines)

Step	Minutes	Power (%)	Speed (%)
1 ⁽¹⁾⁽²⁾⁽³⁾	120	100	100
2	60	60	100
3	10	5	Idle ⁽⁴⁾
4	110	100	100
5	10	5	Idle ⁽⁴⁾
6	30	50	90 ⁽⁴⁾
7	10	5	Idle ⁽⁴⁾
8	10	85	100
9	120	102	100
10 ⁽⁵⁾⁽⁶⁾	20	15	100

Notes:

1. Times to achieve the specified load and speed shall not exceed the values given in Table F-3. Times to achieve the specified load and speed shall be recorded. Due to the response time of the dynamometer the load step of the first and last test cycles shall be recorded by manual operation of the water brake system.
2. Fuel consumption shall be measured at rated power during the first and last Standard Test Profile Cycles. Results shall be corrected to a common calorific value.
3. For each step, with the exception of the idle condition, the load shall be maintained within plus 1% or minus 0% of the specified load value, and the speed shall be maintained within plus or minus 1% or plus or minus 10 RPM (whichever is less) of the specified speed value.
4. Speed shall remain at 100% for generator applications.
5. The time of step 10 is a cool down period and does not count towards the required endurance test hours.
6. Upon completion of step 10, the engine shall be shut down for a minimum of 10 minutes before beginning the next cycle.

a. Forced Shutdowns: ABS shall be notified in writing of any forced shutdown, component replacement, or abnormal condition. An abnormal condition may be identified by either the Contractor or ABS monitoring the testing. When the cause of the forced shutdown, component replacement, or abnormal condition has been determined, an engineering report with supporting documentation, analyses, and rationale detailing the cause, corrective action, and impact on the test completion criteria shall be submitted to ABS for evaluation to determine if additional testing is warranted.

b. Test Profile Completion Criteria: The Test Profile will be considered complete after the engine has successfully run all the conditions contained in the Test Profile and the following conditions are met:

- 1) No shutdown or fail to start has occurred because of engine malfunction.

2) No forced shutdown has occurred during the test.

3) No internal component of the engine (i.e., parts requiring access cover removal) has been replaced, repaired, or adjusted during the test unless the component has been replaced as part of the approved scheduled preventive maintenance program.

4) No external component has been replaced or repaired other than as may be required by engine malfunction (sub para. b immediately above). Preventive maintenance parts identified in the approved scheduled preventive maintenance program are excluded.

5) Vibration levels shall not have exceeded the manufacturer's limits for production acceptance. These limits shall have been specified prior to the start of testing.

6) Lube oil and jacket water analyses shall not exceed the manufacturer's trending limits for in-service engines.

7) Components presented for inspection shall not have exceeded the manufacturer's wear limits if measurements are taken or appearance limits if comparison photographs are used for production acceptance.

8) All engine performance parameters are within production limits and fuel consumption has not increased during the rating certification test. Fuel consumption shall be within the manufacturer's specified limits.

9) The cumulative time due to unscheduled engine shutdowns shall not exceed 1% of the test length. The test may be continued to as needed to achieve a period of testing equal to the required test length that meets the requirements. The shutdown period following each cycle, shutdowns due to facility problems, and shutdowns at the end of the test day do not count in determining the total unplanned engine shutdown time.

7. Inspections After Rating Certification Test: The following inspections shall be performed following completion of the rating certification test:

a. Visual and Dimensional Evaluation: Upon completion of rating certification testing, the engine running clearances shall be measured. The engine and its attached and unattached assemblies shall be disassembled. Each piece shall be reinspected, and measurements made before commencing any other testing. Special tools furnished with the engine shall be used during this inspection. Additional inspections may be requested such as further disassembly of a particular component, or nondestructive tests such as hydrostatic or crack detection tests. The scope of disassembly shall include the components of one cylinder for in-line engines and one cylinder from each bank for V-engines, and the following components, which shall be presented:

1) Piston removed and dismantled.

2) Crosshead bearing dismantled (if applicable). Crank bearing and main bearing dismantled.

3) Cylinder liner in the installed condition.

4) Cylinder head, valves, and valve train disassembled.

5) Control gear, camshaft, turbocharger, and crankcase with open covers.

- 6) Injection pump, injector, and injection pump operating gear.
- 7) Access for inspection of gears and wearing surfaces shall be provided.
- 8) Any component or measurement forming the material condition baseline shall be inspected relative to the material condition baseline acceptance criteria.
- 9) Any components related to, or effected by, a forced shutdown.
- 10) If deemed necessary by the ABS representative based on the observed condition of engine parts examined and recorded test data, further dismantling of the engine shall be required.

b. Reassembly: After the inspection is completed, the engine shall be reassembled to meet new product specifications and shall be subjected to the Production Unit Inspection and Tests including one cycle of the standard 8-hour endurance cycle.

c. Evaluation Criteria: The failure of any component to meet the manufacturer's wear limits or the evidence of cracks, cavitation, pitting, scuffing, galling, fretting, or overheating shall be cause for the rejection of the engine. The wear limits are to be proposed by the manufacturer based on the test duration and agreed upon by ABS prior to the start of the test. These wear limits are not the maximum limits specified in the service manual of the engine for the replacement of the components. Failure to meet evaluation criteria shall be cause for the rejection of the engine. The engine failure to meet the requirements of these rules shall result in a restart of the first article tests. In any case, any design deficiency (or any evidence of design discrepancies) must be reported, analyzed and co-signed by the engine supplier's Chief Engineer and its Quality Assurance Manager. When a OEM's part is involved, its Chief Technical Officer and its Quality Assurance Manager shall also provide their analyses of the design discrepancy and/or part failure.

8. Test Acceptance. The approval test will be considered successful when the following conditions are satisfied:

- a. All Test Profile Completion Criteria are met.
- b. All engine performance parameters are within production limits and fuel consumption has not increased by more than 3 percent.
- c. Any additional testing resulting from any forced shutdown, component replacement, or abnormal condition has been successfully completed.
- d. All fuel oil, lube oil, and jacketwater analyses are acceptable to ABS.
- e. Exhaust emissions comply with requirements.
- f. Engine condition as determined by the inspection following the Test Profile is acceptable to ABS.
- g. Modifications developed as a result of testing and modifications developed as a result of final engine inspections shall be proven effective by means of a validation program acceptable to ABS.
- h. Test report delivered to the Government is fully acceptable to the Government. The Government will be the final approval authority for the engine rating.

Generator Package Test Requirements

1. General: In addition to the Validation Test Requirements, packaged generator sets shall undergo the tests and inspections listed in this section:

- a. Engine-to-generator alignment limits shall be determined and measured.
- b. Monitoring during testing shall include the displays and alarms in the Local Control Panel provided for the application.
- c. The generator package test shall consist of the steps described below.

2. Examinations: The generator set shall be examined for access to accessories, such as oil sight flow gauges, lube oil fill and drain, air and oil filter, instruments, and so forth. The fit of parts shall be observed with particular reference to the interchangeability of such parts as are likely to require replacement during the normal service life of the generator set.

3. Packaging Test: The first production generator set, even when employing a diesel engine that does not require any testing as indicated by the Diesel Engine Certification Test Matrix, shall undergo the Packaging Test. When testing is required in accordance with Table F-1, the Rating Certification Test and Generator Package Test may be combined:

a. Twelve standard 8-hour test profile cycles per Table F-5.1 shall be performed:

- 1) Monitored parameters shall include those items for a ship service diesel generator set provided for this application.
- 2) Monitoring during testing shall include the indications and alarms on the Generator Control Unit (Control Panel).
- 3) Measurements of monitored parameters shall be made at intervals specified in the engine monitoring requirements of the rating certification test.
- 4) Lubricating oil samples shall be collected before and after the cycle and analyzed as specified in the rating certification test and tests.
- 5) Exhaust smoke and emissions shall be measured. Exhaust emissions shall comply with requirements set forth in qualifying emissions testing.

b. **Other Tests Conducted Before, During, and After the Packaging Test:**

- 1) The emergency shutdown device shall be tested.
- 2) Governor response and overspeed protection device operation shall be measured.
- 3) The response of each alarm switch shall be tested. The alarm activation value of each parameter shall be measured for each test.
- 4) Testing of the generator set shall include all parts being supplied by the manufacturer for installation with the generator set such as the governing system.

4. Approvals: The generator package test results shall be consolidated with the rating certification test report or the low load test report in the case where rating certification is not required. In either case, the test report delivered to the Government shall be fully acceptable

to the Government. The Government will be the final approval authority for the generator package test.

Low Load Testing Requirements

1. General: Unless otherwise specified, the first production engine shall be subjected to low load testing in accordance with these requirements.

a. The purpose of this testing is to demonstrate satisfactory engine operation over the range of low load operations. The range of low load operation is 15% to 50% of rated power. This test is not applicable for emergency diesel generator applications.

b. An engine material condition baseline shall be established prior to the start of testing, which will support the post testing inspection requirements. The material condition baseline shall include measurement of all parts to be presented for inspection following testing, documentation of visual appearances of accessible wearing surfaces, and a record of torques, thrust measurements, hydraulic pressures, and other measurements data to establish the assembled condition of the engine.

c. Acceptance criteria for all portions of the material condition baseline shall be established prior to the start of testing.

2. Inspections before Low Load Testing: The requirements of the Inspections Before Rating Certification Test section of the Rating Certification Test are applicable to Low Load Testing.

3. Low Load Test Conditions: The requirements of the Test Method section of the Rating Certification Test are applicable to Low Load Testing.

4. Operation Criteria: The requirements of the Operation Criteria section of the Rating Certification Test are applicable to Low Load Testing, with the exception that during Step 2 of the low load test profile, no shutdowns are permitted. For the purposes of the low load test, minimum power is the minimum power required for loitering speed for engines mechanically driving propulsion shafts, and 15% of rated power for generator sets.

5. Performance Tests Conducted Before, During, and After the Low Load Test: The requirements of the Performance Tests Conducted Before, During, and After the Rating Certification Test section of the Rating Certification Test are applicable to Low Load Testing.

6. Low Load Test Profile:

a. The complete unit, including the engine, instruments, controls, and attached accessories, shall be subjected to the test profile of Table F-6 and as specified below. The target speed conditions shall be a percentage of the rated speed specified in Table F-5.1 or Table F-5.2 as appropriate. The target load conditions shall be a percentage of the maximum load at the percentage of speed specified for that test profile step. The standard low load test steps shall be performed in the order given in Table F-6.

b. For each engine operating condition, the load shall be maintained within plus 1% or minus 0% of the target load value, and the speed shall be maintained within plus or minus 1% or plus or minus 10 rpm (whichever is less) of the target speed value.

c. Forced shutdown(s), which cause cessation of the test, will require the test cycle to be repeated starting from Step 1.

d. ABS shall be notified in writing of any forced shutdown, component replacement, or abnormal condition. An abnormal condition may be identified by either the manufacturer or ABS monitoring the testing. An engineering report with supporting documentation, analyses, and rationale detailing the cause, corrective action, and impact on the test completion criteria shall be submitted for evaluation to determine if additional testing is warranted.

Table F-6: Low Load Test Profile

Step	Load ⁽¹⁾ (%)	Speed ⁽²⁾ (%)	Time (hours)
1	100	100	2 (minimum)
2	Minimum Power	Idle	96 ⁽³⁾
3	Post 96-hour continuous run inspection (see Section 7)		
4 a) ⁽⁴⁾	50	75	1
	Shutdown for visual and borescope inspection to establish oil burn-off rate		
4 b) ⁽⁵⁾	60	100	1
	Shutdown for visual and borescope inspection to establish oil burn-off rate		
5	Post-test inspection (see Section 7)		
6	20	45	1 (minimum)
7	30	55	1 (minimum)
8	40	65	1 (minimum)
9	50	75	1 (minimum)
10	Shutdown for visual and borescope inspection to establish oil burn-off rate Post-test inspection		
11	50	75	⁽⁶⁾
12	Post-test inspection (see Section 7)		

Notes:

1. The times specified for load changes between steps in Table F-3 are applicable to Low Load Testing.
2. Ship service generator set speeds shall be 100% of rated speed for all load points.
3. Step 2 shall be done in one continuous 96-hour period. No shutdowns are permitted during Step 2.
4. After completion of Step 2, if there is oil accumulation note, Step 4 a) shall be conducted.

e. After completion of Step 4 a), if there is oil accumulation then Step 4 b) shall be conducted. If there is oil accumulation after Step 4 b), a water wash of the turbocharger compressor (inlet) shall be performed prior to securing the engine.

f. If there is oil accumulation after Step 11, Step 4 b) shall be conducted. If there is oil accumulation, a water wash of the turbocharger compressor (inlet) shall be performed prior to securing the engine.

7. Low Load Test Profile Completion Criteria: The requirements of the Test Profile Completion Criteria section of the Rating Certification Test are applicable to Low Load Testing. The low load test profile will be considered complete after the engine has successfully run all the conditions contained in the Low Load Test Profile, and the Low Load Test Profile Completion Criteria are met.

8. Inspections After Low Load Tests: The following inspections shall be performed upon completion of the low load test:

a. Visual and Dimensional Evaluation.

1) After completion of 96-hour low load test:

a) An inspection for the accumulation of oil and soot in the turbocharger and engine combustion intakes and exhaust areas shall be performed upon completion of the 96-hour low load test. A light coating of oil on surfaces is acceptable. Standing or pooling of oil is not acceptable. A light layer of loose soot or carbon buildup is acceptable. Step 4 a) of Table F-6 shall be conducted to establish the oil burn-off rate. If oil is still remaining after the 50% load burn-off, then Step 4 b) shall be conducted.

b) Three engine cylinders are to be opened out for inspection. These cylinders shall be selected at the discretion of the ABS representative. Cylinder liners may be inspected in place.

c) After completion of Steps 4a), 4b), or 11 of the low load test, the inspections listed in sub para 1a above shall be repeated on the same components.

b. Reassembly: After the inspection is completed, the engine shall be reassembled to meet new product specifications and shall be subjected to the manufacturer's standard production test but shall not less than 8 hours of testing.

c. Evaluation Criteria: The failure of any component to meet the manufacturer's wear limits or the evidence of cracks, cavitation, pitting, scuffing, galling, fretting, or overheating shall be cause for the rejection of the engine.

Failure to meet evaluation criteria shall be cause for the rejection of the engine. The engine failure to meet the requirements herein shall result in a restart of the test.

In any case, any design deficiency (or any evidence of design discrepancies) shall be reported, analyzed and co-signed by the engine supplier's Chief Engineer and its Quality Assurance Manager. When a OEM's part is involved, its Chief Technical Officer and its Quality Assurance Manager shall also provide their analysis of the design discrepancy and/or part failure.

9. Test Acceptance Criteria: The low load test will be considered successful when the following conditions are satisfied:

a. All Test Profile Completion Criteria above are met.

- b. Any additional testing resulting from any forced shutdown, component replacement, or abnormal condition has been successfully completed.
- c. All fuel oil, lube oil, and jacket water analyses are acceptable to ABS.
- d. Exhaust emissions comply with requirements.
- e. Engine condition as determined by the inspection following the Low Load Test Profile is acceptable to ABS.
- f. Modifications developed as a result of testing and modifications developed as a result of final engine inspections shall be proven effective by means of a validation program acceptable to ABS.
- g. Test report delivered to the Government is fully acceptable to the Government. The Government will be the final approval authority for the low load test.

Production Unit Test Requirements

1. General: These inspection and test requirements are applicable for all production engine models following satisfactory completion of the rating certification test and tests for the first engine of the model. Each engine tested under this category shall be subjected to the minimum testing in accordance with the following production unit inspection and tests.

2. Main Propulsion Engines: Production engines, duplicates of the one that completed the qualification test, shall be tested as follows:

- a. One standard 8-hour endurance cycle composed as specified in Table F-5.2.

- 1) Monitored parameters shall include those items on the main propulsion engines specified in qualification test. Measurements of monitored parameters specified by the manufacturer shall be made at intervals specified in the engine monitoring requirements of the rating certification test.

- 2) Lubricating oil samples shall be collected before and after the cycle and analyzed as specified in the rating certification test.

- 3) Exhaust smoke emission shall be measured using the methods specified for the rating certification test at each operating point of the standard 8-hour endurance cycle.

- b. Start-up tests (starting and reversing maneuvers, as applicable).

- c. The emergency shutdown device shall be tested.

- d. Governor response and overspeed protection device operation shall be measured.

- e. Response of each of the following alarm switches shall be tested three times:

- 1) Low Lubricating-oil pressure.
 - 2) High Lubricating-oil temperature from engine.
 - 3) High Inlet manifold air temperature (for turbocharged engines only).
 - 4) High Water outlet temperature.
 - 5) High Crankcase pressure.

f. The parameter activating each switch shall be increased or decreased from the acceptable operating range to the alarm activating point. Static tests are acceptable in lieu of testing alarm switches during engine operation. The alarm activation value of each parameter shall be measured for each test.

g. Standard commercial test cells, detached accessories, and instrumentation may be used for these tests. A failure during the test cycle shall be cause for rejection. A repaired engine shall be retested for one cycle as specified in para. 2.a above.

3. Generator Set: Each generator set shall undergo the production unit inspection and tests in accordance with the requirements of propulsion engine production test except that the 8-hour test shall use the generator set 8 hour endurance cycle as specified in Table F-5.1 applying Note 4.

4. Inspection: Upon completion of production unit testing, borescope one cylinder and one turbocharger turbine, and present one main bearing for inspection as designated by ABS.

5. Test Report: Submit a test report documenting the production unit test.

APPENDIX G PIPING SYSTEM REQUIREMENTS

This Appendix contains piping system material requirements and velocity requirements. Where more than one material type, material standard, or manufacturing standard is cited, they are intended to provide an alternative selection.

Table G-1: Seawater Cooling, Firemain, Seawater Sprinkling (Wet), Magazine Sprinkling, Aqueous Film Forming Foam (Aqueous Film Forming Foam Concentrate see Table G-3), Washdown Countermeasure, FW Generator Seawater, and Exterior Deck Drains

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTINGS
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
SEAWATER COOLING, FIREMAIN, SEAWATER SPRINKLING (WET), MAGAZINE SPRINKLING, AFFF CONCENTRATE (SEE TABLE G-3), WDCM, AND FW GENERATOR SEAWATER AND EXTERIOR DECK DRAINS (SEE NOTE 7)	50 & BELOW	90/10 Cu-Ni, ASTM B466, ASTM B467, MIL-T-16420, CLASS 200 (SEE NOTE 3)	UNIONS, Welded Cu-Ni Tail Fittings, BRONZE, ASTM B61, ASTM B62, MIL-F-1183, NAVSEA 803-7063850	N/A	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, Union End with Welded Cu-Ni Tail Fittings per NAVSEA 803-7063850, BRONZE, ASTM B61, ASTM B62, ASME B16.34 OR MSS SP-80 (SEE NOTE 5) BALL, Union End with Welded Cu-Ni Tail Fittings per NAVSEA 803-7063850, BRONZE, ASTM B61, ASTM B62, MSS SP-110	Ni-Cu, ASTM B164, OR EQUIVALENT	90/10 Cu-Ni SOCKET WELD NAVSEA 803-6387430 BUTT WELD OR SOCKET WELD, 90/10 Cu-Ni, MIL-C-15726, ASME B16.9, ASME B16.11 OR MSS SP-119
	65 & ABOVE	90/10 Cu-Ni, ASTM B466, ASTM B467, MIL-T-16420, CLASS 200 (SEE NOTE 3)	FLANGES, SOCKET WELD OR BUTT WELD, 90/10 Cu-Ni, ASME B16.5 Drilling Commercial OR NAVSEA , 810-7525226 SOCKET WELD OR BUTT WELD, 90/10 Cu-Ni, ASTM B466, ASTM B467, MIL-C-15726, ASME B16.5 (SEE NOTE 4)	BOLTS & STUDS, CARBON STEEL, ASTM A307, GR B OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, , FLANGED , BRONZE, ASTM B61, ASTM B62, ASME B16.34 OR MSS SP-80 (SEE NOTE 5) BALL, FLANGED, ASTM B61, ASTM B62, MSS SP-110 OR MSS SP-72 BUTTERFLY, LUGGED OR WAFER (SEE NOTES 8 & 9)	Ni-Cu, ASTM B164, OR EQUIVALENT	BRAZED, BRONZE, ASTM B61, ASTM B62, MIL-F-1183 BUTT WELD OR SOCKET WELD, 90/10 Cu-Ni, ASTM B466, ASTM B467, MIL-C-15726, ASME B16.9, ASME B16.11 OR MSS SP-119
SEAWATER INLETS AND OVERBOARD DISCHARGES (OUTBOARD OF WASTER PIECES)	ALL	CARBON STEEL, ASTM A53, GR B TYPE S, ASME B36.10, SCH 80 or SDH XS	FLANGES, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTE 4)	BOLTS & STUDS, CARBON STEEL, ASTM A307, GR B OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, FLANGED, SOCKET WELD OR BUTT WELD, CARBON STEEL, ASTM A216 GR WCB, ASTM A105 OR DUCTILE IRON ASTM A395, ASME B16.34	Ni-Cu, ASTM B164, OR EQUIVALENT	BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9, SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11
NOTES: 1. NOT USED 2. FLANGE BOLTS AND STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE CRES 3. TEFLON SHEETING SHALL BE INSTALLED BETWEEN Cu-Ni PIPE AND FERROUS SUPPORTS TO PREVENT SHAVING OF Cu-Ni 4. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED 5. MSS SP-80 VALVES LIMITED TO 75% OF VALVE DESIGN PRESSURE 6. THE USE OF DISSIMILAR METALS SHALL REQUIRE SPECIAL ATTENTION TO AVOID GALVANIC CORROSION 7. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155 8. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION 9. BUTTERFLY VALVES SHALL BE IAW G-14 10. MAGAZINE SPRINKLING SYSTEM PIPING SHALL BE SEAMLESS OR WELDED								

Table G-2 Seawater Sprinkling (Dry), Oily Waste Transfer, Bilge, Ballast and Fresh Water Cooling

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
SEAWATER SPRINKLING (DRY), OILY WASTE TRANSFER, BILGE, BALLAST, FRESHWATER COOLING (SEE NOTE 4)	50 & BELOW	CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASME B36.10	UNIONS, SOCKET WELDED, CARBON STEEL, ASTM A105, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASTM F682
						BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, MSS SP-110		
	65 & ABOVE		FLANGES, SLIP-ON, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTE 3)	BOLTS & STUDS, CARBON STEEL, ASTM A307, GR B OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR IFG 5500/9900 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, FLANGED OR BUTT WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 OR FLANGED, DUCTILE IRON, ASTM A395, ASME B16.34	BUTTERFLY, LUGGED OR WAFER (SEE NOTES 6 & 7)	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 OR MSS SP-119 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASTM F682

- NOTES:
 1. NOT USED
 2. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 3. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 4. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 5. Not used.
 6. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 7. BUTTERFLY VALVES SHALL BE IAW TABLE G-14

Table G-3: Aqueous Film Forming Foam Concentrate Piping

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTINGS
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
AFFF CONCENTRATE (SEE NOTES 3)	50 & BELOW	CRES 316L, ASTM A312, ASME B36.19 (SEE NOTE 7)	UNIONS, SOCKET WELD, CRES 316L, ASTM A182, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ANSI B16.34,	CRES, ASTM A182 GR F6a OR EQUIVALENT	SOCKET WELD, BUTT WELD, CRES 316L, ASTM A182, ASME B16.11 OR MSS SP-119, ASME B16.9
	65 & ABOVE		FLANGES, BUTT WELD OR SOCKET WELD, CRES 304L OR 316L, ASTM A182, ASME B16.5 (SEE NOTE 2)	BOLTS & STUDS, CARBON STEEL, ASTM A307, GR B OR CRES 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 OR CRES 316, ASTM A194, ASME B18.2.2 (SEE NOTE 9)	GARLOCK 3000 OR IFG 5500/9900 OR EQUIVALENT (SEE NOTE 4)	GATE, GLOBE, ANGLE, CHECK, BUTT WELD, FLANGE OR SOCKET WELD, CRES 316, ASTM A351 OR ASTM A182, ASME B16.34 (SEE NOTE 11) BUTTERFLY, LUGGED OR WAFER (SEE NOTES 5 & 8)	CRES, ASTM A182 GR F6a OR EQUIVALENT	SOCKET WELD OR BUTT WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.11 OR MSS SP-119, ASME B16.9

- NOTES:
1. NOT USED.
 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 3. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 4. ABS FIRE RATED GASKET REQUIRED FOR TANK VALVES WHEN SUBJECT TO HEAD FROM THE CONTENTS OF THE TANK
 5. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 6. NOT USED.
 7. AFFF CONCENTRATE PIPING AND ALL PIPING LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE CRES 316L
 8. BUTTERFLY VALVES SHALL BE IAW TABLE G-14
 9. FLANGE BOLTS/STUDS LOCATED IN BILGES, TANKS OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 10. BUTT WELDING SHALL ENSURE COMPLETE PENETRATION WELDS BY MEANS OF A GROOVE WELD, 1ST PASS INERT GAS BACKUP, BACKING RINGS, OR CONSUMABLE INSERTS IN ACCORDANCE WITH 46 CFR SUBPART 56.70
 11. FLANGED VALVES SHALL NOT BE USED FOR AFFF CONCENTRATE

Table G-4: Waste Oil, Ship's Fuel and Lube Oil

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
WASTE OIL, SHIP'S FUEL AND LUBE OIL (SEE NOTE 4)	50 & BELOW	CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASME B36.10	UNIONS, SOCKET WELDED, CARBON STEEL, ASTM A105, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 BALL, SOCKET WELD, FLANGED, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, MSS SP-110	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASTM F682
	65 & ABOVE		FLANGES, SLIP-ON, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTE 3)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 (SEE NOTE 2) NUTS CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2	GARLOCK 3000 OR IFG 5500/9900 OR EQUIVALENT (SEE NOTE 5)	GATE, GLOBE, ANGLE, CHECK, FLANGED, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 OR FLANGED, DUCTILE IRON, ASTM A395, ASME B16.34 BUTTERFLY, LUGGED OR WAFER (SEE NOTES 6 & 8)	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASTM F682

- NOTES:
1. NOT USED.
 2. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 3. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 4. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 5. ABS FIRE RATED GASKET FOR TANK VALVES WHEN SUBJECT TO HEAD FROM THE CONTENTS OF THE TANK
 6. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 7. Not used.
 8. BUTTERFLY VALVES SHALL BE IAW TABLE G-14

Table G-5: Chilled Water and Potable Water

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS				VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL	
CHILLED WATER, HVAC HOT WATER, AND POTABLE WATER (SEE NOTES 6, 9 & 10)	50 & BELOW	COPPER, ASTM B88 TYPE K OR L, HARD DRAWN (SEE NOTE 3)	UNIONS, SOLDER JOINT, BRONZE, ASTM B61, ASTM B62, ASTM B584, OR WROUGHT COPPER, ASTM B75, ASME B16.15, ASME B16.22 OR MSS SP-104		N/A	GATE, GLOBE, ANGLE, CHECK, BALL, BRAZED, BRASS OR BRONZE, ASTM B61, ASTM B62, ASTM B584, MSS SP-80, MSS SP-139 (SEE NOTE 5) BALL, BRAZED, BRASS OR BRONZE, ASTM B61, ASTM B62, ASTM B584, MSS SP-110	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOLDER JOINT, CAST OR WROUGHT COPPER, ASTM B75 OR ASTM B88, ASME B16.18 OR ASME B16.22 THREADED, BRONZED, ASTM B584, ASME B16.15 BRAZED, BRONZE, ASTM B61, ASTM B62, MIL-F-1183	
	65 - ABOVE	90/10 Cu-Ni, ASTM B466, ASTM B467 OR MIL-T-16420, CLASS 200 (SEE NOTE 3)	FLANGES, SOCKET WELD OR BUTT WELD, 90/10 Cu-Ni, ASME B16.5 Drilling Commercial OR NAVSEA 810-7525226 SOCKET WELD OR BUTT WELD, 90/10 Cu-Ni, ASTM B466, ASTM B467, MIL-C-15726, ASME B16.5 (SEE NOTE 4)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, FLANGED, BRONZE, ASTM B61, ASTM B62, ASTM B584, CAST IRON, ASTM A126, ASTM A536, MSS SP-70, MSS SP-80, MSS SP-125, MSS SP-139 OR ASME B16.34, (SEE NOTES 5 & 11) BALL, SOLDER JOINT, BRASS OR BRONZE, ASTM B61, ASTM B62, ASTM B584, MSS SP-110 BUTTERFLY, LUGGED OR WAFER (SEE NOTES 7, 8 & 11)	CRES, ASTM A182 GR F6a, BRASS OR BRONZE, ASTM B61, ASTM B62, ASTM B584, ASTM B283 OR EQUIVALENT	SOCKET WELD OR BUTT WELD, 90/10 Cu-Ni, ASTM B466, ASTM B467 OR MIL-C-15726, MSS SP-119, ASME B16.11 OR ASME B16.9	

- NOTES:
1. NOT USED.
 2. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL.
 3. TEFLON SHEETING SHALL BE INSTALLED BETWEEN COPPER/Cu-Ni PIPES AND STEEL SUPPORTS TO PREVENT SHAVING OF COPPER/Cu-Ni
 4. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 5. MSS SP-80 VALVES LIMITED TO 75% OF VALVE DESIGN PRESSURE
 6. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 7. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 8. BUTTERFLY VALVES SHALL BE IAW TABLE G-14
 9. WHERE ALLOWED, ABS APPROVED CPVC PIPING (GEORG FISCHER SEACOR OR EQUIVALENT) FOR INSTALLATION IN CONCEALED SPACES WITHOUT SMOKE DETECTORS IS ACCEPTABLE AS AN ALTERNATIVE MATERIAL
 10. POTABLE WATER SYSTEM COMPONENTS SHALL BE CERTIFIED FOR COMPLIANCE WITH NSF/ANSI 372 AND SHALL OTHERWISE CONFORM TO REQUIREMENTS FOR "LEAD-FREE" PLUMBING AS DEFINED BY THE U.S. SAFE DRINKING WATER ACT, 42 U.S.C.
 11. WHERE NON-FERROUS MATERIALS ARE NOT AVAILABLE, VALVES OF CAST IRON MAY BE USED ONLY IN POTABLE WATER SERVICE TO MEET THE LEAD-FREE REQUIREMENTS OF NOTE 10.

Table G-6: Graywater and Interior Deck Drains

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
GRAYWATER AND INTERIOR DECK DRAINS (SEE NOTES 4 & 7)	50 & BELOW	CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASME B36.10	UNIONS, SOCKET WELDED, CARBON STEEL, ASTM A105, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, MSS SP-110	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASTM F682
	65 & ABOVE		FLANGES, SLIP-ON, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTE 3)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, FLANGED, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 OR FLANGED, DUCTILE IRON, ASTM A395, ASME B16.34 BUTTERFLY, LUGGED OR WAFER (SEE NOTES 5 & 6)		SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASTM F682

NOTES:
 1. NOT USED
 2. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 3. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 4. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 5. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 6. BUTTERFLY VALVES SHALL BE IAW TABLE G-14
 7. WHERE ALLOWED, ABS APPROVED PVDF PIPING (GEORG FISCHER SEADRAIN PLUS OR EQUIVALENT) FOR INSTALLATION IN CONCEALED SPACES WITHOUT SMOKE DETECTORS IS ACCEPTABLE AS AN ALTERNATIVE MATERIAL

Table G-7: Vacuum Collection Sewage

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTINGS
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
VACUUM COLLECTION SEWAGE (SEE NOTES 3, 4, 5 & 9)	50 & BELOW	CRES 316L, ASTM A312, ASME B36.19, CuNi 90/10	UNIONS, SOCKET WELD, CRES 316L, ASTM A182, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ANSI B16.34	CRES, ASTM A182 GR F6a OR EQUIVALENT	SOCKET WELD OR BUTT WELD, CRES 316L, ASTM A182, ASME B16.9 OR MSS SP-119
	65 & ABOVE		FLANGES, BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A182, ASME B16.5 (SEE NOTE 2)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.34	CRES, ASTM A182 GR F6a OR EQUIVALENT	BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.9 OR MSS SP-119
				NUTS, CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 7)		BUTTERFLY, LUGGED OR WAFER (SEE NOTES 6 & 8)	(SEE NOTE 8)	

NOTES:
 1. NOT USED.
 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 3. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 4. WHERE ALLOWED, ABS APPROVED PVDF PIPING (GEORG FISCHER SEADRAIN PLUS OR EQUIVALENT) FOR INSTALLATION IN CONCEALED SPACES WITHOUT SMOKE DETECTORS IS ACCEPTABLE AS AN ALTERNATIVE MATERIAL
 5. 90/10 Cu-Ni PIPING IS ALSO ACCEPTABLE FOR THIS SYSTEM (SEE TABLE D FOR Cu-Ni MATERIALS)
 6. WAFER TYPE BUTTERFLY VALVES SHALL NOT BE USED FOR EQUIPMENT ISOLATION
 7. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 8. BUTTERFLY VALVES SHALL BE IAW TABLE G-14

Table G-8: Starting Air

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
STARTING AIR (SEE NOTE 3)	50 & BELOW	CARBON STEEL, ASTM A53 GR B TYPE S OR E, ASTM A106 GR B, ASME B36.10 (SEE NOTE 4)	UNIONS, SOCKET WELDED, CARBON STEEL, ASTM A105, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 BALL, SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, MSS SP-110	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD OR THREADED, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9
	65 & ABOVE		FLANGES, SOCKET WELD OR BUTT WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTES 2 & 5)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B, CrMo, ASTM A193 GR B7, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 GR A, ASTM A194 GR 2H, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 1)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, BALL, FLANGED SOCKET WELD OR BUTT WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 (SEE NOTE 5)		SOCKET WELD OR BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 (SEE NOTE 5)
NOTES: 1. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED 3. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155 4. THE DESIGN PRESSURE OF ASTM A53 GR B TYPE E, PIPE IS LIMITED TO 24 bar 5. SOCKET WELDED JOINTS MAY BE USED FOR CLASS I AND ii PIPING UP TO AND INCLUDING DN30 AND IN CLASS IB APPLICATIONS WITHOUT LIMITATION								

Table G-9: Ships Service and Control Air

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
SHIPS SERVICE AND CONTROL AIR (SEE NOTE 5)	50 & BELOW	COPPER, ASTM B88 TYPE K	UNIONS, SOLDER JOINT, BRONZE, ASTM B61, ASTM B62 OR WROUGHT COPPER, ASTM B75, ASME B16.22 OR MSS SP-123	N/A	N/A	GATE, GLOBE, CHECK, SOLDER JOINT, BRONZE, ASTM B61, ASTM B62, MSS SP-80 (SEE NOTE 5) BALL, BRAZED OR THREADED, BRONZE, ASTM B61, ASTM B62, MSS SP-110 OR ASME B16.34	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	WROUGHT COPPER, ASTM B88, ASME B16.18 OR ASME B16.22 OR BRAZED, BRONZE, ASTM B61, ASTM B62, MIL-F-1183
		CARBON STEEL, ASTM A106 GR B TYPE E, ASME B36.10.	UNIONS, SOCKET WELD OR THREADED, CARBON STEEL, ASTM A105, MSS SP-83			GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD OR THREADED, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34		SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASTM F682
	65 & ABOVE	CARBON STEEL, ASTM A106 GR B TYPE E, ASME B36.10 (SEE NOTE 4)	FLANGES, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A105, AMSE B16.5 (SEE NOTE 3)	BOLTS & STUDS, CARBON STEEL, ASTM A307, GR B, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, FLANGED, BUTT WELD, OR SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 OR BALL, BUTT WELD OR FLANGED, CARBON STEEL, ASTM A105 OR ASTM A216 GR WCB, MSS SP-72		SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B, ASTM A106 GR B, ASTM F682
<p>NOTES:</p> <ol style="list-style-type: none"> NOT USED. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155 MSS SP-80 VALVES LIMITED TO 75% OF VALVE DESIGN PRESSURE 								

Table G-10: Water Mist Distribution, Piping To Nozzle and To Drain Valves, Engine Exhaust Treatment Reducing Agent

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
WATER MIST DISTRIBUTION, PIPING TO NOZZLE AND DRAIN VALVE, ENGINE EXHAUST TREATMENT REDUCING AGENT (SEE NOTE 1)	50 & BELOW	CRES 316L, ASTM A312, ASME B36.19 OR CRES 316L, ASTM A269, ASME B36.19	UNIONS, CRES 316L, SOCKET WELD, ASTM A182, CRES 304L OR 316L, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, SOCKET WELD, CRES 316L, ASTM A351, ASME B16.34, BALL, SOCKET WELD, CRES 316L, ASTM A351, MSS SP-110 OR ASME B16.34	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT	SOCKET WELD, CRES 316L, ASTM A182, ASME B16.11 OR MSS SP-119
	65 & ABOVE		FLANGES, BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A182, ASME B16.5 (SEE NOTE 2)	CRES 316, ASTM A193, ASME B18.2.1 OR CRES 316, ASTM A194, ASME B18.2.2	GARLOCK 5500/9900 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, SOCKET WELD, FLANGE OR BUTT WELD, CRES 316L, ASTM A351, ASME B16.34 OR BALL, FLANGE OR BUTT WELD, CRES 316L, ASTM A351, MSS SP-72		SOCKET WELD OR BUTT WELD, CRES 316L, ASTM A182, ASME B16.11, MSS SP-119, OR ASME B16.9

NOTES:
 1. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED

Table G-11: Sounding Tubes, Vents and Overflows for Freshwater, Seawater, Waste Oil/Oily Waste, DFM, and Lube Oil

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
SOUNDING TUBES, VENTS AND OVERFLOWS FOR FRESHWATER, SEAWATER, DFM AND LUBE OIL (SEE NOTE 4)	50 & BELOW	CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASME B36.10	UNIONS, SOCKET WELDED OR THREADED, CARBON STEEL, ASTM A105, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD OR THREADED, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34 BALL, THREADED, SELF-CLOSING, BRONZE, DIN 86120 (FOR SOUNDING TUBE APPLICATIONS) GATE, THREADED, QUICK OPEN SELF-CLOSING, BRONZE, ASTM 862, STEEL SPRING (FOR SOUNDING TUBE APPLICATIONS)	CRES, ASTM A182 GR F6a, BRONZE, ASTM B61, ASTM B62 OR EQUIVALENT BRASS, ASTM B16 OR EQUIVALENT (FOR GATE VALVES IN SOUNDING TUBE APPLICATIONS)	SOCKET WELD, CARBON STEEL, ASTM A234 GR WPB OR ASTM A105, ASME B16.11 BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 SLEEVE COUPLING, CARBON STEEL, ASTM A53 GR B OR ASTM A106 GR B, ASTM F682
	65 & ABOVE		FLANGES, SLIP-ON, BUTT WELD, OR SOCKET WELD, CARBON STEEL, ASTM A105, ASME B16.5 (SEE NOTE 3)	BOLTS & STUDS, CARBON STEEL, ASTM A307 GR B OR CRES 304 OR 316 ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A563 GR A, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2 (SEE NOTE 2)	GARLOCK 3000 OR EQUIVALENT			GATE, GLOBE, ANGLE, CHECK, BALL, FLANGED, BUTT WELD OR SOCKET WELD, CARBON STEEL, ASTM A216 GR WCB OR ASTM A105, ASME B16.34

NOTES:
 1. NOT USED.
 2. FLANGE BOLTS/STUDS LOCATED IN BILGES OR EXPOSED TO WEATHER SHALL BE STAINLESS-STEEL
 3. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED
 4. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155

Table G-12: Steering Gear and Hydraulic Systems

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTINGS
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
STEERING GEAR AND HYDRAULIC SYSTEMS (SEE NOTE 1)	50 & BELOW	CRES 316L, ASTM A312, ASME B36.19	UNION, SOCKET WELD, CRES 316L, ASTM A182, MSS SP-83	N/A	N/A	GATE, GLOBE, ANGLE, CHECK, BALL, SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.34	CRES ASTM A182 GR F6a OR EQUIVALENT	SOCKET WELD, BUTT WELD, CRES 316L, ASTM A182, ASME B16.11 OR MSS SP-119, ASME B16.9
	65 & ABOVE		FLANGE, BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A182, ASME B16.5 (SEE NOTE 2)	BOLTS & STUDS, CrMo, ASTM A193 GR B7, ASME B18.2.1, OR CRES 304 OR 316, ASTM A193, ASME B18.2.1 NUTS, CARBON STEEL, ASTM A194 GR 2H, OR CRES 304 OR 316, ASTM A194, ASME B18.2.2	GARLOCK 3000 OR EQUIVALENT	GATE, GLOBE, ANGLE, CHECK, BALL, FLANGED, BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.34		BUTT WELD OR SOCKET WELD, CRES 316L, ASTM A351 OR ASTM A182, ASME B16.9, ASME B16.11 OR MSS SP-119
1. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS. MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES IS PROHIBITED								

Table G-13: Diesel Engine and Incinerator Exhaust

SYSTEM / SERVICE	SIZE (MM)	PIPE	FLANGE & TAKE DOWN JOINTS			VALVES		FITTING
		MATERIAL	TYPE / MATERIAL	BOLTS & NUTS	GASKETS	BODY	TRIM	TYPE / MATERIAL
DIESEL ENGINE EXHAUST (SEE NOTE 1)	ALL	CrMo STEEL, SEAMLESS, ASTM A335 GR P11, ASME B36.10 OR CrMo STEEL, PLATE FORMED, ASTM A387, COMMERCIAL DESIGN SPEC., (SEE NOTE 3) MAX. TEMP. 590° C	FLANGES, BUTT WELD OR SOCKET WELD, CrMo STEEL, ASTM A182 GR F11, ASME B16.5, (SEE NOTE 2) ANSI/AWWA C207-01 Standard Steel Hub Flanges, Class D DIN 86044 (SEE NOTE 6), OR CrMo STEEL, PLATE, ASTM A387 GR 11, CLASS 2	CrMoV STEEL, ASTM A193 GR B16 ASME B18.2.1 OR CrMo STEEL, ASTM A194 GR 4, ASME B18.2.2	SPIRAL WOUND, GRAPHITE FILLED, INNER & OUTER RING, ASME B16.20 OR FIBERGLASS, RING TYPE, TEXTURED WOVEN	N/A	N/A	BUTT WELD, CrMo STEEL, ASTM A234 GR WP-11, ASME B16.9 OR MITERED FITTINGS, CrMo STEEL, ASTM A335 GR P11 OR ASTM A387 (SEE NOTES 4 & 5)
		CARBON STEEL, ASTM A106 GR B OR ASTM A53 TYPE S OR E, ASME B36.10 MAX. TEMP. 400° C	FLANGES, BUTT WELD, SOCKET WELD OR SLIP-ON, CARBON STEEL, ASTM A105, ASME B16.5 (SEE NOTE 2) ANSI/AWWA C207-01 Standard Steel Hub Flanges, Class D DIN 86044-1 (SEE NOTE 6), OR CARBON STEEL, PLATE, ASTM 516 GR 70	CrMo STEEL, ASTM A193 GR B7 ASME B18.2.1 OR CARBON STEEL, ASTM A194 GR 2H, ASME B18.2.2				BUTT WELD, CARBON STEEL, ASTM A234 GR WPB, ASME B16.9 OR MITERED FITTINGS, CARBON STEEL, ASTM A106 GR B, ASTM A53 TYPE S OR E (SEE NOTES 4 & 5)

NOTES:
 1. THIS MATERIAL SCHEDULE PROVIDES MINIMUM REQUIREMENTS; MATERIAL REQUIREMENTS NOT ADDRESSED HEREIN SHALL BE IAW ASTM F1155
 2. USE OF VANSTONE OR SIMILAR LAP JOINT FLANGES ARE PROHIBITED
 3. THE USE OF PLATE FORMED PIPE SHALL REQUIRE SPECIFIC COAST GUARD AND ABS APPROVAL OF INTENDED PIPING DESIGN/FABRICATION. MAXIMUM TEMPERATURE LIMITATIONS SHALL BE IN ACCORDANCE WITH ASME B31.1 PARAGRAPH 124.1.1.
 4. MITER SEGMENTS SHALL BE IN ACCORDANCE WITH ASME B31.1, PARAGRAPH 104.3.3 AND 46 CFR 56.07-10(f)
 5. HIGHER TEMPERATURE MATERIALS ARE ACCEPTABLE IN LOWER TEMPERATURE SERVICE
 6. ONLY APPLICABLE WHERE FLANGES ARE MATED TO EQUIPMENT PROVIDED BY EUROPEAN MANUFACTURERS INCLUDING EXPANSION JOINTS, SCR REACTORS, SILENCERS, AND MIXING TUBES.

Table G-14: Butterfly Valve Specifications

SYSTEM/SERVICE	VALVE SPEC	MATERIAL			LOCATION/ APPLICATION
		BODY	TRIM	SEAT	
FRESH WATER AND OILY WASTE SYSTEMS (FRESHWATER COOLING, POTABLE AND NON-POTABLE, CHILLED WATER, AND OILY WASTE TRANSFER SYSTEMS)	MSS SP-67	DUCTILE IRON, ASTM A395, ASTM A536, ASTM A126, OR CARBON STEEL, ASTM A216 GR WCB OR ASTM A105	BRZ, ASTM B61, ASTM B62, ASTM B148, CRES, ASTM A182 GR F6a OR EQUIVALENT	NPR OR EPDM (SEE NOTE 2)	ALL LOCATIONS
NON-CIRCULATING SEAWATER SYSTEMS (BILGE AND BALLAST AND DRY FIREMAIN SYSTEMS)	MSS SP-67	DUCTILE IRON, ASTM A395, OR CARBON STEEL, ASTM A216 GR WCB OR ASTM A105	BRZ, ASTM B61, ASTM B62, AL-BRZ, NI-AL-BRZ ASTM B148 OR EQUIVALENT	NPR	ALL LOCATIONS EXCEPT FOR APPLICATIONS INTENDED FOR THROTTLING
	TOTS	BRZ, ASTM B61, ASTM B62, AL-BRZ, NI-AL-BRZ ASTM B148 OR EQUIVALENT	Ni-Cu ASTM B164 OR EQUIVALENT	RESILIENT METAL SEAT IAW MANUFACTURER RECOMMENDATIONS	APPLICATIONS INTENDED FOR THROTTLING INCLUDING BILGE AND BALLAST PUMP DISCHARGES, AND BALLAST TANK FILL AND SUCTION
CIRCULATING SEAWATER SYSTEMS (WET FIREMAIN, AFFF EXCEPT AFFF CONCENTRATE PIPING, FW GENERATOR SEAWATER & SEAWATER COOLING SYSTEMS)	TOTS	BRZ, ASTM B61, ASTM B62, AL-BRZ, NI-AL-BRZ ASTM B148 OR EQUIVALENT	Ni-Cu ASTM B164 OR EQUIVALENT	RESILIENT METAL SEAT IAW MANUFACTURER RECOMMENDATIONS	ALL LOCATIONS
AFFF CONCENTRATE PIPING	MSS SP-68	CRES	CRES, ASTM A182 GR F6a OR EQUIVALENT	RTFE	ALL LOCATIONS
SHIP'S FUEL (DFM), LUBE OIL AND WASTE OIL SYSTEMS	MSS SP-68	DUCTILE IRON, ASTM A395, OR CARBON STEEL, ASTM A216 GR WCB OR ASTM A105	BRZ, ASTM B61, ASTM B62, CRES, ASTM A182 GR F6a OR EQUIVALENT	RTFE	ALL LOCATIONS
WASTEWATER SYSTEMS (SEWAGE AND GRAYWATER SYSTEMS)	MSS SP-67	DUCTILE IRON, ASTM A395, OR CARBON STEEL, ASTM A216 GR WCB OR, ASTM A105	CRES, ASTM A182 GR F6a OR BRZ, ASTM B61, ASTM B62	NPR	ALL LOCATIONS

NOTES:
 1. TOTS VALVES SHALL BE TRIPLE OFFSET TORQUE SEATED VALVES, VANESSA SERIES 30,000 OR EQUIVALENT.
 2. EPDM SHALL BE USED FOR POTABLE WATER APPLICATIONS ONLY. NBR SHALL NOT BE USED IN POTABLE WATER SERVICE.

Table G-15: Fluid Velocity Design and Limits

SYSTEM	FUNCTION	FLUID / MATERIAL OR TEMPERATURE		FLUID VELOCITY	
				DESIGN (FPS) (NOTE 1)	NOT TO EXCEED (FPS)
CIRCULATING SEAWATER SYSTEMS & FOAM SYSTEMS (WET FIREMAIN, AFFP, FW GENERATOR SW & SW COOLING)	SUCTION	SEAWATER	90/10 Cu-Ni OR C. STEEL	3 X D ^{1/2}	8
	DISCHARGE	SEAWATER	90/10 Cu-Ni OR C. STEEL	5 X D ^{1/2}	8
NON-CIRCULATING SW SYSTEMS (DRY FIREMAIN, BILGE & BALLAST, AND DEWATERING SYSTEMS)	SUCTION	SEAWATER		3 X D ^{1/2}	8
	DISCHARGE			5 X D ^{1/2}	15
SW SPRINKLING SYSTEMS	DISCHARGE	SEAWATER		5 X D ^{1/2}	32
WATER MIST SYSTEM	FEED WATER SUCTION	FRESHWATER (LOW PRESSURE)		3 X D ^{1/2}	8
	FEED WATER DISCHARGE			5 X D ^{1/2}	15
	HP DISTRIBUTION	FRESHWATER (HIGH PRESSURE)		SIZED BY OEM	40
SHIP'S FUEL SYSTEMS	SUCTION	DFM		3 X D ^{1/2}	8
	DISCHARGE	DFM		5 X D ^{1/2}	12
	LOADING	DFM		N/A	25
OIL SYSTEMS (SLUDGE & OILY WASTE SYSTEMS)	SUCTION	LUBE OIL		1 X D ^{1/2}	4
	DISCHARGE	LUBE OIL		2 X D ^{1/2}	6
	SUCTION	OIL SLUDGE		1 X D ^{1/2}	4
	DISCHARGE	OIL SLUDGE		1.5 X D ^{1/2}	6
FRESHWATER COOLING SYSTEMS (CHILLED WATER)	CIRCULATING	FRESHWATER		5 X D ^{1/2}	15
	MAINS, RISERS, AND CROSS-CONNECTS	FRESHWATER		90/10 Cu-Ni	5 X D ^{1/2}
SLUDGE & OILY WASTE SYSTEMS (POTABLE WATER DISTRIBUTION SYSTEM)	BRANCHES	OIL SLUDGE		COPPER	3 X D ^{1/2}
	COLD DISTRIBUTION	FRESHWATER		Cu-Ni OR C. STEEL	5 X D ^{1/2}
FRESHWATER COOLING SYSTEMS	CIRCULATING	FRESHWATER		COPPER	3 X D ^{1/2}
CHILLED WATER	HOT DISTRIBUTION	FRESHWATER	< 60 °C	3 X D ^{1/2}	8
	BRANCHES		≥ 60 °C	3 X D ^{1/2}	8
HYDRAULIC SYSTEMS (COMPRESSED AIR SYSTEMS)	SUCTION DISCHARGE	HYDRAULIC OIL HYDRAULIC OIL	1.5 X D ^{1/2}	8	15
			8 X D ^{1/2}	20	8
	DISTRIBUTION HEADER OR MAIN SERVICE CONNECTIONS	AIR	N/A	30	5
			N/A	40	4
VENTS, SOUNDING TUBES & OVERFLOWS	VENTS	VARIOUS		BASED ON PRESSURE DROP/CLASS SOCIETY RULES	
	OVERFLOWS	VARIOUS		BASED ON PRESSURE DROP/CLASS SOCIETY RULES	
REFRIGERANT PIPING SYSTEMS	REFRIGERATION CYCLE	REFRIGERANT BLACK WATER		OEM RECOMMENDATION	

T-ARC(X) SYSTEM SPECIFICATION VERSION 1.0 (11 JUNE 2020)

SYSTEM	FUNCTION	FLUID / MATERIAL OR TEMPERATURE	FLUID VELOCITY	
			DESIGN (FPS) (NOTE 1)	NOT TO EXCEED (FPS)
PLUMBING DRAINS, COLLECTION SYSTEM & TREATMENT	VACUUM SYSTEM		OEM RECOMMENDATION	
	EJECTOR DISCHARGE	BLACK WATER	OEM RECOMMENDATION	
VENTS, SOUNDING TUBES & OVERFLOWS	WASTE SYSTEM (GRAVITY)	GRAYWATER	BASED ON FIXTURE UNIT METHOD (INTERNATIONAL PLUMBING CODE)	
	SOIL DRAINS (GRAVITY)	BLACK WATER	BASED ON FIXTURE UNIT METHOD (INTERNATIONAL PLUMBING CODE)	
REFRIGERANT PIPING SYSTEMS	DRNS, DK & SCUPPERS	RAIN/SEAWATER	BASED ON DECK AREA, SEE SECTION 3.529	
WEATHER DECK & MISC. DRAINS SYSTEM NOTE: "D" UNDER THE FLUID VELOCITY DESIGN IS THE INTERNAL PIPE DIAMETER IN INCHES				

APPENDIX H MSC PAINT APPROVAL PROCEDURES AND PRESERVATION INSTRUCTIONS

Encl: (1) Paint Approval Procedures
(2) Paint and Preservation Instructions for MSC Ships

1. Purpose. To establish policy and procedural guidelines for surface preservation and painting of ships assigned to COMSC and to provide a comprehensive list of approved paint products and coating(s)/system for use on these ships.

2. Policy. The following paragraphs broadly define major policies to be followed in planning and performing paint maintenance on MSC ships:

a. The approved coating(s)/systems in enclosure (1) are subject to occasional change. Most changes are anticipated to be adding newly approved coating(s)/systems; however, it is possible that approval for some systems may be modified or even rescinded. MSC Engineering Directorate (N7) will maintain the current status of approved coatings and should be contacted concerning any approval matters. Enclosure (1) will be updated and distributed as required.

b. NAVSEA S9086-VD-STM-010/020/030 CH-631 and NAVSEA S9086-VG-STM-010/CH-634 reflect current technical information on painting and preservation of Navy ships in service. Human health, environmental considerations, and safety precautions also have been thoroughly addressed. It is to be used as general guidance for situations not directly addressed by this instruction.

3. Service Requirements.

a. Antifouling Systems

(1) Underwater hull coating shall use two coats of epoxy anticorrosive with one of the following options:

- (a) Three coats ablative antifouling
- (b) One coat conventional antifouling overcoated with two coats ablative antifouling
- (c) Two coats ablative antifouling from a NAVSEA approved five year system

In each case, Enclosure (1) shall be used to determine acceptable manufacturers and products. MSC Code N7 personnel will act as point of contact and shall be contacted for updated information pertaining to NAVSEA approved five year hull systems. Option C listed above may only be exercised when used with NAVSEA approved anticorrosive for five year systems. In cases where ships are set up to meet UWILD requirements, it is prudent to use a system with three coats of ablative antifouling paint.

(2) Cathodic Protection Systems: Impressed Current Cathodic Protection System anodes require special electrically resistant coatings in accordance with the equipment manufacturer's requirements.

b. Hull and Topsides Paints

(1) MSC uses a high performance topside coating(s)/system comprised of inorganic zinc primer, epoxy anticorrosive, and polyurethane topcoat. This system was selected to both increase corrosion protection and minimize cosmetic painting. Once applied, it should provide 6 to 8 years of protection. Maintenance consists of low-pressure water cleaning with freshwater and detergent instead of cosmetic painting.

c. Tank Paints

(1) Potable Water Tanks shall be coated with National Sanitation Foundation (NSF) approved coatings as required for Public Health certification. Because NSF approval is for toxicology only, MSC will maintain a list of approved NSF coatings that also comply with performance, odor, and taste requirements. Strict application requirements are included in Enclosure (2) and N0720-100.00-P to prevent curing problems.

(2) Ballast Tanks shall be coated with two coats of approved epoxy over blasted steel. Shop primers shall be removed. Additionally, cathodic protection by zinc anodes shall also be used.

(3) Cargo Tanks shall be coated with two coats of approved epoxy over blasted steel. All inorganic or organic zinc coatings are banned from use in MSC petroleum cargo tank service.

(4) Ship's Service Tanks, such as FO, DO, or LO shall be left uncoated with the following exceptions. Any ship that spends extended time in ROS status and all new construction ships shall be coated with two coats of approved epoxy over blasted steel. Tanks for JP-5 shall be coated.

(5) No metallic zinc based shop primers are allowed in any tank coating(s)/system. Existing shop primers shall be removed by blasting to near white metal prior to application of the tank coating(s)/system.

(6) No coating containing metallic zinc shall ever be used in conjunction with the interior of any aviation fuel service (tanks or pipelines).

(7) All tanks shall be stripe coated.

d. Non-Skid Paints

(2) Non-skid decks for vehicular and pedestrian service shall be coated with an approved non-skid over steel primed with an approved inorganic zinc and epoxy from the Exterior section of enclosure (1). "Do-it-yourself" non-skid coatings (e.g., sandblasting grit stirred into or sprinkled over ordinary deck paint) are not to be used. On RO/RO ramps or decks equipped with mechanical devices to increase traction (e.g., expanded metal or welded bars), non-skid coatings are not required.

(3) Non-skid areas shall not be touched-up or painted over with ordinary deck paint. Where necessary to paint markings on a non-skid surface, thin film build coatings specifically designed for use as color toppings on non-skid shall be used.

e. Primers:

(1) Primers are included in the approved coating(s)/systems in enclosure (1).

(2) Primers that contain metallic zinc shall never be topcoated in direct seawater service (e.g., ballast tanks or underwater hull), or in conjunction with any tank coating.

(3) Shop primers (also known as preconstruction primers) may be left in place if all the following requirements are met:

- (a) Area of application is interior space such as machinery spaces, cargo holds, "dry" voids, or habitability spaces. In all other areas such as exterior surfaces, tanks, and underwater hull, it shall be removed.
- (b) The shop primer is intact, uncontaminated, and compatible with the system to be applied over it. In cases where the shop primer is damaged or contaminated, it shall be cleaned or abrasive swept prior to paint application. In cases where the shop primer is incompatible with the paint system, it shall be removed.

f. Surface Preparation and Paint Application: Surface preparation standards and paint application procedures for each service requirement category (antifouling, hull and topsides, tanks, non-skid, etc.) are found in Enclosure (2) and N0720-100.00-P.

4. Approvals and Disapprovals.

a. The list of MSC approved coatings systems are provided as enclosure (1).

b. The paint approval procedures are provided in enclosure (1).

c. MSC will disapprove coatings that perform poorly in MSC service. Poor performance of 10% or more overall of the coated surface will be grounds for disapproval. Assuming that the coatings were properly applied in accordance with the manufacturer's application instructions, then poor performance is defined as follows:

(1) For tank and exterior coating(s)/systems: Areas of coating which have delaminated, blistered, rusted-through, dissolved, softened, flaked, cracked, peeled, or have had any other defect within two years of application.

(2) For antifouling coating(s)/systems: Areas of coating which have become fouled with barnacles, shell, or worms, or which have delaminated, blistered, flaked, cracked, peeled, or have had any other defect within two years of application.

5. Environmental Policies.

a. By Congressional directive and IMO requirements, no coating containing organo-tin ingredients may be applied.

b. MSC shall only use paints that comply with all federal, state, and local volatile organic compound (VOC) and any other environmental laws and regulations. All procurement actions shall include requirements to this effect.

c. Where metallic zinc coatings are not permitted, they shall be replaced with an additional 5-6 mil DFT coat of an epoxy approved for that particular service.

6. Occupational Safety and Health Policies.

a. The following limitations to products approved by MSC are in force:

(1) Paints used in MSC service shall comply with all federal, state, and other occupational safety and health laws and regulations. Areas of current concern include lead, chromates, tributyltin and coal tar, including coal tar derivatives. It should be noted that other materials may be added to the list of banned materials as a result of International Convention and/or federal, state or local regulation. All procurement actions shall include requirements to this effect.

(2) The application of lead based paints is prohibited in MSC service. Totally “lead free” paints are generally not available because trace amounts of lead can be found as contaminants in some of the paint’s constituents. “Lead free” paint is defined by the Consumer Product Safety Commission’s Ban of Lead-Containing Paint and Certain Consumer Products Bearing Lead-Containing Paint (16 CFR 1303) as containing 0.06% or less lead by weight in the dry paint film.

(3) Application of coal-tar epoxies or paints containing coal-tar derivatives is prohibited in MSC service.

(4) Application of paints containing zinc chromate is prohibited in MSC service.

7. Record Keeping Requirements.

a. Introduction: This section addresses proper documentation and recordkeeping necessary to monitor and plan for effective coating maintenance of MSC ships.

b. Surface Area Schedule: For each ship, there shall be developed a "Surface Area Schedule", which shall list the painted surface areas of all major shipboard areas.

c. Paint Schedule: For each ship, there shall be developed a "Paint Schedule", which records all paint applied to the major surface areas by shipyards.

ENCLOSURE (1)

PAINT APPROVAL PROCEDURES

**Military Sealift Command Quality Management System
Procedures Manual N0712-006.00-P dated 1/29/2012**

1. **PURPOSE:** To define a process for coating(s)/system approval and provide a list of approved products.

2. **BACKGROUND / OBJECTIVES / APPLICABILITY:**

2.1 Background: Ships operated by the Military Sealift Command (MSC) may experience operating conditions not experienced by Navy or commercial counterparts.

2.2 Objectives: MSC strives to use proven, commercially available products and maintains a list of products approved for use aboard MSC vessels.

2.3 Applicability: Paint manufacturers who wish to have their products added to the MSC Approved Paint Products List.

3. **PROCEDURES / PROCESSES:**

3.1 MSC requires approved products for the following areas:

3.1.1 Critical Service: Surface areas that can affect a ship's mission capability.

- a. Antifouling, Underwater Hull and Propellers
- b. Helo Deck Non-Skid
- c. Cargo Petroleum Tanks
- d. Potable Water/Cargo Water Tanks

3.1.2 Non-Critical Service: Surface areas that do not degrade a ship's mission capability.

- a. Anchor
- b. Anchor Chain
- c. Chain Locker
- d. Cofferdams and Voids
- e. Pedestrian and Vehicular Non-Skid Decks
- f. Freeboard and Topside areas
- g. Bilges
- h. Holds
- i. Manned Spaces
- j. Machinery Spaces
- k. Ballast and Sanitary Tanks
- l. Feedwater/Freshwater Ballast Tanks
- m. Waste Oil and Lube Oil Service Tanks
- n. Oily Waste Tanks
- o. Other Miscellaneous areas

3.2 In order to secure approval, coating(s)/systems shall meet the requirements of Section 3.6-3.8 or have the coating(s)/system on the appropriate US Navy Qualified Product List (QPL).

- 3.2.1 All coating(s) requested for approval shall meet US Federal Volatile Organic Compound (VOC) compliance per 40 CFR Part 62, Subpart II, Table 2 and Volatile Organic Hazardous Air Pollutant (VOHAP) limits for Marine Coatings. The VOC limit provided by the manufacturer shall be measured in grams/liter using Environmental Protection Agency (EPA) Method 24. Failure to meet these standards will result in disapproval.
- 3.2.2 The following substances are not permitted in any coating(s)/systems used aboard MSC government owned ships:
 - a. Organo-tin
 - b. Coal-tar
 - c. Zinc Chromate
 - d. Lead
- 3.3 Coating(s)/Systems Approval Requests
 - 3.3.1 Requests can be submitted via mail or email.
 - a. Mail to:
Commander, Military Sealift Command
Attn: Engineering Office (N7)
Washington Navy Yard
914 Charles Morris Court SE
Washington, DC 20398-5540
 - b. Email to: MSCHQ-N7_Orders.fct@navy.mil. The correspondence subject line should state: Paint Approval Request.
 - 3.3.2 All requests from manufacturers for coating(s)/system approvals shall include:
 - a. A Cover letter, including:
 - (1) Statement requesting approval for the complete coating(s)/system.
 - (2) Identification of a point of contact within the company.
 - (3) A brief description of the coating(s)/system (e.g. type of coating, areas of service, surface preparation, millages, top coating requirements, etc.).
 - (4) Identification of any additional approvals i.e. MIL-SPEC, QPL, or other Federal approvals (e.g. MARAD, USCG).
 - b. A Product Data Sheet for each of the components of the coating(s)/system.
 - c. A Material Safety Data Sheet (MSMDS) for each of the components of the coating(s)/system.
 - 3.3.3 MSC requires a record of successful performance in commercial marine service equivalent to MSC service for which the product is to be used. For each coating to be approved, manufacturers shall submit, in addition to the

data required by paragraph 3.3.2, at least three (3) comprehensive service records, QMS N0712-006.01-F, reflecting the use of coating(s)/system. The service records shall come from at least two (2) different owners.

3.3.4 Some paint systems, listed in Paragraph 3.5, require additional information for approval.

• 3.4 Product List. All ship areas requiring approved coating(s)/systems are provided in QMS Form N0712-006.02-F.

3.5 The following applications require special documentation for MSC approval:

3.5.1 Antifouling, Underwater Hull and Propeller Coatings

a. Manufacturer shall provide proof of Environmental Protection Agency (EPA) registration for any anti-foulant (AF) approval and all existing state approvals, if required. In addition, manufacturers shall meet one of the following:

(1) NAVSEA approval to MIL-PRF-24647 (SH). Manufacturer shall submit documentation showing approval.

(2) Successful commercial service of three years on marine, ocean going steel hull vessels exceeding 700 DWT. Manufacturer shall provide at least three (3) comprehensive service records, QMS N0712-006.-01-F, reflecting the use of coating(s)/system. The service records shall come from at least two (2) different owners.

b. Approvals are for an entire antifouling underwater hull system: both Anti-Corrosive (AC) and Anti-Fouling (AF) coatings. MSC requires antifouling systems to consist of two coats of anticorrosive at 5-6 mils Dry Film Thickness (DFT) each and two coats of antifouling at 5-6 mils DFT each. Manufacturers shall warrant the coating(s)/system and use with the MSC required DFT.

c. Only foul-release coatings are approved for propellers.

3.5.2 Tank Coatings

a. Cargo Petroleum (JP-5 & F-76): Manufacturer shall submit QPL or documentation showing Naval Sea Systems Command (NAVSEA) approval to MILSPEC MIL-PRF-23236 class 5.

b. Potable Water/Cargo Water: Shall have National Sanitation Foundation (NSF) approval for potable water tanks greater than 1000 gallons. Additionally, the paint system shall meet (a) and (b) and either (c) or (d) below:

(1) NSF approved with a water contact size restriction greater than

1,000 gallons.

(2) Pass taste and odor tests as follows:

(a) Flavor Threshold Test values shall not be greater than 2 when tested in accordance with Standard Method ALPHA 2160B from the American Water Works Association (AWWA) Standard Methods for the Examination of Water and Wastewater.

(b) Threshold Odor Test values shall not be greater than 2 when tested in accordance with Standard Method ALPHA 2150B from the AWWA Standard Methods for the Examination of Water and Wastewater.

(3) Approved to MIL-PRF-23236 class 9 and listed in the QPL.

(4) Show two (2) years of successful commercial distilled water service in at least three (3) applications comparable to MSC service. This service shall include exposure to 140°F. distilled water. Manufacturer shall provide at least three (3) comprehensive service records, QMS N0712-006.01-F reflecting the use of coating(s)/system as a potable water tank coating.

3.5.3 Interior Space Coatings

- a. Manned Spaces: Coatings for Manned Spaces such as accommodation, service spaces and control spaces shall meet the requirements of SOLAS Chapter II-2 Regulation 5.3.2.4 and 6.2.
- b. Machinery Spaces: Water based fire-retardant coatings shall comply with MIL-PRF-24596 (SH). Fire retardant chlorinated alkyds shall comply with MIL-DTL-24607.

3.5.4 Exterior Coatings

- a. Helo Deck Non-Skid: Shall be approved per QPL to MIL-PRF-24667 with Type I, Composition G rollable epoxy non-skid.
- b. Vehicular Non-Skid: Shall be approved with Type I, Composition G rollable epoxy non-skid approved per QPL to MIL-PRF-24667.

3.5.5 Heat Resisting: Manufacturer shall comply with Federal Specification TT-P-28 for up to 1,000°F.

3.6 Approval for Reformulated Products. When a manufacturer reformulates a previous MSC-approved product, the manufacturer shall submit, in addition to the data required by Section 3.2, a letter explaining what has been changed and the reasons for it. MSC will determine what steps will be necessary to retain approval. Reformulated coatings shall have different product numbers than the original.

- 3.7 Approval for Renamed Products. When a manufacturer renames a previously MSC-approved product, and the change is in name only and not formulation, then MSC will re-approve the product under its new name, provided that the manufacturer submits a written request per 3.2 and warrants that the formulation has not changed.
- 3.8 System/Product Approval. MSC N7 will provide written notification of new approved products to the requesting manufacturer.
- 3.9 System/Product Disapproval
- 3.9.1 Disapproval of Approved Products. MSC will disapprove coatings that perform poorly in MSC service. Poor performance of 10% or more overall of the coated surface will be grounds for disapproval. Assuming that the coatings were properly applied in accordance with the manufacturer's application instructions, then poor performance is defined as follows:
- a. For tank and exterior coatings: Areas of coating which have delaminated, blistered, rusted-through, dissolved, softened, flaked, cracked, peeled, or have had any other defect within two years of application.
 - b. For antifouling coatings: Areas of coating which have become fouled with barnacles, shell, or worms, or which have delaminated, blistered, flaked, cracked, peeled, or have had any other defect within two years of application.
- 3.9.2 Manufacturers are advised that approvals are subject to revocation should MSC determine that the coating is not performing satisfactorily or no longer complies with federal regulations.

4. DEFINITIONS:

- 4.1 Lead Free. Defined by the Consumer Product Safety Commission's Ban of Lead-Containing Paint (16 CFR 1303) as containing 0.06% or less lead by weight in the dry paint film.
- 4.2 Foul Release Coating: Foul release coatings have a biocide free smooth slippery surface that minimizes the adhesion of bio-fouling. Being biocide free, fouling can attach to the coating, but the organisms tend to release from the coating once the vessel attains a certain speed.
- 4.3 Ablative (reverse colors for boottopping): A coating that prevents fouling due to biocides contained in the coating that leach out over time. The coating matrix dissolves or ablates over time to allow biocides within the film to prevent fouling

for longer periods of time than conventional antifouling coatings. It typically lasts up to five years.

- 4.4 Underwater Hull and Boottop Conventional (reverse colors for boottopping): A coating that prevents fouling due to biocides contained in the coating that leach out over time. The coating matrix does not dissolve or ablate in any way. Once the biocide leaches out of the film, it no longer has antifouling properties. It can last up to 24 months.

5. PROCESS MANAGEMENT:

- 5.1 Office of Primary Responsibility (OPR): N712
- 5.2 Interfaces: Commercial Paint Manufacturers
- 5.3 Performance Indicators: Approved paint products on MSC Ships

ENCLOSURE (2)

**PAINT AND PRESERVATION INSTRUCTIONS
FOR MSC SHIPS**

TABLE OF CONTENTS

Chapter One: COATING TECHNOLOGY

- 1.1 Introduction
- 1.2 Galvanic Corrosion and Zinc Anodes
- 1.3 Impressed Current Systems

Chapter Two: COATINGS FOR STEEL

- 2.1 General Preparation
- 2.2 Surface Preparation
- 2.3 Application Methods, Techniques and Requirements
- 2.4 Primers
- 2.5 Anti-Fouling Systems
- 2.6 Specialized Coatings
- 2.7 Inspection and Evaluation Techniques

Chapter Three: COATINGS FOR ALUMINUM

- 3.1 Introduction
- 3.2 Surface Preparation
- 3.3 Painting

Chapter Four: COATINGS FOR FIBERGLASS HULLS

- 4.1 Introduction
- 4.2 Blistering
- 4.3 Surface Preparation
- 4.4 Painting

Chapter Five: COATINGS FOR WOOD

- 5.1 Introduction
- 5.2 Surface Preparation
- 5.3 Application Methods and Techniques
- 5.4 Painting

Chapter Six: APPLICATIONS ABOARD MSC SHIPS

- 6.1 Introduction
- 6.2 Underwater Hull
- 6.3 Boot Topping
- 6.4 Topsides, Hull
- 6.5 Topsides, Superstructure and Deckhouses
- 6.6 Decks, General

- 6.7 Engine Room, Pump Rooms and Machinery Spaces
- 6.8 Machinery, Interior and Deck
- 6.9 Masts, Booms, and Kingposts
- 6.10 Standard Tensioned Replenishment Alongside Method, Underway Replenishment, and Fueling-at-Sea Equipment
- 6.11 Cargo Holds
- 6.12 Tanks and Voids
- 6.13 Rudders, Kort Nozzles, Inaccessible Voids
- 6.14 Stacks
- 6.15 Lifeboats, Life Rings, Life Rafts, Davits
- 6.16 Piping Systems
- 6.17 Fire and Washdown Systems
- 6.18 Wiring Systems
- 6.19 Hazard Markings
- 6.20 Hull Markings
- 6.21 Damage Control Lockers
- 6.22 Decontamination Stations
- 6.23 Anchors & Anchor Chains

Figure 6-1 Stack Markings

Figure 6-2 Bow and Stern Markings

Table 6-3 Piping Color Codes

Chapter Seven: SPECIAL MSC SHIPS

- 7.1 Introduction
- 7.2 Hospital Ships
- 7.3 Special Mission Ships
- 7.4 Tankers (T-AOT Class)

Chapter Eight: INTERIOR SPACES AND COLOR SCHEMES

- 8.1 Introduction
- 8.2 Work Spaces
- 8.3 Living Spaces

CHAPTER 1 COATING TECHNOLOGY

1.1 Introduction

The technology of marine coating systems has continued to advance and is becoming increasingly sophisticated. The purpose of this document is to provide MSC personnel with direction on COMSC policies concerning maintenance, preservation, and appearance standards for USNS ships.

(a) Marine coatings serve three important functions aboard ships:

(1) Preservation.

Preservation is necessary since the sea is an extremely hostile environment to steel ships, and the cost of constantly renewing corroded metal would become prohibitive if left unprotected. Preservation (coating) systems are also subject to degradation due to weather exposure and shall also be maintained or renewed.

(2) Cosmetic appearance.

Cosmetic appearance of the ship serves several functions, the most important being identification (hull color, distinctive markings, color codes, etcetera). A clean, well maintained ship is also an impressive public symbol of the U.S. Government, especially when visiting overseas ports.

(3) Prevention of bottom fouling.

Bottom fouling increases the power output required to maintain a given speed. As power levels rise, so does fuel consumption (and cost). Eventually, the plant reaches its maximum output, after which increasing fouling will reduce the vessel's maximum continuous rated speed.

1.2 Galvanic Corrosion and Zinc Anodes

NOTE: Zinc anodes are not normally installed on hulls using an impressed current protection system (the impressed currents will greatly accelerate the corrosion rate of the zincs). Some vessels do, however, have small numbers of zinc anodes installed in discrete locations such as sea chests and thruster tunnels.

(a) Proper performance of a zinc anode system requires that the zincs be fully exposed to seawater. Therefore, zincs shall never be painted and should be masked during preservation work.

(b) Maintenance of an existing zinc anode system shall be the responsibility of the Program Manager/Port Engineer. Zincs shall be inspected upon each drydocking and replaced if they are more than 50% wasted.

1.3 Impressed Current Systems

The nature of the electric field in the vicinity of the shields is detrimental to most paints (tending to make them brittle and easily cracked), and therefore requires careful application. If the impressed current system is slightly out of tune and generating an over-voltage, the paint coating will blister (non-ruptured blisters will contain a liquid which feels soapy to the touch). The steel hull within a radius of five feet from the shield should be initially abrasive blasted then coated with 20-25 mils of epoxy paint as general anti-corrosion protection. Reference cells and shield points shall never be coated and should be securely masked against abrasive blasting and painting.

NOTE: When applying dielectric shield material, ensure the masking used to protect the anode from damage during surface preparation does not extend down the side of the anode. If it does, the shield material will not seal to the side of the anode and may develop a short circuit of the system.

CHAPTER 2 COATINGS FOR STEEL

2.1 General Preparation

Prior to beginning surface preparation for painting, there are several items that shall be accomplished to protect the ship and its equipment from the effects of blasting and painting. The Port Engineer should ensure that the shipyard contractor has taken all of these steps:

- (a) Mask impressed current reference cells and anodes
- (b) Mask zinc anodes
- (c) Remove or mask sonar domes
- (d) Run overboard discharge hoses from deck scuppers
- (e) Plug scuppers, outlets, discharges, etcetera
- (f) De-grease as necessary
- (g) Remove sea-chest covers or strainers
- (h) Cover all exposed deck machinery
- (i) Seal all ventilation openings to ship interior
- (j) Mask all portholes, windows, etcetera

2.2 Surface Preparation

There are numerous methods of preparing a surface for coating. The specific type of surface preparation and the degree of cleanliness required are functions of the specific coating to be applied and the desired service life. While some coatings will tolerate less than perfect conditions, others will not. Even with “surface tolerant” coatings, it should be remembered that, while they will accept less than perfect conditions, their service life will be shorter than if applied to a properly prepared surface. It is important, therefore, to understand the surface preparation requirements of the coating system to be applied.

- (a) **Hose washing:** Hose washing refers to rinsing a surface with fresh water to remove salts and other loose dirt and contaminates. When a ship is dry docked, hose washing the underwater hull may remove some slimes and grasses, but its most useful contribution to surface preparation is a) removing surface chloride contamination and b) preventing the heavier slimes, grasses and hard growth from drying and thus becoming harder to remove by more aggressive means.

(b) **Water cleaning and water jetting:** are defined by Surface Preparation Standards SSPC-SP WJ-1/NACE WJ-1, SSPC-SP WJ-2/NACE WJ-2, SSPC-SP WJ-3/NACE WJ-3, and SSPC-SP WJ-4/NACE WJ-4. These standards define varying degrees of surface preparation as follows:

- Low Pressure Water Cleaning (LPWC) <
5,000 psi
- High Pressure Water Cleaning (HPWC) 5 –
10,000 psi
- High Pressure Water Jetting (HPWJ) 10 –
25,000 psi
- Ultrahigh Pressure Water Jetting (UHPWJ) >
25,000 psi

For MSC's purposes, LPWC equipment that will produce 2,500-3,000 psi at 10-15 gallons/minute will be satisfactory for most applications. LPWC with fresh water in this pressure range will remove loose paint, contaminants, slime, grasses, most hard marine growth and, in the case of ablative antifouling paint, the hydrolyzed binder. This technique offers the advantage of a) not damaging undercoats of paint and b) eliminates dust and grit problems. Heavy hard fouling or coating delamination may require higher pressures to effect complete removal. An emulsifying agent or detergent may have to be added to the water as necessary to remove oils and greases.

(c) **Ultra-High Pressure Water Jetting:** Ultra-High Pressure Water Jetting is performed with specialized equipment capable of producing nozzle pressures of greater than 25,000 psi. This method will remove all existing coatings, rust, scale, dirt and chlorides down to bare metal. It will not produce an anchor pattern, but rather will clean out the existing anchor pattern, or profile, in preparation for recoating.

Standards for UHP water jetting are defined by SSPC (The Society for Protective Coatings) {formerly the Steel Structures Painting Council} and NACE (The National Association of Corrosion Engineers). The applicable (joint) standards are SSPC-SP WJ-1/NACE WJ-1, SSPC-SP WJ-2/NACE WJ-2, SSPC-SP WJ-3/NACE WJ-3, and SSPC-SP WJ-4/NACE WJ-4. WJ-4 is equivalent to an abrasive sweep. WJ-2 is equivalent to a near white metal blast, in terms of the amount of paint and rust/scale that may remain on the finished surface. WJ-1 is equivalent to a white metal blast in that no residual coatings, scale, etcetera may remain on the finished surface.

It should be remembered that the surface produced by UHP water jetting would not look the same as that of a dry abrasive blasted surface. Visual Guide SSPC-VIS 4/NACE VIS 7 is a photographic reference guide for determining the degree of surface preparation achieved by water jetting.

It is imperative to remember that when UHP water jetting is used for surface preparation, there will be varying degrees of flash rusting. The extent of flash rusting

will be a factor of weather conditions and the type of blasting equipment used. Equipment using a vacuum to remove the blast water and removed contaminants will usually evidence less flash rust than equipment not using vacuum removal. Several of the epoxy coatings used by MSC will tolerate light flash rust. If heavier flash rust is present it may be necessary to “sweep” the area with 3,000 psi water to remove the excessive rust film and restore the surface to a coatable condition.

(d) **Abrasive blasting:** A mechanical means of removing old coatings, rust, and scale, including mill scale, to prepare metal for coating. Organizations such as SSPC and NACE have established standards for varying degrees of blast cleaning. Blast cleaning uses grit or shot (steel or mineral) propelled either by compressed air or mechanical means against the surface to be cleaned. This is the fastest, most-efficient way to prepare large surface areas. It does, however, generate very large amounts of dust and grit. The depth of the abrasive blast profile of the surface will vary depending upon the grit or shot used, the sieve size of the grit/shot and the force of impact against the surface being blasted. The profile required is dependent upon the requirements of the coating being applied, and should be listed on the coating product data sheet, but will normally be somewhere in the range of 1 ½ - 3 mils as measured on a Keane-Tator Blast Profile Comparator and/or Testex Replica Tape (or equivalent) (profiles which are deeper than this leave un-coated peaks, and waste considerable paint). One other point that should be kept in mind is that abrasive blasting will not remove chlorides from the surface. Rather, it may actually drive the chlorides into the valleys of the anchor pattern.

Dry abrasive blasting may be very thorough or very superficial depending upon the surface preparation standard selected for use. The most commonly used surface preparation standards used for abrasive blasting, listed in descending order of cleanliness, are:

- (1) SSPC-SP 5/NACE No. 1, White Metal Blast Cleaning
- (2) SSPC-SP 10/NACE No. 2, Near-White Metal Blast Cleaning
- (3) SSPC-SP 6/NACE No. 3, Commercial Blast Cleaning
- (4) SSPC-SP 7/NACE No. 4, Brush-Off Blast Cleaning

In each standard, Section 2: Definition, provides a description of the surface that will be obtained. This description should be used as the acceptance criteria for surface preparation performed to that particular standard. Note that in each case the definition is based on viewing the surface using the naked eye only; i.e. without magnification.

(e) **Other commonly used surface preparation standards:** that produce finished surfaces of lesser quality, in descending order, are:

- SSPC-SP 11, Power Tool Cleaning to Bare Metal
- SSPC-SP 3, Power Tool Cleaning
- SSPC-SP 2, Hand Tool Cleaning

SSPC-SP 3 and SSPC-SP 11 are similar. Under SP 3, tightly adherent paint, which is defined as any paint film that cannot be lifted with a dull putty knife, can remain on the surface. Similarly, tightly adherent rust can also remain. Under SP 11 all existing paint and rust shall be removed.

As with the standards for abrasive blasting, Section 2: Definition, provides a description of the prepared surface that should be used as criteria for acceptance of the work. SSPC-VIS 3 visual standard is a useful tool to assist in judging the prepared surface to determine if the specification requirements have been met.

In virtually each surface preparation standard, SSPC-SP 1: Solvent Cleaning, is referenced as a prerequisite to performance of the work required by that particular standard. SSPC-SP 1 invokes requirements to clean the surface of oil, grease, dirt, weld slag and weld spatter and other foreign material that, if not removed, could interfere with coating adhesion. While SSPC-SP 1 should be performed because it is referenced in whichever surface preparation standard was specified, it is a good practice to invoke SSPC-SP 1 directly to avoid oversight on the part of the contractor performing the work.

(f) Non U.S. Surface Preparation Standards: When surface preparation and coating work is performed overseas, contractors may ask if the work can be performed to other industry standards such as ISO (International Organization for Standardization) or BSI (British Standards Institute). This decision is a judgment call, but it shall be remembered that these standards do not correlate exactly with those of SSPC and NACE. There are differences. Even though roughly equivalent, an ISO Sa 2 ½ cannot be judged using the definition of Near White Metal Blast Cleaning found in SSPC-SP 10/ NACE No. 2. Even assessment of surface profile will be different. Using ISO surface comparators to define the surface profile will result in descriptions such as, “finer than fine”, “fine”, “medium”, “coarse” and “coarser than coarse”. Understand what you are agreeing to before you make the agreement!

(g) Standard Surface Preparation Requirements:

The following surface preparation requirements shall be followed for all major painting evolutions where paint removal to bare metal is required:

- (1) The surface shall be abrasive blast to near white metal in accordance with SSPC-SP 10/NACE No. 2.
- (2) The surface profile of the blasted steel shall be angular and shall be in the range of ½ to 3 mils.
- (3) The surface cleanliness after blasting shall be less than 10 micrograms/square cm for topsides; less than 7 micrograms/square cm for underwater hull; less than 7 micrograms/square cm for all tanks; and in no other case greater than 12 micrograms/square centimeter for chlorides.

- (4) In cases where waterjetting is called for, the surface shall be waterjetted to near white metal in accordance with SSPC–SP WJ-2/NACE WJ-2. If flash rusting occurs, it shall be no more than “light” per WJ-2 L prior to coating application. Surface profile and surface cleanliness requirements above still apply.
- (5) In cases where surface preparation is performed on partial areas, like spot blasting, the junction between the prepared and intact coating are required to be “tight” (no visible blistering, flaking, delamination, etc.) and the edges of the intact coating are required to be “feathered” to provide an exceptionally good surface for the new paint to adhere to. Feathering may be accomplished by use of a power disc sander or other appropriate tool.
- (6) All steel plate sharp edges shall be rounded to at least a 3 millimeter radius. All welds shall be prepared to NACE grade D welds.
- (7) Deviations from these requirements shall be allowed in special cases. Requests for deviations shall be submitted to N7 for approval.

(h) **Inspection:** When the surface has been prepared, both the port engineer and the paint manufacturer’s representative should inspect and approve it before allowing application to proceed.

(i) **Ventilation, Dehumidification and Heating:** Ventilation is important when dealing with confined spaces, whether a tank or a cargo hold. It maintains a clear atmosphere in order to see the work. Coatings contain varying amounts of solvent, and without adequate ventilation flow, or even if the flow is adequate but the relative humidity is extremely high, the evaporation of the solvent from the coating will be slowed or, in the extreme, even stopped. This can cause slow curing of the coating and/or solvent entrapment in the film that may show up later in the form of blistering.

Where tanks to be blasted and coated are so large that the work will span several days, the Port Engineer shall specify use of dehumidification equipment and/or heaters and ducting to ensure preservation of the blasted surfaces until they can be coated and to maintain surface and ambient conditions that meet the requirements established by the coating manufacturer for the coating to be successfully applied.

Coating applications in potable water tanks are especially critical in this regard. Without proper and continuous ventilation, solvents could remain in the film, which in turn could leach out into the potable water. For that reason, ducting shall be positioned to assure there are no “dead” spots in the tank. Dehumidification and/or heating equipment shall be used to ensure that the ambient conditions in the tank are at least 70° F with low relative humidity throughout the paint application and curing times. No less than 48 hours shall elapse between coats of paint and no less than seven (7) days shall elapse between the last coat of paint and the introduction of water to the tank.

(j) **Galvanized steel**, such as ventilation ducting or lifeboat hulls, shall never be abrasive swept or blasted since the protective galvanized coating may be damaged. The proper method to prepare a galvanized surface is either with mechanical brushing or using a wash primer (discussed below). Heavy galvanized structures may be lightly swept with dry abrasive to etch the surface for painting if required.

2.3 Application Methods, Techniques and Requirements

(a) **Ambient conditions:** Ambient weather conditions are critical. Winter temperatures in northern shipyards may preclude the use of certain coatings, as may summer humidity in southern shipyards. When it is possible that weather conditions could impact on the paint work, the Port Engineer shall specify that the shipyard use a feasible method to avoid these problems. Erecting a temporary shelter around the work area, using heat lamps, dehumidifiers and/or portable ventilators, or altering the type and/or amount of solvent added to the coating are all methods that have been successfully used in the past. It shall be kept in mind that every application job is unique and is likely to present its own problems. Finally, paint shall not be applied when the relative humidity is greater than 80% or when the surface temperature is less than 5 °F above the dew point.

(b) **Multiple coats:** As a general rule, each overcoat shall be a different color from its undercoat to ensure good contrast during application.

(c) **Stripe coating:** Areas of critical service, such as tank interiors and non-skid applications, should also have a stripe coat applied to welds, corners, edges, threaded surfaces and other areas that are difficult to coat in order to ensure proper film formation and to fill pinholes and pits. In tanks, also stripe coat all limber holes, snipes, corners, weld seams, edges and other areas that are not conducive to proper coverage by spray application. On weather exposed welds, deck edges penetrating beyond the exterior hull, vent plenums (edges and welds) and deck machinery welds shall be stripe coated. Stripe coat all welds in fan rooms and propulsion motor room(s). Edges on the exterior surfaces of the ship that do not have a 3 millimeter radius require a stripe coat. Weld seams on exterior and underwater hull surfaces that are not equal to NACE D welds require a stripe coat.

2.4 Primers

By definition, a primer is a coating that will enhance the adhesion of subsequent coatings. Many epoxies that MSC uses are self-priming and need no other primer prior to their application. Many refer to the first coat of paint applied to the surface as the “primer” coat, even though the paint isn’t technically a primer.

(a) **Wash primers** contain phosphoric acid, which etches the metal and provides better adhesion for the succeeding overcoats. Wash primers are regularly used on aluminum and galvanized steel. They are applied in very thin coats and do not count as part of the DFT of the anti-corrosive system. If applied to a blasted surface, it is not unusual to see peaks of the substrate surface profile breaking through the primer film.

2.5 Anti-Fouling Systems

Boot topping, interior of seachests, thruster tunnels, bilge keels, sea bays, scupper guards, etcetera, should be coated in the same manner as the rest of the underwater hull. Although seachest strainers are best coated by dipping, this is usually not practical. Care should be exercised to ensure that all surfaces of strainer plates are adequately covered. Shields around impressed current systems should not be painted with anything other than an anti-corrosive as the cuprous oxide in anti-fouling paint may react adversely with the cathodic protection system.

2.6 Specialized Coatings

In addition to the paints discussed above, there are several coatings for specialized service aboard ship.

- (a) **Heat-resistant** coatings are used to paint hot surfaces, such as steam lines, boilers, and steam-powered equipment. These coatings are flexible enough to survive thermal expansion and contraction, and do not blister at high temperatures. Use of these coatings is discussed in Chapter 6 (Sections 6.7 and 6.15).

- (b) **Fire-retardant** coatings are paints that have been formulated so that the dry film does not burn (although these paints are still flammable before the solvents have evaporated) or, in the case of intumescent coatings, actually foam up when exposed to high temperatures to form an insulating layer. These coatings will not necessarily prevent a combustible substrate from burning. The most common of these paints are chlorinated alkyds, which are extensively used in interior spaces, though water-borne fire retardant coatings are also now on the market.

- (c) **Soft coatings** are thick fluids or gels which can be sprayed or “floated” onto a surface, and which never harden. These coatings can be applied to less-than-perfect surfaces, and are well suited for small, inaccessible voids where conventional painting methods are impractical or too expensive (such as rudder interiors). While some ship operators have used these coatings in seawater ballast tanks, their life in this service is short due to the washing effect of the ballast water. Other problems associated with these coatings are 1) they tend to support microbial corrosion (anaerobic bacteria) and may mask active corrosion. **Use of these coatings, other than specified in Chapter 6 (Section 6.12) shall not be done without explicit approval from COMSC (Code N7).**

2.7 Inspection and Evaluation Techniques

This section addresses how the Port Engineer should inspect and approve paint work.

(a) **General preparations:**

- (1) The Port Engineer shall ensure that the shipyard prepare a test and inspection plan that includes all work areas to be painted. Each area should be broken down into

phases such as “surface preparation,” “1st Coat,” “2nd Coat,” etcetera. Each of these phases should have sign-off lines for the Port Engineer, the shipyard’s paint foreman, and the paint manufacturer’s representative.

- (2) To conduct inspections the Port Engineer should be equipped with flashlight, pocket mirror, sharp putty knife, dry film gauge, wet film gauge, psychrometer, metal temperature gauge, and surface comparator.

(b) Surface preparation: With exception of small area touch-up work, all specifications should require the Port Engineer’s approval of the surface preparation prior to coating application. A near-white surface should be a rough, metallic gray color, with no more than 5% uniformly dispersed staining from rust, mill scale, and previous coats of paint. Inspect any pitting to ensure that they have been blasted. All grit and dust should have been blown-down, vacuumed or swept out, and no surfaces should feel gritty. Make sure that scaffolding was shifted around so that obstructed points were exposed and blasted. An abrasive swept surface should be free of loose paint or rust flakes, and any remaining paint should be tight. There should be no residual oil, grease, or water on any surfaces to be coated. Port Engineers should refer to visual comparator cards (such as SSPC-VIS 1) to help assess the quality of the surface preparation.

(c) Applications: Coatings should be applied in the thickness range recommended by the coating manufacturer and in accordance with the recommended cure times for the coating. Areas of critical service, such as tank interiors and non-skid applications, should also have a stripe coat applied to welds, corners, edges, threaded surfaces and other areas that are difficult to coat in order to ensure proper film formation and to fill pinholes and pits. Each coat should be inspected after it has cured (refer to the coating’s Product Data Sheet). The Port Engineer should make personal notes on points of low or excess film, missed areas (“holidays”), pinholes, blisters, sags, runs, puddles, dry-spray (evidenced by a slightly gritty, rough surface), sand/grit/dust inclusion, lifting of feathered edges, sharp edges, and welds. Defects should be corrected as follows:

- (1) Blisters, sags, runs, and puddles should be scraped smooth and any entrapped solvents wiped away. When cured, these areas should be lightly sanded, wiped down and touched-up to restore the film integrity.
- (2) Dry-spray (over-spray) should be lightly sanded and wiped/blown down to remove generated debris.
- (3) Sand, grit, or other included material shall be completely removed and the coating touched-up to restore the film integrity.
- (4) Holidays, or areas of low film build, should be touched-up to increase the film thickness to the specification work item requirements.

The Port Engineer should re-inspect the coating after the contractor has taken corrective action, referring back to his notes from the first inspection. When all is in order, both the Port Engineer and the paint manufacturer’s representative should sign-off the T&I plan with approval to proceed. The next coating should be applied as soon as possible in order to minimize further surface contamination.

(d) **Shipyard proposals:** At times, a shipyard may propose using an alternate coating due to procurement lead time, weather conditions, application problems, etcetera. If the proposed alternative coatings are not MSC approved, the Port Engineer is not authorized to approve such alternate proposals, since these may impact on future coating work, or entitle the government to a credit (if the new coating requires less cost or effort on the part of the contractor). Such proposals are to be referred to the Program Manager or COMSC N7, as appropriate for evaluation.

CHAPTER 3 COATINGS FOR ALUMINUM

3.1 Introduction

This chapter discusses paint technology as applied to external aluminum surfaces (i.e., those exposed to seawater or weather). Major use of aluminum in the MSC fleet is generally limited to work boats, lifeboats, accommodation ladders, brows and some deckhouse structures.

(a) Oxidized aluminum has a tough, adhesive surface film, which effectively seals the underlying metal from further exposure. Therefore, ordinary corrosion of aluminum is not a serious problem. The Port Engineer should, however, keep an eye out for galvanic corrosion where steel or other metal fittings have come into prolonged contact with the aluminum.

(b) The main purpose of painting aluminum is to maintain a cosmetic appearance (i.e., to match surrounding color schemes).

3.2 Surface Preparation

Most of the basic preparation methods previously described in Chapter 2 can be used on aluminum surfaces. It is imperative to remember, however, that aluminum is a relatively soft metal. Abrasive blasting can be performed, but 80-grit aluminum oxide or garnet abrasive at a low air pressure (65 psi) should be used. Higher pressures and/or harder grits will cause gouging of the surface, imbedding of grit in the surface and generally damage the aluminum. Similarly, disc sanders should use fine grit pads.

3.3 Painting

Clean, bare aluminum may be coated by any of the normal application methods, i.e. brush, roller or spray. If in doubt as to the adequacy of the anchor pattern, a wash primer may be used to enhance surface profile if it is compatible with the coating system to be applied. Always check with the coating manufacturer before allowing the use of a wash primer. Otherwise, epoxies may be applied directly onto the surface and, when properly cured, top coated. Under no circumstances shall zinc containing coatings (e.g. inorganic zinc, zinc rich epoxies) be applied to aluminum.

CHAPTER 4 COATINGS FOR FIBERGLASS HULLS

4.1 Introduction

This chapter discusses paint coatings for fiberglass. In the MSC fleet, major fiberglass use is limited to lifeboats, workboats, life raft canisters, and weather-tight housings for exposed electronic systems (i.e., radar, radio, COMSAT antennas, etcetera). This chapter is specifically intended for maintenance of fiberglass hulls; if other situations arise concerning fiberglass, the MSC Engineering staff (Code N7) can be consulted.

(a) The primary reason for painting fiberglass is for cosmetic appearance. Being non-metallic, fiberglass does not corrode, and generally has good weather resistance. After several years of exposure, however, the gel coat may become dull and require painting.

(b) There are many types of paint systems that can be used to paint fiberglass. However, for the purposes of providing a good, long lasting coating, polyurethane coatings are acceptable for MSC service.

4.2 Blistering

For unknown reasons, molded fiberglass hulls occasionally form blisters in the gel coat (an affliction sometimes known as “the pox”). These blisters can form at any time, in a new hull or old, and they shall be repaired to preserve the integrity of the hull. Blisters should be removed by disc sanding, and the exposed craters thoroughly cleaned of all loose debris and then filled with epoxy putty. When the putty has cured, it should be sanded flush with the surrounding surface and painted.

4.3 Surface Preparation

Fiberglass is not to be abrasive swept or blasted. The proper method of preparation is disc sanding, to provide a slightly roughened surface. New fiberglass hulls shall be thoroughly de-waxed before being coated.

4.4 Painting

(a) Fiberglass may be coated with one or two coats of epoxy or a commercial fiberglass primer compatible with the final topcoat.

(b) If painted, exteriors of open lifeboats shall match topside color of the vessel and interiors shall be international orange. Totally Enclosed lifeboats shall be maintained international orange as original.

CHAPTER 5 COATINGS FOR WOOD

5.1 Introduction

This chapter discusses preservation methods for weather-exposed woodwork. In the MSC fleet, such woodwork is typically outfitting of open lifeboats (seats, oars, rudders, etcetera). Refer to Chapter 6 (Section 6.14) for required color schemes for lifeboats.

5.2 Surface Preparation

Wooden items shall not be abrasive blasted, or abrasive swept. Proper surface preparation is disc sanding, hand scraping, and the use of paint solvents. All loose paint, blisters, oil, and grease shall be removed. Only tightly adhering paint should be left. Wood shall be completely dry.

5.3 Application Methods and Techniques

Brush painting is best for small areas and touch-up, especially bare wood since the brushing action can work the paint into the pores of the wood better than other methods. Spray application can be used for larger areas and topcoats.

5.4 Painting

After the wood surface has been prepared, it shall be treated as follows:

- (a) One coat of copper naphthenate wood preservative, and
- (b) Two coats of an alkyd paint for the finish color

CHAPTER 6 APPLICATIONS ABOARD MSC SHIPS

6.1 Introduction

(a) This chapter addresses coatings for specific areas of MSC service. Certain areas of shipboard use require critical performance from the coating (such as anti-fouling paints, which affect fuel consumption; and cargo tank coatings, which affect cargo quality), and the coatings to be used in these areas shall have specific COMSC approval.

(b) Most MSC ships are “gray hulls,” like regular Navy vessels. However, there are some MSC vessels (such as hospital ships, oceanographic ships, etc.), which are not gray. The color schemes for these special hulls are addressed in Chapter 7.

(c) For MSC ships that are maintained by contracted commercial operators, the paint and coating provisions of that contract shall supersede the requirements of this chapter wherever a conflict of instructions occurs.

(d) In the discussions below, a “new” coating means that the original coating has been completely removed; a “renewed” coating means completely overcoating an existing one (after suitable surface preparation); and “touch-up” refers to renewing just a small, localized area.

6.2 Underwater Hull

The underwater hull is defined as all areas of the hull from keel to 6 inches below the light load line, including rudder(s), bilge keels, thruster tunnels, but excluding the boot topping.

NOTE: This is an area of critical service and only those coating systems approved by MSC shall be used.

(a) **Fleeting:** When the underwater hull is specified to be fully blasted to near white metal, the shipyard shall be required to fleet the ship in order to ensure that there is full 100 percent coverage of the hull with respect to the new anti-corrosive and anti-fouling coatings. When only the anti-fouling coating is to be renewed it is not necessary to fleet the ship. However, Port Engineers shall ensure that subsequent docking positions allow the previously masked portions of the hull to be coated properly.

6.3 Boot Topping

The boot topping is that portion of the hull from 6 inches below the light load line to 6 inches above the deep load line. The boot topping shall always be a black anti-fouling of the same type of coating as the underwater hull (i.e., conventional, ablative, etcetera). In no case should a conventional hard anti-fouling be applied over an ablative anti-fouling. Doing so encapsulates the ablative anti-fouling, rendering it useless.

6.4 Topsides, Hull

The topside hull comprises all of the freeboard from 6 inches above the deep load line to the railings, including bulwarks. Unless otherwise specified in Chapter 7, the freeboard hull color for MSC ships shall be Haze Gray (Fed Std Color #26270). Hull markings are discussed in Section 6.20.

6.5 Topsides, Superstructure and Deckhouses

The general topsides include all weather-exposed vertical surfaces, such as superstructure, deck houses, deck lockers, mast houses, railings, ladders, hatches, hatch coamings, and ventilation plenums, but excluding stacks, masts, cargo gear, lifeboats and davits, decks, deck machinery and deck piping which are each addressed separately in this chapter. (a) Unless otherwise specified in Chapter 7, the topside color for MSC ships shall be Haze Gray (Fed Std Color #26270).

6.6 Decks, General

- (a) Interior deck coverings in habitability areas are addressed in COMSCINST 9330.6 and N0720-100.00-P. Interior decks in non-habitability areas are usually painted with a semi-gloss coating.
- (b) Exterior decks include all weather-exposed horizontal surfaces, with exception of helo/hangar decks and specific non-skid areas, which are addressed in COMSCINST 4750.2, and hospital ships, which are addressed in Chapter 7.
- (c) All decks and horizontal surfaces visible to surface or air detection shall be Dark Gray (Fed Std Color #26081).
- (d) Decks should be blasted to near-white metal and completely recoated only when necessary. Large deteriorated areas shall be done with industrial assistance; ship's force shall perform small area touch-up work and shall be responsible for general maintenance and appearance.

6.7 Engine Room, Pump Rooms and Machinery Spaces

This section applies to bilges, bulkheads, decks, and overheads of engine rooms, motor rooms, boiler rooms, auxiliary machinery rooms, shaft alleys, and steering gear flats. Machinery and piping within these spaces are addressed separately.

- (a) The deck color shall be extended 6" up all bulkheads to form a dado band.

(b) The machinery spaces shall be painted using the following types and colors:

- (1) Bilges, including foundations: Two (2) coats of a surface-tolerant epoxy at 5 mils DFT with the final coat being Terracotta (red oxide similar to Fed Std 595 color number 20109).
- (2) Decks: Two (2) coats of a surface-tolerant epoxy with the final coat Terracotta or one (1) coat of surface tolerant epoxy and one coat of Terracotta alkyd.
- (3) Bulkheads: Fire retardant Soft White.
- (4) Overheads: Same as bulkheads.
- (5) Deck gratings: Same as decks.
- (6) Platform gratings: Black.

(c) All new steel for replacement of floor bearers shall be blasted to near white metal and coated with one coat of inorganic zinc primer at 2-3 mils DFT, followed by two coats of epoxy as noted in paragraph (b1) above.

(d) New deck plates and gratings, and existing deck plates/gratings, if possible to remove to an off-site location, shall be blasted to near white metal and coated with one coat of inorganic zinc primer at 2-3 mils DFT, followed by two coats of paint as noted in paragraph (b)(2) above.

(e) Pump Room valves and piping shall be color-coded for the particular cargo system.

(f) Piping in machinery spaces other than pump rooms shall be painted as detailed in Section 6.16.

6.8 Machinery, Interior and Deck

Machinery falls into three categories: deck machinery (weather-exposed), interior machinery (in engine room or auxiliary spaces), and hot machinery (steam-powered, whether exposed or interior).

- (a) Deck machinery: Haze Gray
- (b) Interior machinery: Equipment Gray trimmed out with Black
- (c) Hot machinery: Heat-resisting paint, aluminum in color

6.9 Masts, Booms, and Kingposts

All masts, booms, kingposts, etcetera, shall be painted with Haze Gray (Fed Std Color 26270). The past practice of painting of the outboard six feet of all boom tips forward of the stack to be white and the outboard six feet of all boom tips aft of the stack to be black (Fed Std Color 27038) has been eliminated.

6.10 Standard Tensioned Replenishment Alongside Method, Underway Replenishment, and Fueling-at-Sea Equipment

All machinery shall be Haze Gray (Fed Std Color 26270), marked white in accordance with NTTP 4-01.4.

6.11 Cargo Holds

- (a) Bulkheads, overheads, the interior of cargo hatch coamings, cargo trunks, etcetera, in way of cargo spaces shall be painted white.
- (b) Decks shall be painted Dark Gray.
- (c) Wooden cargo battens shall also be painted Dark Gray.
- (d) Vertical ladders, and bulkheads in way of ladders, shall be gloss black with hazard markings per Section 6.18.
- (e) All U-bolts, D-rings, padeyes, and other fittings intended for use during cargo handling shall be painted gloss Red.

6.12 Tanks and Voids

The importance of ensuring proper coating lifetime in tanks, especially cargo tanks, requires proper attention to surface preparation and paint application. Prior to the start of any abrasive blasting, all surfaces shall be cleaned to remove residues of petroleum products (especially for cargo petroleum or other fuel, lube or hydraulic fluid tanks. SSPC-SP 1, Solvent Cleaning is a useful standard for this cleaning operation. Similarly, seawater ballast tanks or fresh water ballast tanks that contain corrosion inhibitors should first be thoroughly cleaned by means of LPWC and the use of products such as Chlor-Rid or equivalent to remove salts from the surfaces to be prepared. The Port Engineer should specify the use of dehumidification and/or heating equipment, careful clean-up of blasting grit and dust, full stripe coating of all edges, corners, threads, welds and other difficult to coat surfaces, and thorough inspection at each phase of the coating work.

- (a) Prior to beginning general spray painting, all edges, corners, and other places difficult to reach or properly spray shall be given stripe coats by brush or roller. If it will take too much time to stripe coat before the blasted surface flash rusts, the stripe coat can be applied between the first and second coat.
- (b) In the case of Potable Water Tanks, all coats shall be cured no less than 48 hours (at 70° F minimum) between coats. The final coat shall be cured no less than 7 days (at 70° F minimum) prior to flushing and chlorination. Forced ventilation shall be maintained during curing periods, and heaters shall be set up when necessary to maintain the minimum temperatures.

(c) Dry voids may, if accessible for blasting, be prepared to near white metal and coated with inorganic zinc and top coated with epoxy. If preparation of dry voids to near white metal is not practical, mechanically cleaned surfaces shall be coated with two (2) coats of surface tolerant epoxy.

6.13 Rudders Kort Nozzles, Inaccessible Voids

(a) The exterior areas of rudders and Kort Nozzles are considered part of the high-turbulence regions of the underwater hull. If turbulence induced erosion is noted, these areas should be coated with one of the MSC approved coatings for high turbulence areas.

(b) Interior surfaces of rudders, stern frames, bilge keels, Kort Nozzles or other inaccessible voids may be "float" coated with any commercially available "float" coatable corrosion preventive compound having the following salient characteristics:

- (1) Forms a soft or semi-soft film.
- (2) Is rust penetrating.
- (3) Is not seawater soluble.
- (4) Is non-polluting (will not produce a sheen on water) and/or is self-oxidizing.
- (5) Has a flash point of not less than 100 °F (38 °C).

6.14 Stacks

Stacks shall receive the same maintenance attention as the deckhouse and superstructure. All MSC ships, regardless of type or hull color, shall have their stacks painted with the distinctive color bands described below. The painting of other insignia or markings is prohibited.

(a) The widths of the color bands are proportional to the overall height of the stack "H" as illustrated in Figure 6-1.

- (1) Top band: Black, for a width of two-fifteenths of "H"
- (2) 2nd band: Haze Gray, for one-fifteenth of "H"
- (3) 3rd band: Blue, for one-fifteenth of "H"
- (4) 4th band: Yellow, for one-fifteenth of "H"
- (5) Lower portion: The remainder of the stack (below the yellow band) shall be painted the same color as the surrounding deckhouse, except as otherwise directed in Chapter 7.

6.15 Lifeboats, Life Rings, Life Rafts and Davits

(a) **Lifeboats** shall be prepared in a manner suitable for their construction, i.e., galvanized steel, aluminum, or fiberglass. On open lifeboats the hull color shall match surrounding superstructure color. Exteriors of encapsulated lifeboats shall be maintained international orange as original. The interior of open lifeboats shall be given two topcoats of International Orange, except where the lifeboats are stowed forward of the bridge and the bright color would interfere with navigation (in such situations, the interior

may be given two topcoats of Haze Gray). On each side of the bow in black letter not less than 3" high shall be stenciled the vessel's name and lifeboat number. Also, on each side of the bow, in black letters not less than 1-1/2" high, stencil the cubic capacity of the boat and the number of allowed persons that can be carried. Additionally, on at least two thwarts, in black letters not less than 3" high, shall be stenciled the number of allowable persons that can be carried.

(b) **Lifeboat oars** shall be International Orange with grips and blade tips painted White. Stenciled on each oar shall be the ship's name.

(c) The lifeboat **release levers** shall be gloss Red, with red luminous tape around the handle ends. The raised lettering on the levers shall be white. The background hull and footings in way of, and for 6" around, the levers also shall be painted white to ensure good contrast for night visibility.

(d) **Life rings** and **life rafts** shall be maintained in accordance with manufacturer's recommendations. Ship's name should be stenciled on each item.

(e) **Davits** shall be painted to match superstructure color. "Witness marks" shall be painted on both tracks and arms to indicate the point at which power hoisting of the davits should be stopped. Such witness marks shall normally be White, at least 1-1/2" wide, located where they are readily visible to the winch operator, and should be in alignment before the limit switch is required to function.

6.16 Piping Systems

Interior piping, except fire systems discussed in Section 6.16, shall be painted to match surrounding areas and stenciled with white lettering to identify service and flow. In the event that the piping is painted white to match the surroundings, all stenciling shall be black. Piping Systems shall be stenciled on either side of bulkhead and deck penetrations and at least once each 20 feet of pipe run. Valve bodies and wheels shall be painted gloss Black, except those un-insulated valves subjected to high temperatures; these shall be painted with heat-resistant aluminum colored paint.

(a) When painting valves, label plates are to be properly masked.

(b) **Steam piping on weather decks** exposed to green seas shall be coated with 4 mils of inorganic zinc primer and top coated.

(c) **Exterior riser plugs** for shore side connections shall have white stenciling to identify their service and shall be color-coded as follows:

(1) Fresh water:	Blue
(2) Fireman:	Red
(3) JP-5:	Purple
(4) Steam:	Haze

Gray
(5) Fuel:
Gray

Haze

(d) Markings for interior valve and piping systems shall be in Table 6-3, Piping Color Codes.

6.17 Fire and Washdown Systems

(a) **Firemain**s shall be painted to match surrounding compartment or deck colors and stenciled in red to read “FIREMAIN” with an arrow indicating direction of flow. Piping shall be stenciled on either side of bulkhead and deck penetrations and at least once every 20 foot of pipe run. All valve bodies and handles, fire cabinets and associated fittings shall be painted or trimmed with gloss Red.

(b) **Carbon Dioxide (CO₂) piping** shall be gloss Red, with white stenciling “CO₂” and an arrow indicating direction of flow. Piping shall be stenciled on either side of bulkhead and deck penetrations and at least once every 20 feet of pipe run. This includes nozzles, valves, and control handles.

(c) **Halon piping** shall be painted to match surrounding compartment or deck colors, stenciled in red to read “HALON” with an arrow indicating direction of flow. Piping shall be stenciled on either side of bulkhead and deck penetrations and at least once every 20 feet of pipe run. Valves, and control handles shall be painted or trimmed with Gray and White stripes. All nozzles shall be trimmed with gloss Red.

NOTE: In the event that the color of the piping is such that there is poor color contrast with the red stencil markings, a rectangular area in way of the stenciling shall be painted white for contrast.

(d) **Washdown system brackets** for chemical, biological, and radiological (CBR) defense shall be painted International Orange.

6.18 Wiring Systems

Wireways, stuffing tubes, and similar electrical fittings shall be painted to match surrounding compartment surfaces.

6.19 Hazard Markings

All points posing inherent hazards to personnel shall be clearly and distinctively painted with alternating black and yellow stripes. This includes low beams, high hatch coamings, protruding corners, and other stumbling or tripping hazards.

(a) Such hazard markings shall be diagonal, alternating stripes of gloss Black and Yellow. The width of the stripes should be proportional to the hazardous area, ranging from 1-1/2" to 4" in width.

(b) **Interior stairways** shall have the top and bottom risers painted with a 4" band of yellow or white.

(c) **Vertical ladders** shall have the top one foot and bottom six feet of the handrails painted yellow. Top and bottom rungs also shall be yellow.

(d) Professional judgment and experience shall be used to guide the use of these hazard markings.

6.20 Hull Markings

The following markings are to be applied to all MSC ships. All letters and numbers shall be outlined with welding beads and shall be Black unless otherwise indicated. Refer to Figure 6-2 for additional illustration.

(a) On **ships longer than 200 feet other than Naval Fleet Auxiliary Ships**, the ship's name shall appear on both the bow and stern in lettering 15" high and 1-7/8" nominal thickness. Above the name shall be the caption "U S NAVAL SHIP" in lettering 10" high and 1-1/4" thick. At the bow, this caption shall be spaced 6" above the ship's name; at the stern, this caption shall be spaced 24" above the name.

(b) **Naval Fleet Auxiliary Ships** longer than 200 feet shall have stern markings identical to the above. Instead of the vessel's name, the port and starboard sides of the bow shall be stenciled with Navy hull numbers (light gray with ocean gray shadowing) in accordance with NAVSEA S6360-AG-MAN-010 and in accordance with NAVSHIPS Drawing No. S2804-921819.

(c) **Ships less than 200 feet** in length shall have name and/or number appearing on both bow and stern, in lettering 12" high and 2" thick. Above this shall be the caption "U S NAVAL SHIP" in lettering 9" high and 1-1/4" thick. At both bow and stern, this caption shall be spaced 12" above the name.

(d) **Draft marks:** All ships shall have draft marks both the port and starboard at the bow, midships and stern. All numbers shall be Arabic numerals, precisely 6" high and spaced 6" vertically. The bottom of the number shall coincide with the draft it represents. These marks should extend 3 feet above the boot topping at the bow and stern, and 6 feet above the boot topping amidships. Numbers above the boot topping shall be black; numbers within and below the boot topping shall be white. All marks shall extend in a vertical line perpendicular to the baseline (bow marks shall not follow rake of the stem).

(e) **Projection marks:** Where a sonar dome or some other obstacle projects more than 6" below the keel, a separate set of Arabic numeral draft marks shall be applied to the

hull both port and starboard, representing the draft from the bottom of the projection. These marks shall continue 5 feet above the boot topping, and 6” above the uppermost mark should be lettered “PROJ.” Where two projections are less than 10% of the ship’s length-between-perpendiculars (LBP) apart, only the deeper projection need be marked.

(f) **Load line and Plimsoll markings:** These markings are determined by the American Bureau of Shipping and shall not be changed unless a new Load Line certificate is issued. Markings shall be white.

(g) **IMO Ship Identification Number:** The IMO Ship Identification Number shall be located on the stern of the vessel under the vessel’s name. The number is to be preceded by the letters “IMO”. The letters and numbers are to be 200 millimeters in height and proportionate in width. Center punching or weld beading shall outline each letter and number such that they cannot be easily expunged. The letters and number shall be painted black within the outline.

(h) **Name boards:** All MSC ships shall be equipped with teak or varnished name boards, engraved with the name of the ship only. Lettering shall be 12” high and 1-7/8” nominal thickness (except where the name would require boards of excessive length). Lettering and border shall be trimmed with gold.

(i) **Awards:** The Chief of Naval Operations has approved participation of MSC ships in the CNO Surface Ship Safety Awards program. Each winner is authorized to display a green “S” (for safety) marking on the bridge bulwarks (port & starboard). Letters shall be Green, measure 15” x 12”, of standard Navy block shape and shading.

6.21 Damage Control Lockers

Distinctive markings of damage control (DC) lockers and equipment stowed therein are considered necessary to provide ready identification, and to avoid misplacement or misuse of equipment. Therefore, in order that the identifying paint markings for all DC lockers and equipment in MSC ships will be standardized, the following markings shall be used:

(a) The inner and outer sides of the door shall be International Orange with 3” black stencil lettering reading, “DAMAGE CONTROL LOCKER.” If there are two or more lockers onboard, each locker will be given one, two or more vertical black stripes, as appropriate, 1” wide, identifying the locker. Ships with only one DC locker shall omit this black stripe.

(b) The handles or other suitable parts of tools and other equipment stowed in any DC locker also shall be painted International Orange and, where practical, shall be marked with one, two, or more black bands, as appropriate, to identify the DC locker where it is stowed.

6.22 Decontamination Stations

(a) Weather doors to decontamination stations shall be Haze Gray. Door dogs shall be gloss Black. On the weather side of the door shall be 3" black letter stenciling **"DECONTAMINATION STATION ENTRANCE"**. On the interior side of the same door shall be stenciled **"EXIT TO WEATHER"**.

(b) Interior doors to decontamination stations shall be painted to match surrounding areas, with the stenciled captions **"DECONTAMINATION STATION ENTRANCE"** and **"EXIT TO INTERIOR."**

6.23 Anchors & Anchor Chains

Except as otherwise noted (Chapter 7, Section 7.3), anchors shall be painted to match freeboard hull color. MSC uses U.S. Navy markings for anchor chains (as opposed to merchant marine markings).

(a) Detachable links are painted red, white, or blue:

- Red at 15 fathoms;
- White at 30 fathoms;
- Blue at 45 fathoms;
- Red at 60 fathoms;
- White at 75 fathoms, and so on.

(b) Links on either side of the detachable link are painted white:

- (1) One white link each side at 15 fathoms;
- (2) Two white links each side at 30 fathoms;
- (3) Three white links each side at 45 fathoms, and so on.

(c) All links on the next-to-last shot are painted yellow.

(d) All links on the last shot are painted red.

(e) In addition to painted links, wire wraps or band-it material around stud links on either side of the detachable links may be used:

One turn of wire on first stud from each side of detachable link at 15 fathoms;
Two turns of wire on second stud from each side of detachable link at 30 fathoms;
Three turns of wire on third stud from each side of detachable link at 45 fathoms, and so on.

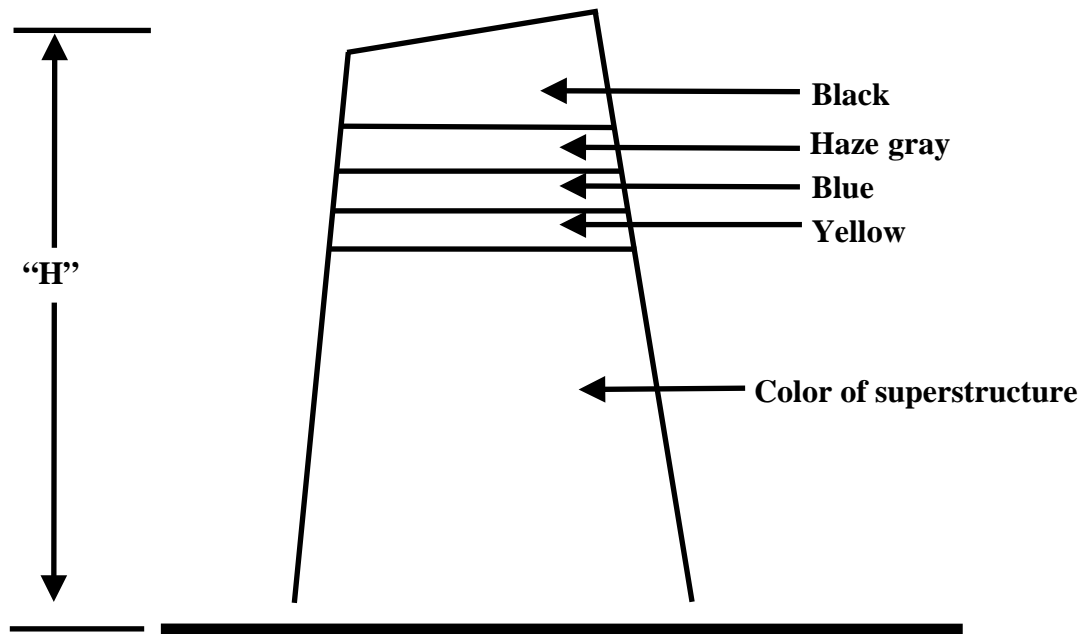


FIGURE 6-1: STACK MARKINGS

NOTES:

1. Bands shall be parallel to baseline, outlined by weld beads.
2. Black band shall be $2/15$ of "H" in height.
3. Other color bands shall each be $1/15$ of "H" in height.
4. Refer to Paragraph 6.14 for general discussion; refer to Chapter 7 for special MSC vessel discussion.

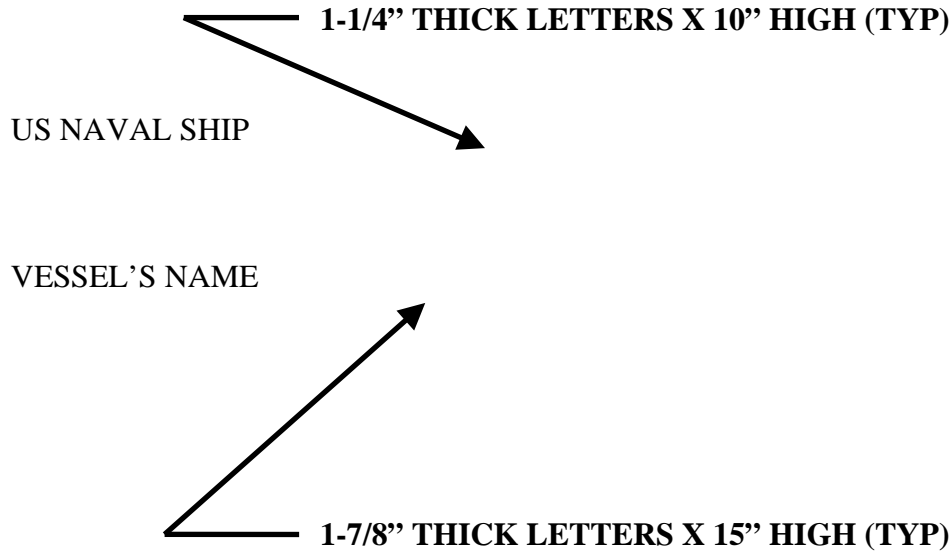


FIGURE 6-2: BOW & STERN MARKINGS

NOTES:

1. This sketch is representative of MSC vessels longer than 200 feet (refer to Paragraph 6.20 for shorter vessels)
2. All lettering shall be Black, outlined by weld beads.
3. Vertical separation "V" at bow shall be 6 inches, at stern 24 inches.
4. Typical starboard bow markings shown above (port side similar) Stern markings similar except cruiser sterns shall be marked on both port & starboard sides, fantail sterns shall be marked on centerline.
5. Naval Fleet Auxiliary ships shall have stern markings as above (stern centerline only), but only Navy numbers on each side of bow.

**TABLE 6-3
PIPING COLOR CODES**

Fluid	Valve Hand Wheel and Operating Lever	FED STD 595 Color Number	Interior Pipe Lines*
Steam and Steam Drains	White	17886	A and B
Potable Water	Dark Blue	15044	A and B
Nitrogen	Light Gray	16376	A
HIP Air	Dark Gray	16081	A
LP Air	Tan	10324	A
De-ballast Air	Striped Tan/Black	10324/17038	B
Oxygen	Light Green	14449	Light Green
Seawater (other than fire main, sprinkling, and washdown)	Dark Green	14062	A and B
JP-5	Purple	17141	Purple
Fuel Oil	Yellow	13538	A and B
Lube Oil	(Striped Black) Yellow	17038/13538	A
Fire Plugs	Red	11105	A and C
Foam Discharge Plugs (AFFF)	Striped Red/Green	11105/14062	A
Gasoline	Yellow	13538	Yellow
Feedwater (includes condensate)	Light Blue	15200	A and B
Hydraulic	Orange	12246	A
Freon (refrigerant)	Dark Purple	17100	A
Sewage	Gold	17043	A and Note 6
Halon	Striped Gray/White	16187/17886	B
Fire Main (including root valves)	Red	11105	A and B
Chilled Water	Striped Light Blue/Dark Green	15200/14062	A and B
De-mineralized. Electronic Cooling Water	Striped Light Blue/Dark Purple	15200/17100	B
AFFF Concentrate	Striped Light Blue/Red	15200/11105	B
Jacket Water/Waste Heat	Striped Light Blue/Black	15200/17038	B
AFFF Solution (concentrate and S.W.)	Striped Red/Dark Green	11105/14062	B
Carbon Dioxide (CO ₂)	Red	11105	Red

**PIPING COLOR CODES
(CONTINUED)**

SYMBOLS LIST:

A - To avoid conflict between dockside shore connections and shipboard shore connections for the same system, no color-coding of shore connection valve hand wheels, but label plates or plain language markings shall clearly delineate the service for each connection.

B - No color-coding.

C - Plug body shall be color-coded.

* - Applies to valves on weather decks and interior piping only¹.

GENERAL NOTES:

1. Valve hand wheels and operating levers in interior locations may be painted with commercially available alkyd paint, where surface temperature does not exceed 180°F, but should not be applied to hand wheels or levers where they are located in tanks.
2. Exterior valve hand wheels and operating levers should be coated with polyurethane coatings to match the surrounding system. Transfer vessels or new vessels delivered with an alkyd system on the exterior may use alkyds for hand wheels and operating levers until the exterior system is converted to polyurethane.
3. If necessary, thin the coatings or clean equipment using the appropriate paint thinner for the coating.
4. Surface preparation and priming shall be as specified by the coating manufacturer.
5. Because of potential flammability and toxicity hazards, especially in confined interior spaces, safety precautions appropriate to the specific situation and as dictated by the applicable Material Safety Data Sheet shall be taken.
6. The only known manufacturer for the gold paint is/was:
Far West Paint Co.
4522 South 133rd Street
Tukwila, Washington 98168
(206) 944-8844
7. CO₂ piping shall additionally be stenciled "CO₂" with white paint and shall have white arrows indicating direction of flow.
8. Halon piping shall be stenciled "HALON" and shall have arrows indicating direction of flow.
9. Interior fire main piping shall be stenciled "FIREMAIN" in red and shall have arrows indicating direction of flow.

¹ Taken from NSTM Chapter 505, Piping Systems

CHAPTER 7 SPECIAL MSC SHIPS

7.1 Introduction

Some ships within the MSC fleet are exempted from the normal exterior paint colors. Hospital ships (T-AH class), special mission ships, transport tankers (T-AOT class), and certain other ships when requested by the sponsor. This chapter addresses the specific changes for these vessels; all other markings and colors shall be in accordance with Chapter 6. Where contracted commercial operators maintain certain MSC ships, the paint and coating provisions of that contract shall supersede the requirements of this chapter wherever a conflict of instructions occurs.

7.2 Hospital Ships

USNS hospital ships shall conform to all appropriate Geneva Convention requirements. The color schemes discussed below conform to the Convention.

(a) Hospital ship red crosses shall have widths approximately equal to their heights, with the width of the arms approximately 1/3 the height of the cross. All crosses shall be outlined with welding bead and painted gloss Red (Fed Std Color 11105).

NOTE: In order to improve the infrared signature of the crosses, each cross shall first be painted with one coat of black paint, over which the red topcoat shall be applied.

(b) All exterior vertical and horizontal surfaces above the waterline shall be White except as discussed below. This includes deckhouses, decks, stacks, booms, davits, masts, lifeboat exteriors, etcetera.

(c) The stack shall be White with the normal black, gray, blue and yellow MSC color bands (per Section 6.14). Additionally, there shall be four red crosses, as large as practical, on the stack. These crosses shall be positioned so that at least one is visible when viewed from any side of the ship.

(d) Helo decks shall be painted and marked in accordance with Naval Air Engineering Center (NAEC) requirements.

(e) All hospital ships over 450' long shall have their name appear on both bow and stern, in black lettering 20" high and 1-7/8" nominal thickness. Above the name shall be the caption "U S NAVAL HOSPITAL SHIP" in lettering 16" high and 1-1/4" nominal thickness. This caption shall be spaced 6" above the name at the bow and 24" above the name at the stern. All lettering shall be outlined with welding bead.

(f) There shall be three red crosses on each side of the hull. The centers of the crosses shall all be at the same height above the load line. The height of the crosses shall be

approximately 9/10 of the freeboard. The forward cross shall be located in the vicinity of the stem to enhance its visibility when the ship is seen from dead ahead. The center cross shall be located abaft the bridge. The after cross shall be located approximately one-half the distance between the center cross and stern.

(g) There shall be one red cross, as large as practical, on the forward vertical surface of the superstructure, located for maximum visibility when the ship is viewed form dead ahead.

(h) There shall be red crosses, preferably 34 x 34 feet, on top of the superstructure deck fore and aft, located for maximum visibility from the air.

(i) Lifeboat exteriors shall be white with the normal black markings (refer to Chapter 6, Section 6.14). Additionally, there shall be red crosses, 15 x 15 inches, on each side of bow and stern. Interiors shall be in accordance with the normal requirements for lifeboats.

7.3 Special Mission Ships

Special Mission Ships shall be painted using MSC approved coating systems as follows:

(a) The following structures shall be painted white:

- (1) Hull, from boot topping to bulwark rail
- (2) Inboard side of bulwark
- (3) All exterior vertical surfaces
- (4) Masts and booms
- (5) Antenna and platforms
- (6) Stack (below MSC color bands)
- (7) Davits and lifeboat exteriors
- (8) Vent cowls, interior and exterior
- (9) Crosstrees and mast extensions

(b) The following structures shall be painted gloss Black (Fed Std Color 17038):

- (1) Anchors and chains
- (2) Bitts, chocks, and rollers
- (3) Door dogs
- (4) Mast tops and boom tips (6') on booms aft of stack

(c) The following structures shall be painted Dark Gray (Fed Std Color 26081):

- (1) All decks, and exposed horizontal surfaces
- (2) All deck machinery

7.4 Tankers (T-AOT Class)

- (a) **Underwater hull** shall be an MSC-approved ablative anti-fouling system.
- (b) **Boot Topping** shall be an MSC-approved ablative anti-fouling, black.
- (c) **Hull (deep load line to railing)** to be painted gloss Black (Fed Std Color 17038)
- (d) **Stacks (below color bands)** to be painted Haze Gray (Fed Std Color 26270).
- (e) **Cargo-handling valves** shall be color-coded per cargo system (using red, blue, green, tan, and orange paints).
- (f) To be painted White:
 - (1) Superstructure
 - (2) Deckhouses, msthouses
 - (3) Other exterior vertical surfaces, etcetera
 - (4) Aprons (above railing level)
 - (5) Railings
 - (6) Masts, booms, kingposts
 - (7) Expansion trunks
 - (8) Valve stands
 - (9) Lifeboats, davits
 - (10) Deck
tripping hazards
 - (11) Draft
marks
- (g) To be painted Dark Gray (Fed Std Color 26081):
 - (1) Decks
 - (2) Catwalks
 - (3) Manifolds (except valve wheels to be color coded)
- (h) To be painted gloss Black (Fed Std Color 17038):
 - (1) Winches, windless
 - (2) Anchors, chains
 - (3) Bitts, chocks, rollers
 - (4) Door dogs

CHAPTER 8 INTERIOR SPACES AND COLOR SCHEMES

8.1 Introduction

This chapter addresses paint and color schemes for those spaces not called out in Chapter 6. Where contracted commercial operators maintain certain MSC ships, the paint and coating provisions of that contract shall supersede the requirements of this chapter wherever a conflict of instructions occurs.

In general, the interior areas aboard ship fall into two categories: work spaces (such as offices, workshops, duty stations, etcetera), and living spaces (such as quarters, lounges, recreational areas, etcetera). COMSCINST 9330.6 and N0720-100.00-P provides direction on outfitting interior spaces with respect to deck tiles, carpets, bulkhead and joiner colors, and furnishings. This chapter is intended to supplement that instruction.

8.2 Work Spaces

Unless otherwise authorized by COMSCINST 9330.6, all work areas shall be painted in accordance with the color schemes listed in N0720-100.00-P .

8.3 Living Spaces

Unless otherwise authorized by COMSCINST 9330.6, these areas shall be painted in accordance with the color schemes listed in N0720-100.00-P. However, in those spaces generally used for relaxation and recreation by the crew, the pastel colors may be coordinated with the overall decor of the space.

NOTES:

1. Decks covered with magnesite, tile, quarry tile, or other similar materials shall be maintained in accordance with NAVSEA S9086-VG-STM-010/CH-634. One listed cleaner is General Purpose Detergent (NSN 7930-00-249-8036).
2. Wherever deck paint is used, a 6” dado (mopping band) should be carried up the adjacent bulkheads.

APPENDIX I DECK COVERINGS

This Appendix provides the furnishing requirements for the ship. Item numbers in the furnishing tables serve as the legend for the respective notional space arrangements.

II. Deck Coverings.

Deck coverings shall be provided in accordance with Table I-1 and Table I-2.

Table I-1: Deck Coverings

Space	Acceptable types (See Table I-2: Legend for Deck Coverings)
Administrative spaces	3
Bath/T&S (Non-Prefab Units)	5 or 6
Bridge Wings, exterior weather	1 with 11 or 13
Deck Head	5 or 6
Electronics spaces	1
Elevator, passenger	3 or 4
EOS	3 or 4 (with 8 A/R)
Fan Rooms	1
Galley & Scullery	5, 6, or 7 (with 9 A/R)
Gymnasium	3 or 4
Ladders, exterior	9 A/R
Laundries and Engineer's Change Room	5 or 12
Lockers, Cleaning Gear	5 or 12
Lounges	3
Medical Facility	5, 6, or 12
Messrooms	
Passageways, general	3 or 4
Passageways, provision stores	5 or 6
Pilot House	3 or 4 (with 8 A/R)
Quarterdeck Stations	3, 4, or 5

Space	Acceptable types (See Table I-2: Legend for Deck Coverings)
Refrigerated spaces	6 (with 10 or 11 A/R)
Solid Waste Processing Facility	5, 6, or 12
Stairs & Stairtowers, interior	3 or 4 (with 9 A/R)
Staterooms, general	3
Staterooms, Senior Licensed	2 or 3
Storerooms, not specified otherwise	1 (with 10 or 11 A/R)
Vestibules	5, 6, or 12
Workshops and Laboratories	1 (with 8 and 9 A/R)
Control Rooms (Mission Control, ROV and Plow Control, UUV Control)	3 or 4 (with 8 A/R)

Table I-2: Legend for Deck Coverings

Legend for deck covering	
1	Paint
2	Carpet
3	Resilient tile and plank flooring (Note 1)
4	Rubber tile
5	Epoxy resin terrazzo or epoxy resin vinyl chip
6	Latex mastic
7	Quarry tile
8	Electrical grade rubber mat (Note 2)
9	Slip-resistant deck pads (Note 3)
10	Grating, aluminum, removable
11	Grating, fiberglass, removable
12	Polyurethane (PRC)
13	Perforated rubber tile

Notes:

1. Resilient tile and plank flooring shall comply with ASTM F1700, IMO Standards, and be USCG Type Approved. Resilient tile and plank flooring shall pass IMO FTP Code Flammability/ Smoke/ Toxicity Standards, gauge to be a minimum 2 mm across the complete range with wear layer thickness 0.66 mm.

2. Electrical grade sheet and mat for equipment up to 3000 Volts shall be in accordance with NAVSEA S9086-VG-STM-010/CH-634. Electrical grade sheet and mat for equipment over 3000 Volts shall be in accordance with ASTM D178, Type II, Class II.
3. Slip-resistant deck pads shall have mineral coated abrasive surfaces. Slip resistant deck pads shall be glued to surfaces. Slip resistant deck pads shall be provided as a minimum at the following locations, except where non-skid or gratings are provided:
 - a. Top and bottom of stairs and inclined ladders.
 - b. Each side of doors with sills greater than 100 mm.
 - c. Each side of doors to messrooms, galleys, sculleries, and sanitary spaces.
 - d. Outside doors to refrigerated spaces.