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MILITARY SPECIFICATION

CRANE, ROTATING SHIPBOARD

This specification is approved for use by the Naval Sea systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification defines the general characteristics and performance requirements of electro-mechanical, electro-hydraulic, and diesel powered rotating cranes acquired by the Navy for installation on ships and floating drydocks. These cranes handle ship equipment and weapons using fixed reach, variable reach, or extendible reach booms.

1.2 Classification. The shipboard cranes defined in this specification are classified according to three features: crane type, boom type, and drive system type as follows:

Crane type

K - Kingpost
P - Pedestal
O - Portal
T - Traveling

Boom type

F - Fixed reach (new-topping)
V - Variable reach (topping)
E - Extendible (telescopic)

Drive system type

EM - Electro-mechanical
EH - Electro-hydraulic
DE - Diesel-electric
DH - Diesel-hydraulic

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications. standards. and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

RR-W-410 - Wire Rope and Strand.
TT-E-490 - Enamel, Silicone Alkyd Copolymer, Semigloss (For Exterior and Interior Non-Residential Use).

MILITARY

MIL-P-116	Preservation, Methods of.
MIL-S-901	Shock Tests H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for.
MIL-E-917	Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-M-3184	Machinery: Deck and Vehicle Mounted with Associated Equipment and Provisioned (Repair Parts) Items; Packaging of.
MIL-L-17331	Lubricating Oil, Steam Turbine and Gear, Moderate Service.
MIL-H-17672	Hydraulic Fluid, Petroleum, Inhibited.
MIL-P-17869	Pumps and Motors, Power, Oil Hydraulic (Naval Shipboard Use).
MIL-G-18458	Grease, Wire Rope and Exposed Gear.
MIL-E-24091	Extinguisher, Fire, Portable, Potassium Bicarbonate, Dry Chemical, Cartridge-Operated Type.
MIL-G-24139	Grease, Multipurpose e, Water Resistant.
MIL-F-24402	Filters, (Hydraulic), Filter Elements (High Efficiency), and Filter Differential Pressure Indicators, 'General Specification for.
MIL-P-24441	Paint, Epoxy-Polyamide, General Specification for.
DOD-G-24508	Grease, High Performance, Multipurpose. (Metric)
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for.
DOD-P-24648	Primer Coating, Zinc Dust Pigmented for Exterior Steel Surfaces. (Metric)

MILITARY (Continued)

MIL-V-24695 - Valve, and Hose Assembly, Vent and Test Hydraulic Service General Specification for. (Metric)
MIL-V-24695\1 - Valve, Vent and Test Hydraulic Service.
MIL-S-24711 - Switch, Proximity, Solid-State.
MIL-I-45208 - Inspection System Requirements.
MIL-B-81934 - Bearings, Sleeve, Plain and Flanged, Self-Lubricating, General Specification for.
MIL-V-81940 - Valve, Sampling and Bleed, Hydraulic, Type II Systems.
MIL-R-83248 - Rubber Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant.

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-278 - Welding and Casting Standard.
MIL-STD-454 - Standard General Requirements for Electronic Equipment.
MIL-STD-882 - System Safety Program Requirements.
MIL-STD-1310 - Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.
MIL-STD-1399 Section 300 - Interface Standard for Shipboard Systems Section 300 Electric Power, Alternating Current. (Metric
MIL-STD-2193 - Hydraulic System Components, Ship. (Metric)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, BLDG. 4D,700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents. drawings. and Publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

S6430-AE-TED-010 - Piping Devices, flexible Hose Assemblies, Volume 1.
0900-LP-008-2010 - Instruction for Design and Care of Wire Rope Installations.

(Application for copies should be addressed to the Standardization Documents Order Desk, BLDG. 4D), 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

UNITED STATES COAST GUARD (USCG)

CG-259 - Electrical Engineering Regulations.

(Application for copies should be addressed to the Department of Transportation, U.S. Coast Guard, Washington, DC 20591.)

2.2 Non-Government Duplications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the isues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA (AIA)
NAS 1638 - Cleanliness Requirements of Parts Used in Hydraulic Systems.

(Application for copies should be addressed to the Aerospace Industries Association of America, Inc., 1250 Eye Street, NW, Washington, DC 20005.)

AMERICAN BUREAU OF SHIPPING (ABS)
Rules for Building and Classing Steel Vessels.

(Application for copies should be addressed to the American Bureau of Shipping, 45 eisenhower Drive, P.O. Box 910, Paramus, NJ 07653-0910.)

AMERICAN GEAR MANUFACTURER'S ASSOCIATION (AGMA)
390.03a - Gear Handbook Gear Classification, Materials and Measuring Methods for Bevel, Hypoid, Fine Pitch Wormgearing and Racks Only as Unassembled Gears.
2000 - Gear Classification and Inspection Handbook Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents).
2001 - Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth.
6010 - Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives.

(Application for copies should be addressed to the American Gear Manufacturer's Association, Inc., 1500 King Street, Suite 201, Alexandria, VA 22314.)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)
S 326 - Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

(Application for copies should be addressed to the American Institute of Steel Construction, 1 East Wacker Drive, Suite 3100, Chicago, XL 60601.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
11 - Load Ratings and Fatigue Life for Roller Bearings.
B16.5 - Pipe Flanges and Flanged Fittings. (DoD adopted)
B93.28 - Method for Calibration of Liquid Automatic Particle Counters Using "AC" Fine Test Dust.
S1.13 - Methods for Measurement of Sound Pressure Levels.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 48 - Standard Specification for Gray Iron Castings. (DoD adopted)
A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength. (DoD adopted)
A 325 - Standard Specification for High-Strength Bolts for Structural Steel Joints. (DoD adopted)
A 370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products. (DoD adopted)
A 439 - Standard Specification for Austenitic Ductile Iron Castings.
A 490 - Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength. (DoD adopted)
A 673 - Standard Specification for Sampling Procedure for Impact Testing of Structural Steel. (DoD adopted)
B 584 - Standard Specification for Copper Alloy Sand Castings For General Applications.
D 3961 - Standard Test Method for Trace Quantities of Sulfur in Liquid Aromatic Hydrocarbons by Oxidative Microcoulometry.
E 208 - Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels.
F 1166 - Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities.

(Application for copies should be addressed to the American Society for Testig and Materials, 1916 Race Street, Philadelphia, PA 19103.)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

45 - Recommended Practice for Electric Installations on Shipboard.
444 - Standard Practices and Requirements for Thyristor Converters for Motor Drives.

(Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, Inc. , 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ICS 2 - Industrial Control Devices, Controllers and Assemblies. (DoD adopted)
W C 3 - Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy.
250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

(Application for copies should be addressed to the National Electrical Manufacturers Association, 2101 L Street NW, Suite 300, Washington, DC 20037.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

ARP 598 - Determination of Particulate Contamination in Liquids by the Particle Count Method. (DoD adopted)
J 514 - Hydraulic Tube Fittings. (DoD adopted)
J 534 - Lubrication Fittings. (DoD adopted)
J 744 - Hydraulic Pump and Motor Mounting and Drive Dimensions.

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

STEEL STRUCTURES PAINTING COUNCIL (SSPC)
SP 10 - Near-White Blast Cleaning.

(Application for copies should be addressed to the Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, PA 15213.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General crane requirements. The crane shall be complete in every respect, including all operating controls and equipment necessary for safe and reliable operation (see 6.3 and 6.5). Its fabrication and assembly shall reflect an optimum balance of simplicity, reliability, maintainability, minimum size and weight, and minimum life cycle cost in relation to requirements specified herein. Similar parts and repair parts built to the same drawings shall be fully interchangeable. Crane electrical equipment, except for diesel-electric cranes (see 3.10), shall operate from the shipboard power of 440 volts, 60 Hertz (Hz), 3-phase, 3-wire, ungrounded, type 1 power complying with steady-state and transient characteristics and ranges in accordance with MIL-STD-1399, section 300. Equipment shall demonstrate compliance with all requirements and shall successfully complete the tests specified in section 4. Special tools (see 6.6(q)) required for maintenance shall be provided (one set for each crane), including stowage provision.

3.1.1 Capabilities. The crane shall hoist, top, rotate, travel (if applicable), and extend the boom (if applicable). It shall provide stepless control for any load from zero to full load. It shall be capable of simultaneously providing any two of these motions with rated load at rated speed. A float mode operation for each drive (see 6.6(j)) shall be provided to release the brake and to move the load at minimum speed in either direction of motion (see 3.7.1). If an auxiliary hoist is required (see 6.2), a selector switch shall be provided to select main or auxiliary hoist operation through a single hoist master switch . For every motion of the crane, the speed shall be variable from minimum to maximum in either direction. The crane shall be provided with interlocks, safety devices, and protective devices so that it will have fail-safe operation (see 6.6(i)). Failure of the operating power source or power-operated drive mechanism shall not jeopardize the safety of the personnel or the load being handled.

3.1.2 Standard crane speeds. The standard speeds (without load float engaged) used in shipboard crane motions shall be as listed in table I unless otherwise specified (see 6.2); minimum operating speeds shall be 5 percent of the rated speeds. The speed of operation will remain constant throughout the load range of zero to full load for a particular position of any master switch. Specified speeds shall be achieved within plus or minus 5 percent.

TABLE I. Standardized speed of shipboard crane motions.

Crane function	Standard speed
Main hoist speed	
(cranes rated at more than 75,000 lb)	1 to 20 ft/min
(cranes rated at 75,000 lb or less)	2 to 40 ft/min
Auxiliary hoist speed (if applicable)	5 to 100 ft/min
Topping speed	1.5 to 30 degrees/min
Rotation speed	
(cranes rated at 20,000 lb and over)	9 to 180 degrees/min
(cranes rated at less than 20,000 lb)	18 to 360 degrees/min
Travel speed (if applicable)	50 to 100 ft/min

3.1.3 Crane derating relationship. The main hoist shall lift a reduced rated load capacity when operating beyond its rated reach. Unless otherwise specified (see 6.2), the contractor shall determine the load capacity at maximum reach . For non-extendible boom kingpost and pedestal cranes, the rated reach shall be achieved with the boom topping angle at 30 degrees above horizontal and maximum reach shall be with the boom horizontal. Load capacity shall decrease linearly between rated and maximum reach. In no case shall a derated loading condition govern the design of the crane. For all cranes, auxiliary hoists shall be fully rated for any reach capable by the boom.

3.1.4 Weight and stability. The crane's weight shall be kept to a minimum consistent with the design requirements. It shall be not greater than that specified (see 6.2) when the crane is ready for operation. On traveling-type cranes, stability shall be examined under normal (see 3.2.6.1), maximum (see 3.2.6.2), and stowed conditions (see 3.2.6.3). The crane shall be constructed to ensure stability against tipping, with a minimum margin of safety of 10 percent.

3.1.5 Environmental interface.

3.1.5.1 Service life. The crane shall have a service life of 20,000 operating hours (approximately 20 years) and shall operate over a period of 5,000 hours (approximately 5 years) before overhaul or major repair is needed.

3.1.5.2 Temperatures. Equipment shall operate normally in ambinet temperatures ranging from a minimum of 0 degrees Fahrenheit (°F) to a maximum of 120°F.

3.1.5.3 Shock. If specified (see 6.2), the crane shall withstand shock in accordance with MIL-S-901 when in the unloaded and stowed position.

3.1.5.4 Airborne noise. The. maximum airborne noise produced by the crane while hoisting its rated load shall not exceed the value listed in table II. The crane shall meet either the A-weighted or Preferred Speech Interference Level (PSIL) criteria for both the interior and exterior locations (see 4.5.5).

TABLE II. Crane noise criteria. 1/

Measurement location	A-Weighted sound-level, dB(A)	PSIL dB
Interior and exterior	80	72

1/ The PSIL is the arithmetic average of the measured sound pressure levels in decibels (dB) in the 500, 1000, and 2000 Hz octave bands.

3.1.5.5 Vibration. The crane shall meet the requirements of MIL-STD-167-1 for type I vibrations (non-rotating equipment) when in the stowed position and for type II vibrations (rotating equipment) when in the operating condition. Tests will not be required unless they are requested by specific equipment military specification.

3.1.6 First article. When specified (see 6.2), a sample shall be subjected to first article inspection (see 6.12) in accordance with 4.2.1.

3.2 General desire criteria. The crane shall be designed to operate safely and reliably while being subjected to all stress imposed on members and components as specified herein. Materials to be employed in the manufacture and fabrication of the crane structure and its components shall comply with the requirements as specified herein.

3.2.1 Safety criteria and considerations. Equipment construction shall include, but not be limited to, the following:

(a) Avoid or eliminate identified hazards by design selection or material selection.
(b) Control and minimize hazards to personnel and equipment which cannot be avoided or eliminated.
(c) Isolate hazardous substances, parts, and operations from other activities, areas, personnel, and incompatible materials.
(d) Incorporate fail-safe principles where failures would result in injury to personnel or damage to equipment.
(e) Locate equipment parts so that access to them by personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as chemical bums, electrical shock, cutting edges, sharp points, or toxic atmospheres.
(f) Provide warning and caution notes in operations, assembly, maintenance, and repair instructions.
(g) Include specific warnings of hazards on the equipment.

3.2.2 Failure mode, effects, and criticality analysis (FMECA). An FMECA shall be performed for critical items (see 6.3 and 6.7).

3.2.2.1 Hazard analysis. The contractor shall conduct a system hazard analysis and operating hazard analysis (see 6.3). Safety hazards shall be resolved in "accordance with the precedence established by MIL-STD-882.

3.2.2.2 Data use. Engineering data, procedures, and instructions developed from the engineering design and the FMECA shall be used in support of the effort specified in 3.2.2.1.

3.2.3 Reliability and maintainability. The reliability of the crane shall be evaluated by performing a series of operational cycles as specified herein. The crane maintainability criteria shall be expressed in accordance with the requirements of ASTM F 1166.

3.2.3.1 Reliability demonstration. The crane shall be designed to complete a mission of 40 continuous crane operational cycles without failing (see 6.6(g) and 4.5.4). In the event of any equipment failure, the crane shall be repaired by the contractor and tested for 40 continuous operational cycles. An operational cycle shall include the following:

(a) Hoisting the rated load from full-down to full-up position with the boom at rated reach.
(b) Topping the boom through half of its arc.
(c) Rotating the crane through half of its rotational arc.
(d) Traveling half of the crane's traveling distance (for traveling cranes).
(e) Lowering the load to the full-down position.
(f) Pausing for 5 minutes (brake set).
(g) Returning to the original position by reversing the above cycle with rated load on the hook.
(h) If applicable, fully extending and retracting the boom with the maximum extended rated load suspended from the hook.

Operations listed above shall be run at rated speed. At some intermediate point in each crane motion, the drive shall be slowed down, stopped, and the load floated for a minimum of 10 seconds. The motion will then be continued to the specified end of travel. If the crane has an extendable boom, half of the reliability demonstration shall be run with the boom fully retracted and half with the boom fully extended.

3.2.3.2 Maintainability. The design concept for maintainability shall be expressed in terms of replacing complete assemblies and subassemblies with a minimum disassembly of parts (see 6.3). Subassembly interfaces shall be keyed, wherever necessary and practicable, to help prevent misalignment and incorrect installation. The crane shall have a probability of 95 percent that no fault correction time (nonscheduled) shall not exceed 18 hours, 75 percent that no fault correction time shall not exceed 6 hours, and 50 percent that no fault correction time shall not exceed 1 hour. The time for maintenance shall not include administrative and supply time.

3.2.4 Special tools. The crane design shall minimize the need for special tools (see 6.6(q)) for operation and maintenance. Special tools shall be marked to identify the service for which they are intended.

3.2.5 Component parts requirements. The general requirements for component parts used in the crane design shall be as specified in 3.2.5.1 and 3.2.5.2.

3.2.5.1 Identification Plates. Component parts which will be shipped by the contractor in an unassembled state shall be provided with identification plates so that they may be identified as part of the unit. Identification plates shall be made of non-corrosive material and engraved or embossed with identifying numbers and letters. The identity of each part shall be the same identity as called out on the general arrangement and installation drawings.

3.2.5.2 Interim spare parts. Interim spare parts shall be provided as specified in 6.8.2.

3.2.6 Desire condition. The crane shall withstand loads imposed under normal, maximum, and stowed conditions. The magnitude of the load effects shall be as specified in 3.2.6.1 through 3.2.6.3. Stresses shall be calculated for each structural member and machinery component that is critical or in a load-bearing path.

3.2.6.1 Normal condition. Normal crane operating conditions include operations conducted at the crane's rated and minimum reach with its rated load as specified, and operations conducted at its extended reach with a derated load as determined in 3.1.3. To determine the maximum stress in the various structural and machinery components, the following effects shall be combined:

(a) Rated hook load and derated hook load at various reaches.
(b) Dead load.
(c) Wind load while operating (5 pounds per square foot (lb/ft^2)) (see 6.2).
(d) Loads due to list and trim (see 6.2).
(e) Loads due to acceleration from roll and pitch (see 6.2).
(f) Loads due to acceleration from dynamic motions of the crane.

3.2.6.2 Maximum condition. For the maximum condition, the greater load of the following shall be used to determine the maximum stress in each structural and machinery component:

(a) Load due to stall torque of electric motor or due to the maximum hydraulic system pressure (if applicable).
(b) Load due to an emergency stop condition with rated load on the hook traveling at rated speed in any drive combination.
(c) Load due to a 200 percent static test.

3.2.6.3 Stowed condition. For the stowed condition, the following effects shall be combined to determine the maximum stress:

(a) Dead load.
(b) Wind load (30 lb/ft^2) (see 6.2).

(c) Ice load (7 lb/ft^2) (see 6.2).
(d) Loads due to acceleration from ship motions (see 6.2).
(e) Loads due to shock (see MIL-S-901) if specified (see 6.2).

3.2.7 Permissible stresses. Structural and machinery components shall be analyzed considering bending, tension, compression, shear, buckling, and torsion. Design loads shall be obtained by combining the maximum forces acting on the members under consideration. Wind loads shall be assumed to act in the direction that creates maximum stress. Stresses shall be combined vectorally for each design condition to obtain the maximum principal stress. Structural components shall be designed to meet the requirements of AISC S 326, except as noted in 3.2.7.1.

3.2.7.1 Ductile materials. Allowable stresses for ductile materials (see 3.2.8.2) in machinery applications are listed in table III. Values are listed in percent of the tensile yield point. Allowable stresses for structural applications shall be 85 percent of those listed in AISC S 326.

TABLE III. Allowable stresses for machinery components (percent of tensile yield point).

Stress type	Design conditions		
	Stowed	Normal	Maximum
Direct shear	21	21	42
Torsion	23	23	46
Bearing	56	56	112
Combined stresses	35	35	70

3.2.7.2 Welding requirements. Weld joints and allowable stresses shall be in accordance with MIL-STD-278 and the requirements specified in 3.2.8.8 (see appendix C). In no case shall the allowable weld stress exceed the allowable stress in the base material.

3.2.7.3 Brittle materials. Brittle materials shall conform to material requirements (see 3.2.8.3) and may only be used for machinery components. Allowable stresses shall not exceed values specified in table III.

3.2.7.4 Bolt stresses. Bolted joints shall be in accordance with AISC S 326 using ASTM A 325 and ASTM A 490 bolts except that the allowable stresses shall be reduced to 85 percent of the allowable stresses listed in the specification. Secondary connections, such as handrails and limit switches, may be designed using ASTM A 307 bolts in accordance with AISC S 326.

3.2.7.5 Crane rail contact stress (if amicable). In the maximum condition (see 3.2.6.2), the wheel load shall not exceed the following requirement:

$$P = \frac{\nabla\gamma - 13{,}000}{20{,}000} \times 600 \times d \times w \qquad \text{for } d \leq 25"$$

$$P = \frac{\nabla\gamma - 13{,}000}{20{,}000} \times 3000 \times \sqrt{d} \times w \qquad \text{for } 25" < d < 125"$$

Where: P = maximum wheel load (lbs)
$\nabla\gamma$ = crane rail tensile yield point (psi)
d = crane wheel diameter (in)
w = width of rail head or width of crane wheel, whichever is less (in)

3.2.8 Materials. Materials shall be for use in locations exposed to the weather, including salt spray and seawater. They shall be free from any defects and imperfections that might affect the serviceability of the finished product. Materials shall conform to the requirements specified herein. Those materials not definitely specified herein shall be of a quality to meet the requirements specified herein and shall be selected in the order of preference specified in 3.2.8.1.

3.2.8.1 Preferred material reference. Where materials of identical or equal quality can be identified by more than one specification or standard, drawings shall reference only one such source. In selecting the specification or standard to be referenced for material not specified herein, the following shall be the order of precedence:

(a) Industry and technical society specification or standard.
(b) Federal specification.
(c) Military specification.
(d) Manufacturer's specification or standard.

Foreign industrial and technical society specifications that comply with the requirements of specifications stated herein shall be acceptable if approved by the contracting activity.

3.2.8.2 Ductile materials. The crane shall be fabricated using structural carbon steels as specified herein except where higher strength steels are required to reduce weight.

3.2.8.2.1 Steel. Steel for welded fabrication, including weld repair, shall be of a readily weldable grade or composition and shall have a maximum carbon content of 0.30 percent. Structural steels used in the crane for main load-carrying members, fracture of which would cause a catastrophic failure of the structure or machinery, shall be tested. Steels having a tensile strength greater than 80 kilopounds per square inch (klbs/in^2) shall be tested in accordance with ASTM E 208. These steels shall demonstrate a nil-ductility transition temperature of 0°F or below. Steels with a tensile strength less than or equal to 80 klbs/in shall be subjected to Charpy impact tests in accordance with ASTM A 370 and ASTM A 673. Energy absorption shall be 15 foot-pounds (ft-lbs) at 0°F.

3.2.8.2.2 Aluminum. Aluminum alloys, particularly cast aluminum, shall not be used for structural components. Hydraulic components using aluminum alloys shall be in compliance with MIL-STD-2193.

3.2.8.2.3 Magnesium. Magnesium and magnesium base alloys shall not be used.

3.2.8.3 Brittle material. Brittle material is defined as material showing less than 10 percent tensile elongation.

3.2.8.3.1 Cast iron. Cast iron in any form shall not be used in structural applications except where permitted by referenced specifications. In these instances, the material shall be limited to ASTM A 48, class 35, or classes of lower tensile strength. Cast nodular graphitic iron conforming to ASTM A 439-D2/D2C may be used for machinery equipment components.

3.2.8.4 Asbestos. Asbestos materials shall not be used in any part of the crane, nor in packaging materials.

3.2.8.5 Cadmium plating. Cadmium plating shall not be used on any part.

3.2.8.6 Recovered materials. Unless otherwise speciied herein, all equipment, material, and articles incoorporated in the crane covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.2.8.7 Corrosion resistance. Metals which are usually susceptible to corrosion attack in a seawater environment shall be processed (treated, plated, or painted) to provide corrosion resistance. To minimize corrosion attack due to electrolytic action between dissimilar metals in contact with each other, direct metal-to-metal contacts shall be limited to certain metals. These metals, when coupled, are designated by an open square, an open triangle, or an open triangle with a crossbar shown in the table entitled "Sea Water Corrosion of galvanic Couples", of MIL-E-917 under the following conditions:

(a) For combinations of metals subject to immersion, splashing, or spray from seawater, condition S, E, or L, as applicable shall apply.
(b) For combinations of metals exposed to atmosphere but not subject to immersion, splashing, or spray from seawater, condition E shall apply.

If a metal is coated or plated, the coating or plating metal rather than the base metal shall be considered. Metal-to-metal contact shall be considered to exist between mating parts that depend upon painting for corrosion resistance.

3.2.8.8 Fabrication. Crane machinery and structures shall be fabricated in accordance with MIL-STD-278 as specified for class M machinery.

3.2.8.9 Finish. Before assembly, the crane structure, machinery, and consoles shall be thoroughly cleaned and abrasive-blasted to near-white metal in accordance with SSPC SP-10. Steel parts, except for corrosion resistant steels and parts not to be painted as defined in MIL-E-917, shall be coated with an inorganic zinc primer conforming to DOD-P-24648, applied at 3 to 5 mils dry film thickness (dft). Mixing and curing shall be in accordance with the manufacturer's instructions. Prior to overcoating, residual deposits formed during curing shall be removed by high-pressure fresh water and scrubbing, or by the manufacturer's recommended cleaning procedure. A coat of formula 150 of MIL-P-24441, which has been thinned with one pint of thinner per gallon, shall be applied at a wet film thickness of 3 roils. This shall be followed by a full coat of formula 151 of MIL-P-24441, applied at 2 to 4 roils dft, and two coats of silicone alkyd enamel conforming to TT-E-490 (haze gray), applied at 1 to 2 roils dft per coat. The first coat of enamel shall be applied when the formula 151 is in the tack stage. When tested as specified in 4.5.7, the coating shall exhibit no cohesive or adhesive defects. Other metals that are not inherently corrosion resistant, as defined by MIL-E-917, shall be processed (treated, plated, or painted) in accordance with MIL-E-917 to provide corrosion resistance.

3.2.10 Power requirements. Power for the various crane motions at rated speeds shall be sufficient to meet the conditions specified in table IV. Power requirements shall be analyzed using appropriate factors which shall include, but not be limited to, the following:

(a) Antifriction bearing efficiency: 0.98 per pair of bearings.
(b) Gear efficiency: 0.98 - Herringbone and helical.
0.96 - Machine-cut spur.
0.80 - (Maximum) worm drives.

TABLE IV. Crane Power requirements.

When operating at rated speed	Motor load shall not exceed	Hoist power shall be based on	Topping, rotating, and traveling power shall be based on
W/rated load (no sea states)	Full load current rating (FLC)	b, c, d	b, c, d, e, f
Under normal conditions (w/sea states)	125 percent (FLC)	b, c, d, g, h	b, c, d, e, f, g, h, i
Under test 2/ conditions (dynamic see 4.5.3)	125 percent (FLC)	a, c, d	a, c, d, e, f

a - Test load 1/ d - Efficiency losses g - Load due to pitch
b - Rated load e - Load due to list h - Load due to roll
c - Dead load f - Load due to trim i - Wind load

See footnote at top of next page.

1/ 125 percent of rated load for cranes handling fleet ballistic missiles (FBM) (see 6.2) or intended for floating drydocks (see 6.2) and 150 percent of rated load for all other cranes.
2/ Obtaining rated speed is not required during dynamic testing.

3.3 Crane configuration. The major components of the crane include the structural components, accessories, drive system, limit systems, machinery house, and operator's cab. The tail swing of the crane (see 6.6(r)) shall not exceed the specified radius (see 6.2). The crane shall be configured to meet the specified reach (see 6.2) and the specified lift (see 6.2) requirements. The crane shall be designed to minimize the change in hook height caused by topping the boom with the hoist drive not operating. Crane components shall be designed to eliminate pockets in which water can stand or collect, shall be totally sealed, or shall provide for easy maintenance with access for painting the interiors. Drainage shall be provided to ensure that water will not be trapped.

3.3.1 Structural components. Structural components shall include, but not be Limited to, the following:

(a) Base structure (kingpost, pedestal, portal, or travel base) (see 6.6(c)).
(b) Boom structure.
(c) Rotating structure.
(d) Positive stop devices.
(e) Mast (see 6.6(l)) or A-frame (see 6.6(a)), unless topping cylinders are used (see 3.3.4(a)).
(f) Boom stowage support with hook and block stowage devices.
(g) Foundation rings (if applicable) to attach kingpost or pedestal to ship structure.
(h) Rails (if applicable) to attach portal or travel base to ship structure, unless existing rails are to be used for replacement cranes (see 6.2).
(i) Crane stowage tiedown and stormlocking equipment.

3.3.1.1 Base structure. Interface and envelope of kingpost or pedestal base (see 6.2), or width and height clearances of portal base (see 6.2) shall be as specified. The base shall be strong enough to support the design loads, bearings, rotating structure, and attachments. Forces transmitted to the deck shall include horizontal, vertical, and overturning moment (that is, fixed). On portal and traveling cranes, the base shall be secured to the rails or track by rollers (or hooks) which keep the base from tipping. Trucks shall be connected to the base structure through equalizing trunnions to ensure equal wheel loading. Bedplates, frames, pedestals, mountings, and all bearings for hoisting, topping, rotating, and (if applicable) traveling machinery shall be strong enough to maintain component alignment. Hold-down bolt spacing shall be not greater than 15 times the bolt diameter, and the flange thickness at these bolt holes shall be at least equal to the diameter of the bolts used. Provisions shall be made for locating dowels, body-bound bolts, or welded-down shear strips, to prevent machinery components from shifting or becoming misaligned on the bedplates. The plate forming the main frame and other primary structures shall be not less than 1/4 inch thick. Webs of rolled sections and other secondary members also shall be not less than 1/4 inch thick.

3.3.1.2 Boom structure. The boom may be constructed using tubular or structural shapes proportioned to provide the desired outreach and clearance. Plates in compression forming post or girder flanges, and plates in shear forming girder webs, shall have a width-to-thickness ratio not greater than 60.

3.3.1.3 Rotating structure. The rotating crane structure shall provide support for the rotating components of the crane, including the rigging, boom, and operator's cab. The rotating crane structure shall be supported by the base through antifriction bearings as specified in 3.4.3.1.

3.3.1.4 Positive stop devices. Energy absorbing devices shall be provided on the crane structure to stop motion in the event the crane exceeds the specified limits of travel (see 3.6). This mechanism shall absorb the anticipated force resulting from a rated load traveling at the rated speed and shall include a provision for buffering to limit deceleration so that damage to the crane is prevented.

3.3.1.4.1 Boom positive stop device. A positive stop device shall be provided to prevent topping the boom into the mast or A-frame (as applicable).

3.3.1.4.2 Rotation Positive stop device. Unless full, unrestricted rotation is specified (see 6.2), positive stop devices shall be located to ensure that the rotational limits of the crane as specified (see 6.2) are not exceeded.

3.3.1.4.3 Base travel positive stop device. On traveling type cranes, two safety bumpers shall be located at the ends of the base travel distance as specified (see 6.2) to prevent the crane from running off the rails (or tracks). Each safety bumper shall be equipped with shock absorbers capable of absorbing 70 percent of a shock load resulting from the fully loaded crane running into the bumpers at full speed.

3.3.1.5 Boom stowage support with hook and block stowage devices. Supports and other securing fittings shall be provided to positively secure the crane and boom in the stowed position. These fittings shall withstand the forces due to the stowed condition as specified in 3.2.6.3 and shall be designed to minimize changes in ships structure and shall not impede handling operations. Stow brackets for hoist blocks and hooks shall also be provided. On portal or traveling cranes, wheel chocks or stowage pins which permanently mount on the base shall be used to restrain the base in the stowed position. If stowage pins are used, the mating sockets shall be provided.

3.3.2 Machinery house and operator's cab. Lighting shall be provided in the machinery house and operator's cab for maintenance purposes. The lighting shall provide a minimum initial average of 14.0 footcandles of general illumination calculated for a horizontal plane 30 inches above the deck. Lights shall be controlled by switches mounted adjacent to each access door. Access doors shall be splashproof. The machinery house shall be provided with two double receptacles and the operator's cab with one double receptacle for supplying power for portable lights and power tools. Sound powered telephones and handcrank buzzers shall also be provided in the machinery house and operator's cab.

3.3.2.1 Machinery house requirements. The machinery house shall be splashproof and shall protect the machinery and control equipment. Mechanical ventilation, thermostatically controlled with an on-off override switch, shall be provided to dissipate heat generated by the crane machinery and equipment. Air filters used with forced-air cooling shall be corrosion resistant. For cranes having diesel engines or electro-hydraulic cranes, a small deck sump shall be provided in the machinery space to collect spilled fluids and used engine lubricating oil. The sump shall have a drain and closure valve for discharging fluids via gravity to drums on the deck of the ship or wingwall of the floating drydock. For cranes having diesel engines, exhaust shall be discharged through the roof of the machinery house, away from the operator's cab.

3.3.2.2 Operator cab requirements. A splashproof, insulated operator's cab, (operating station) with operator features designed in accordance with MIL-STD-1472, shall be provided as part of the rotating structure. The following shall also be provided:

(a) Handholds or steps to facilitate safe access to and exit from the cab for all crane operational and stowed positions.
(b) Access route to the operator's cab which is adequately lit for night operations, controlled from both operator's cab and from crane base.
(c) A second means of exiting the cab in case of emergency.
(d) Layout drawing of the operator's cab, showing controls and their location as well as arcs of vision, which permits the operator to observe all operations including stowing of the boom.
(e) An adjustable seat and footrest (for the operator) capable of being secured for the crane stowage condition.
(f) Heating and air conditioning to maintain the cab interior at a 68 ± 3°F temperature during cold weather and 78 ± 3°F temperature during warm weather.
(g) Safety-glass cab windows that are either tinted or equipped with shades.
(h) Windshield defrosters and motor-driven wipers with variable speed operation.
(i) Windows with an edge molding or gutter for roof water, which open in a manner that permits a minimum amount of rain and spray to enter, and have sturdy latches that prevent inadvertent closure.
(j) A ladder or step to provide access to the roof of the cab.

3.3.2.3 Fire extinguisher. The machinery house and operator's cab each shall be equipped with a-class 1, size 1 fire extinguisher in accordance with MIL-E-24091. It shall be mounted to a positive-locking quick-release bracket in an accessible position with the extinguisher nozzle protected from damage.

3.3.3 Accessory components. Plateforms, walkways, ladders, and handrails shall be provided where required for safety and for servicing and maintaining equipment. Adequate lighting shall be provided for safe operation at night.

3.3.3.1 Structural accessories. A catwalk around the base of the machinery house, maintenance platforms, walkways, and fixed and folding platforms shall be provided and shall have nonskid surfaces. Access doors, handrails, ladders, and climber safety rails or ladder cages shall be provided where required. Openings

to ladders and platforms shall have a single safety chain across their openings. Handrails shall be provided around the full periphery of the top of the machinery house. Walkways and handrails accessible from the rotating structure shall be provided the full length of the boom if the top chords of the boom are over 7 feet above the deck in the stowage position.

3.3.3.2 Working area floodlight. One adjustable 300-watt (minimum) sodium vapor or quartz halogen floodlight shall be provided on top of the operator's cab to illuminate the working area. The on-off switch and the joystick type control which adjusts the position of the working area floodlight shall be provided on the console (see 3.7.2.2(g)).

3.3.3.3 Boom tip floodlight. Two 400-watt (minimum) sodium vapor or quartz halogen floodlights shall be provided near the boom tip to illuminate the boom operating area. The on-off switch for the boom tip floodlights shall be provided on the console (see 3.7.2.2(h)).

3.3.3.4 Warning devices. The crane shall be equipped with a warning horn and an alarm bell (if applicable). Aircraft warning lights shall be installed if the crane is the highest point on the ship (see 6.2).

3.3.3.4.1 Warning horn. The crane shall have a warning horn that is manually activated by a switch on the console that is within easy reach of the operator (see 3.7.2.2(f)).

3.3.3.4.2 Alarm bell. The base or car of traveling cranes shall have an alarm bell that automatically sounds when the travel control lever is moved in either direction from the neutral position.

3.3.3.4.3 Aircraft warning lights. If applicable (see 6.2), two aircraft warning lights shall be provided near the highest point on the crane. Each shall consist of a 360-degree prismatic, Fresnel globe of red acrylic or Pyrex glass. The globe shall be mounted on a base that has an international orange finish. The lights shall operate from the ship's power (115 volts alternating current (Vat)) single-phase, 60 Hz) and shall be controlled from both the operator's cab (see 3.7.2.2(k)) and the crane base.

3.3.4 Drive system. Crane machinery used in the drive system shall include, but not be limited to, the following components:

(a) Hoisting and topping winches with wire-rope drums, gearboxes, motors and brakes, and couplings. Twin topping cylinders with counterbalance valves and pilot-operated check valves may be used in lieu of topping winches. Cylinders shall have heads that are removable. Piston rods shall be either steel that is chrome plated to a minimum thickness of 0.003 inch or 17-4 PH stainless steel. Cylinder assemblies shall incorporate piston rod scrapers for removing debris from the rods.

(b) Rotation (slewing) drive with bull gear, pinion gears, reduction gears, motors and brakes, and couplings. If two or more pinion gears are required (see 6.2), they shall be evenly spaced around the bull gear.

(c) Travel drive (for portal and traveling cranes) with racks and pinions if specified (see 6.2), reduction gears, motors and brakes, and couplings.
(d) Hydraulic power unit (HPU) (if applicable) consisting of one or more electric motors and multiple pumps.
(e) Diesel engine (if applicable) complete with alternator or generator, and (if applicable) multiple pumps.
(f) Limit systems, including limit switches and bumpers to control the hoisting, topping, rotating (unless full, unrestricted rotation is specified (see 6.2), and (if applicable) traveling operations of the crane.
(g) Guards to cover moving parts and protect personnel. Corrosion-resistant fasteners. shall be used for all removable covers.
(h) Identification plates and information plates.
(i) Mechanical and electrical devices; operating, centering, and control devices for the hoisting, topping, rotating, and (if applicable) traveling operations of the crane; indicators, bearings, stuffing boxes, brackets, shafts, levers, turnbuckles, and gears, as necessary. If full, unrestricted rotation is specified (see 6.2), a slip ring assembly and (if applicable) swivel valve shall be used to transmit power from the rotating portion of the crane to the base.
(j) Resistors, electrical indicators, and switches. Also, electrical wiring within and between the electrical units and safety devices.
(k) Cable reel (if applicable) to transmit power from the ship to the crane. Means such as level-wind mechanism shall be provided to ensure proper spooling of cable.

3.4 Detail component desire.

3.4.1 Parts. Parts shall be as light and compact as practicable, consistent with the required strength and stiffness. They shall be arranged to provide access for inspection, repairs, replacement, and lubrication. Parts subject to periodic maintenance shall be removable without dismantling adjacent parts. Lifting eyes shall be provided on all equipment components weighing over 75 pounds.

3.4.2 Gears.

3.4.2.1 Load capability. Load capability of the gearing shall be computed and rated in accordance with AGMA 2001 for open gearing and AGMA 6010 for enclosed gear drives. Open gears shall have a minimum quality 6 or better gear tolerance and enclosed gears shall have a minimum quality 7 or better gear tolerance in accordance with AGMA 390.03a and 2000, as applicable. Service factors of 1.0 for hoisting and topping drives, 1.25 for rotation drive, and 1.5 for travel drive (if applicable) shall be applied. Gear rating will be based on 10,000,000 cycles.

3.4.2.2 Slow-speed reductions. Slow-speed reduction, such as bull gears and their pinions, may be straight spur gears and may be of open construction. Open gears shall be furnished with removable covers to protect the machine components from accidental damage, such as that caused by a dropped hand tool, and to

protect personnel from injury caused by the moving open gears. The covers shall permit ready access for lubrication and maintenance. For portal and traveling cranes, covers on travel gears shall have access openings located on the inboard side of the crane.

3.4.2.3 Reduction and transmission gears. Reduction and transmission gearing shall be spur or helical and shall be in accordance with AGMA 6010. Gearing shall have machine-cut teeth and a 20-degree pressure angle or larger. When bull gear rotation exceeds 100 revolutions per minute (r/rein), the gear assembly shall be lubricated by an oil bath and shall be totally enclosed in an oiltight case. Gear shafting shall be installed with antifriction bearings. Heat generated shall be dissipated satisfactorily under the most severe operating conditions without requiring special external cooling.

3.4.2.4 Right-angle drives. Right-angle drives may be bevel gears of true spiral tooth design, or high efficiency worm gearing of the overhauling type which will permit the worm wheel to reverse the drive of the worm.

3.4.2.5 Gear cases. Gear cases shall be provided with an inspection cover and shall permit safe, ready inspection, repair, and removal of gears. Nuts and bolts inside gear cases shall be self-locking. The following shall be provided:

(a) Oil-resistant sealing gaskets to prevent leakage.
(b) Oil filling, drainage, and vent fittings.
(c) A coarse strainer on the filler hole, fixed with fasteners that require hand tools for removal.
(d) Tight-fitting caps or covers.
(e) A dipstick or direct-indicating sight glass for indicating the oil level and marked to indicate the “full” and “add oil” levels.

3.4.2.6 Oil and grease. Lubrication oil shall be 2190-TEP in accordance with MIL-L-17331. Grease shall be in accordance with MIL-G-24139 general purpose, except for open gears which shall use grease in accordance with MIL-G-18458.

3.4.2.7 Seals. Oil seals shall be installed to prevent oil from leaking where shafts penetrate the gear housing. They shall also prevent the gear case oil and bearing grease from mixing.

3.4.2.8 Keyways. Straight-cut keyways in coupling and gear shafts shall be closed-ended to prevent loss of keys.

3.4.3 Bearings and bushings.

3.4.3.1 Bearing life. Antifriction bearings shall be selected to result in a minimum L-10 life of 10,000 hours, calculated in accordance with ANSI 11. Cross-roller bearings may be used for the upper slew bearing of a kingpost crane (when two bearings are used) and for the lower pedestal bearing of a pedestal crane.

3.4.3.2 Lubrication. Antifriction bearings shall be lubricated with oil where practicable, except for main rotation bearings which shall be greased. Access to check, drain, and add oil shall be provided. Where oil lubrication is not practicable, grease lubrication shall be used. High-speed motor and coupling

bearings shall use grease in accordance with DOD-G-24508. Grease-lubricated bearings shall be fitted with corrosion-resistant steel or nickel-copper alloy pressure grease fittings, sized in accordance with SAE J 534. Grease drain plugs or seals with grease relief lip shall be incorporated when pressure grease fittings are used.

3.4.3.3 Bushings. Bronze or non-metallic liner bushings are permitted. Material for bronze bushings shall be in accordance with ASTM B 584, alloy number C94700 or C94700HT. Non-metallic liner bushings shall be in accordance with MIL-B-81934. Positive means shall be provided to prevent bushings from turning and cutting off the supply of lubricant.

3.5 Wire rope systems.

3.5.1 Wire rope installations. The design factor for wire ropes shall be the acceptable breaking strength of the rope (as specified in RR-W-410) in the system divided by the load imposed on the rope when supporting the dead load of structure and crane rated load. The wire rope design factor, when subjected to design loads from normal conditions (see 3.2.6.1), shall be at least 5. For the maximum condition (see 3.2.6.2), the wire rope design factor shall be at least 2-1/2. If a load is supported by more than one rope, the tension in the ropes shall be equalized. If pendants are used for standing rigging, galvanized or corrosion-resistant wire rope shall be used. Wire rope end connections shall be the poured zinc socket type. Wedged socket connections shall not be used. Standing ends shall not be mounted to swivels.

3.5.2 Wire rope requirements. Wire rope shall be in accordance with RR-W-410, type I, class 3 Barrington-Scale construction or equal, independent wire rope core (I\WRC), 6 by 37 improved plow steel or extra-improved plow steel, uncoated, preformed, right or left regular lay. Right-regular-lay wire rope shall be used except when two ropes are used on a single drum. In this case, one rope shall be right-regular-lay and the other shall be left-regular-lay. Wire rope should be broken-in under partial load conditions to straighten it out.

3.5.3 Wire rope drums. Wire rope drums shall be grooved and shall hold the wire rope preferably in a single layer. When payed out to the drum down-stop limit (see 3.6.1.1), at least 2-1/2 turns shall remain on the drums. Drum pitch diameter shall be at least 24 times the nominal rope diameter. The pitch diameter for multiple-layer drums shall be in accordance with the guidance provided by NAVSEA 0900-LP-008-2010. Fleet angles exceeding 1-1/2 degrees shall not be used. Ropes shall be anchored to drums by one of the following methods: poured zinc socket connections, U-bolt (or fist-grip) clip connections, or friction clamps which incorporate a poured ferrule on the end of the wire rope. Friction clamps relying on the torque of a single bolt to secure the rope shall not be used. A clamp-type connection shall be provided to attach the rope to the drum. Wire ropes shall be tagged with the installation date at the drum clamp.

3.5.4 Sheaves. Sheaves shall be made of rolled, forged, or cast steel with a machined groove. The cross sectional radius at the bottom of the groove should form a saddle for the size of the rope used; the sides of the groove should taper outward so that the rope can easily enter the groove. Flange comers shall be rounded and the rims shall run true about the axis of rotation. Sheave diameters

(D) shall be at least 24 times the nominal rope diameter (d) unless otherwise specified (see 6.2). Sheaves shall be fitted with sealed, antifriction bearings. Sheaves shall have close fitting guards to prevent the rope from coming out of the sheave groove.

3.5.5 Single or multipurchase blocks. Single or multipurchase blocks shall be designed with a factor of safety (see 6.6(h)) of at least 5 when subjected to design loads from normal conditions (see 3.2.6.1) and 2-1/2 when subjected to design loads from maximum conditions (see 3.2.6.2). They shall be load tested by the manufacturer to 200 percent of the rated load. Hook, ball assemblies, and load blocks shall be permanently marked with their weight, load rating, and test data.

3.5.6 Hook block twist. When using multiple-part reeving, the wire rope system shall be designed so that hook block twisting does not occur. When the crane is operating at the condition which has the maximum length of fall (see 6.6(k)), the ratio of this rope length (L) divided by the average rope spacing (S) shall be less than 65 when D/d (see 3.5.4) is 24 or greater. If the smaller D/d ratio is permitted (see 6.2), the maximum L/S ratio shall be less than 45 for D/d ratios between 18 and 24. The information in table V shall be used to determine the average rope spacing in various rope systems.

TABLE V. Calculating average rope spacings.

2-part reeving	Average pitch diameter of stationary and traveling block sheaves
3-part reeving	2/3 of 2-part reeving
4-part reeving	Diagonal distance between parts of rope
5-part reeving	4/5 of 4-part reeving
6-part reeving	Diagonal distance between parts of rope
7-part reeving	6/7 of 6-part reeving

3.5.7 Grease for wire ropes. Grease for wire ropes shall be in accordance with MIL-G-18458. Preservatives shall be removed from the wire rope prior to the application of the specified grease.

3.5.8 Hook, ball assembly, and load block. Hooks shall incorporate swivels and safety latches and shall be suitable for capacities specified (see 6.2). Crane hooks, ball assemblies, and load blocks shall be of sufficient weight (considering boom length and number of parts of line in use) to prevent the wire rope from becoming slack when the hoist drum is unwinding at its maximum speed and also to prevent the loss of rope tension at the drum when the drum is stopped. Swivels shall incorporate antifriction thrust bearings. Insulator links shall be provided if specified (see 6.2). Two tram points shall be permanently scribed on the hook on opposite sides of the throat opening. The distance between these points shall be measured (to the nearest 1/64 inch) and permanently marked on the hook .

3.6 Control limit systems. Limit systems shall consist of operational limit switches, overtravel limit switches, and (if applicable) positive stop devices. Operational limit switches shall be installed on the machinery or in an alternate location to safely shut down each drive system within its normal operational limits. In the event of operational limit switch failures, mechanically independent overtravel limit switches shall be provided for all functions. The location of these overtravel limit switches shall be determined by the stopping distance requirement as calculated by the contractor (see 6.3). The positive stop devices as specified (see 3.3.1.4) shall be located just beyond this stopping distance requirement to ensure the maximum limit of travel is not exceeded.

3.6.1 Limit switches. Limit switches shall be proximity type unless otherwise specified herein. Proximity switches shall be in accordance with MIL-S-24711. Limit switches shall be made of corrosion resistant materials and have watertight enclosures. From any tripped limit switch, recovery shall be effected by reversing the motion. The construction of switches shall permit the open limit switch contact to be bypassed.

3.6.1.1 Hoist block up-stop and down-stop limit switches. Main and (if applicable) auxiliary hoist drive systems shall each incorporate an up-stop and a down-stop single gear type limit switch driven by the hoist drum. Unless otherwise specified (see 6.2), the up-stop limit switch shall establish the highest point of the hook which provides a minimum clearance of 8 feet between the traveling sheave block and the stationary sheave on the boom to prevent two-blocking (running the load block into the boom) throughout the entire normal operating range. The down-stop limit switch shall establish the lowest point that the main and (if applicable) auxiliary hooks can be lowered so that 2-1/2 turns of wire rope shall remain on the hoist drums.

3.6.1.2 Hoist block overtravel limit switches. Unless otherwise specified (see 6.2), a proximity limit switch shall be mounted on the boom which will shut down and prohibit further operation of the hoist-up and topping-down motors when the clearance between boom and hoist block components becomes 2 feet or less. For cranes provided with telescoping booms, tripping the hoist block overtravel limit switch shall shut down the boom extension drive.

3.6.1.3 Topping limit switches. Topping limit switches shall be essentially the same as those of the hoist systems (see 3.6.1.1). However, if copping cylinders are used (see 3.3.4(a)), the switches shall be proximity type. The up-stop limit switch shall function when the boom has been raised to an angle which provides minimum reach (see 6.2). For non-extendible boom kingpost and pedestal cranes, the down-stop limit switch shall be set at the rated reach (see 6.2) when the boom angle is at 30 degrees above horizontal. To lower the boom below this point for stowage, the limit switch must be bypassed using the boom stowage switch (boom stow-unstow) provided on the console (see 3.7.2.1(d)). An additional geared type limit switch shall trip when the boom is lowered to horizontal.

3.6.1.4 Topping overtravel limit switches. Topping overtravel proximity limit switches shall be provided in case the topping limit switch fails to stop the boom operation. A topping-up overtravel limit switch shall be located to prevent driving the boom into the positive stop (see 3.3.1.4.1). A topping-down overtravel limit switch shall be located to ensure that 2-1/2 turns of wire rope remain on the drum (if applicable).

3.6.1.5 Rotation limit switches. Unless full, unrestricted rotation is specified (see 6.2), a proximity limit switch shall be used for each direction to establish the extent of normal crane rotation. This distance shall be less than that specified for the crane rotation positive stops (see 3.3.1.4.2). A similar switch shall be used to prevent the crane from rotating if the machinery house ladder is not properly stowed.

3.6.1.6 Rotation overtravel limit switches. Clockwise and counterclockwise rotation overtravel proximity limit switches shall be provided to prevent driving the crane into positive stops (see 3.3.1.4.2), in case the rotation limit switch fails to stop the crane rotation.

3.6.1.7 Base travel limit switches (portal and travel cranes). Fore and aft proximity limit switches shall limit the normal travel distance of the crane. This distance shall be less than that specified for the base travel positive stops (see 3.3.1.4.3). These switches shall be mounted to the base of the crane and shall be actuated by targets permanently mounted on the ship.

3.6.1.8 Base overtravel limit switches. Fore and aft overtravel proximity limit switches shall be provided to prevent driving the base into positive stops, in case the base travel limit switch fails to stop the base travel operation.

3.7 Crane control. Gauges and controls required for operaitng the crane, including those required to start and operate the diesel engine (if applicable), shall be located on a console in the cab. They shall be arranged in accordance with MIL-STD-1472 for ease of operation and observation. A full complement of operating controls, auxiliary services controls (see 6.6(b)), monitoring indicators and gauges, and safety controls shall be provided on the console. The control console shall have an adjustable illumination level. Instruction cards explaining the requirements for safe load operation, and lubrication shall be provided.

3.7.1 "Float" operation. Means shall be provided at each master switch to permit the crane operator to "float" the load (move it slowly) in either direction of travel (see 3.7.2.1(b)) and pass through the neutral position without setting the brake.

3.7.2 Control console. There shall be no combination of controls which could result in a failure or allow the load to fall. When the master switch is placed in neutral, the operation shall stop promptly and the load shall maintain its position. Operating controls, auxiliary services controls, monitoring indicators, and safety controls shall be installed on the control console as specified in this section.

3.7.2.1 Operating controls. Operating controls shall be as follows:

(a) "Power on" switch (green) to control main power contactor supplying power to the drive system controllers. A rotary-type switch shall be provided.

(b) Master switches for hoisting, topping, rotating, and (if applicable) traveling drives shall either provide multiple-circuit switches with coupled stepless speed reference potentiometers (for mechanical cranes) or shall provide stepless speed control (for hydraulic cranes). Master switches shall be lever-operated with central neutral position and spring return to neutral. Operating levers for the switches shall move as follows:

(1) Hoist master switch - back to hoist up and forward to hoist down.
(2) Topping master switch - back to top up and forward to top down.
(3) Rotate master switch - left to rotate counterclockwise and right to rotate clockwise.
(4) Travel master switch (if applicable) - back to travel aft and forward to travel forward.

The thumb-operated momentary contact switch (see 6.6(m)) for brake release at neutral position shall be provided for floating load and obtaining minimum speeds for each drive (see 3.1.2).

(c) Hoist selector switch, 2-position: main and auxiliary (if applicable; see 6.2).
(d) Boom stow-unstow switch to permit bypassing the boom down-stop limit switch, allowing the stowing of the boom using the topping master switch. This shall be a foot operated momentary-contact switch to prevent accidentally leaving the switch in the bypass position during normal operation.
(e) Hoist stow-unstow switch to permit bypassing the two-block limit switches, allowing the hoists to be raised to the boom for stowing. This switch shall be a foot-operated momentary contact type to prevent accidentally leaving the switch in the stow position during normal operation.
(f) Start and stop switches (for mechanical cranes) for hoisting, topping, rotating, and (if applicable) traveling drives.

3.7.2.2 Auxiliary services controls. Auxiliary service controls shall be as follows:

(a) Cab heater on-off switch.
(b) Cab air conditioner on-off switch.
(c) Windshield wiper on-off switch.
(d) Windshield defroster on-off switch.
(e) Operator's cab exhaust fan on-off switch.
(f) Warning horn push-button switch.
(g) On-off switch and lever-operated control for adjusting the working area floodlight.
(h) Boom tip floodlights on-off switch.
(i) Sound-powered telephone headset and handcrank buzzer.
(j) Thermostatically controlled hydraulic fluid heating element on-off switch (if applicable).
(k) Aircraft warning light on-off switch (if applicable).

3.7.2.3 Monitoring indicators and gauges. Monitoring indicators and gauges shall be as follows:

(a) Lights (green) to indicate that the hoisting, topping, rotating, and (if applicable) traveling motor controls are energized.
(b) Light (amber) to indicate boom stow-unstow switch in bypass position.
(c) Lights (amber) to operate when upper and lower boom angle limits are reached.
(d) Light (white) to indicate cab heater on.
(e) Light (white) to indicate cab air conditioner on.
(f) Light (white) to indicate defroster on.
(g) Indicator lights test push-button switch (if double bulb indicator lamps are not used).
(h) Indicator lights dimmer switch (for all green, amber, and white indicator lights).
(i) Readout gauge for anemometer to measure wind speed.
(j) Lights (red) and temperature gauges to operate in conjunction with protection systems to indicate overheating of the various drive motors (for mechanical cranes) or HPU motor (for hydraulic cranes).
(k) Lights (red) and pressure gauges to indicate loss of charge pressure in hydraulic systems (for hydraulic cranes).
(l) Ammeter to indicate current drawn by HPU motor (for hydraulic cranes).
(m) Light (amber) to indicate low diesel fuel level of 10 gallons or less (for diesel cranes).
(n) Light (amber) to indicate low diesel fuel pressure (for diesel cranes).
(o) Tachometer and hourmeter for diesel engine (for diesel cranes).
(p) Lubricating oil pressure and water temperature gauges for diesel engine (for diesel cranes).
(q) Fuel gauge for diesel engine (for diesel cranes).

3.7.2.4 Safety controls. Safety controls shall be as follows:

(a) Emergency stop switch (red) to control main power contactor and shut down all drives and controllers, located remotely from other switches on the console to avoid operator error. This switch shall have a mushroom-type configuration.
(b) Emergency-run on-off switches for hoisting, topping, rotating, and (if applicable) traveling drives to provide emergency operation of drives by bypassing motor protective circuits. This shall be a momentary-contact switch to prevent accidentally leaving the switch in the bypass position during normal operation.
(c) Boom angle and load monitoring system with indicators and audible alarm feature when an unsafe condition exists.
(d) Gravity-operated boom angle indicator visible to the signalman.
(e) Switch for diesel engine fuel shutoff valve.
(f) Switch for transferring power between main and redundant brakes (if applicable).

3.7.3 Illumination of the control console. Illumination of the control console for night operation shall be provided for crane control gauges and indications. The intensity of indicator lights shall be controlled from a single dimmer switch. Night lighting shall provide adequate vision of the controls without impairing the operator's vision of the crane operations.

3.7.4 Warning signal. An audible warning device shall be activated to alert the operator when overheating (see 3.7.2.3(j)), low hydraulic pressure (see 3.7.2.3(k)), low oil lubricating pressure, or high water temperature (see 3.7.2.3(p)) conditions occur. The cycles of sound level pulsations from the alarm shall be of the order of 1 to 2 seconds. The duration of the "on" and "off" intevals shall be approximately equal in length. A manual shut-off for the alarm shall be provided in the machinery house.

3.7.5 Instruction cards. Laminated plastic instruction cards shall be permanently attached to the control console to explain the following:

(a) Safe-load requirements.
(b) Operation instructions.
(c) Lubrication requirements.
(d) Safe fueling method for diesel fuel tank (if applicable).

The safe-load requirements card shall include the maximum lifting loads allowable for safe operation when the boom angle is between 0 to 30 degrees at 5-degree intervals for the fixed boom, or in 5-foot increments for extendible boom cranes. This card shall specify the limiting values of ship motion.

3.8 Electrical requirements. Electrical equipment shall be in accordance with the applicable requirements of ABS Rules, USCG CG-259, IEEE 45, and as specified herein. Electrical requirements pertaining to all crane types are provided in 3.8.1, 3.8.2, and 3.8.3; electric motor requirements are provided in 3.8.4; specific electrical requirements for EM and DE drive systems (see 1.2) are provided in 3.8.5 and 3.8.6. Equipment shall meet the electrical shock hazard requirements of MIL-E-917. Wiring necesary for crane operation shall be installed complete and in accordance with the requirements of IEEE 45. The electrical system shall be ungrounded. Screening shall be provided over ventilation openings for electrical equipment where necessary to meet ratproofing requirements.

3.8.1 Power distribution. Fused or circuit breaker distribution boxes shall be used to provide protection to auxiliary services equipment such as heaters, wiper motors, lighting, and ventilation fans (up to 7-1/2 horsepower (hp)). Circuit breakers shall be provided in appropriate enclosures where loads exceed 7-1/2 hp. Control circuit power shall be installed so as to allow main power to de-energize at the main circuit breaker, yet still allow power to be available for auxiliary services circuits.

3.8.1.1 Controllers. Manual controllers (up to 7-1/2 hp) or magnetic controllers shall be used for heaters and ventilation motors. Line switches shall be provided for cab windshield wipers, defroster, and maintenance lighting in the cab and machinery enclosures.

3.8.1.2 Transformers. Transformers (440- to 115-volt) shall be provided as required for auxiliary services. They shall be located in the circuit to ensure availability of power to accessory circuits when 440-volt main power is off.

3.8.1.3 Contractors. One main line magnetic contactor shall be provided for controlling power either to all electric motor controllers (EM drives), to the HPU motor (EH drives), or to the diesel engine (DE and DH drives). The contactor shall be controlled through the action of the following:

(a) The “power on” switch (see 3.7.2.1(a)) and the "emergency stop" pushbutton switch (see 3.7.2.4(a)) located at the crane operator's control console.
(b) Two “emergency stop” switches located remotely on the ship (kingpost and pedestal cranes) or on opposite ends of the base (portal and traveling cranes).

3.8.1.4 Bonding and grounding. Cable and enclosure bonding and grounding shall conform to MIL-STD-1310. Controllers shall minimize susceptibility of their control circuits to external electromagnetic energy.

3.8.2 Cabling retirements. Cables exposed to the weather shall be watertight. Flexible cables shall be watertight flexing service or nonwatertight flexing service in accordance with MIL-C-24643 or NEMA WC 3. Other cables and conductors shall be in accordance with MIL-C-24643.

3.8.2.1 Armored cables. Armored cabling shall be used in the machinery house and operator’s cab wherever it may be exposed to damage. Cables in walkways shall be covered by steel covers with a nonslip surface to minimize the tripping hazard and protect the cable. The covers shall be flat on top and taper to the floor on both sides.

3.8.2.2 Connection boxes. Connection boxes shall be used where necessary to join flexible cable to fixed cable.

3.8.2.3 Conduit boxes. Conduit boxes and a cable entrance shall be for marine service and shall suit the specified equipment enclosure. Cable entrance plates to accommodate stuffing tubes shall be provided.

3.8.2.4 Cable installation. Cables shall be installed within the kingpost, pedestal, or base (portal or traveling cranes). They shall be long enough to allow for crane rotation and for cable exits through terminal tubes below deck. This cable length is needed to permit connection of associated ship’s cable (for kingpost and pedestal cranes) or for connection to cable reel and travel drive motors (for portal and traveling cranes). Means shall be provided to secure the upper portion of the flexible cables to the rotating portion of the crane so that the cables may be connected to the associated electrical equipment. Cables required to be connected to the crane shall be as follows:

(a) Control for emergency stop switches (see 3.8.1.3(b)).
(b) Communication for sound-powered telephone (voice and call) that connects the cab, machinery house, and remote or base location (as applicable), and including headsets and handcrank buzzers. Handsets (in lieu of headsets) may be used on bases of portal and travel cranes.
(c) For portal and travel cranes, a splashproof male receptacle and associated wiring shall be provided on one leg of the base to supply ship's power (440 Vat, 60 Hz) to the crane when power to the cable reel is disconnected or when the diesel is off (as applicable). The electrical connection shall be connected to the 440/l15V Transformer for auxiliary 115 Vac service via a control power select switch. The electrical connection shall be interlocked to prevent crane hoisting, topping, rotating, or travel when connected. Amperage shall be sufficient to concurrently run aircraft warning lights, cab and machinery house lighting, space heaters, portable lights, power tools, and all 115 Vac control power necessary for maintenance and checkout.

3.8.2.5 Cables between fixed and rotating parts. Power shall be transferred between the fixed and rotating portions of the crane by slip ring assemblies. A loop cable configuration may be used in lieu of slip rings if the rotation arc is restricted (see 6.2).

3.8.3 Controllers and control accessories. Control enclosures shall be splashproof and dust-tight in accordance with NEMA 250, type 4 specifications. Parts such as push-button switches, relays, contractors, master switches, and other electro-mechanical devices shall be in accordance with NEMA ICS-2, type 4 specifications.

3.8.3.1 Operation of controllers. Operation of controllers shall be limited to input current waveform distortion consistent with section 7 of IEEE 444.

3.8.3.2 Control accessories. Controller parts, modules, and drawers which perform similar functions shall be made standard and interchangeable to the maximum extent practicable. The number of different parts in the controllers shall be kept to a minimum consistent with their intended use. Selection of parts shall be in accordance with MIL-STD-454. Requests for the use of nonstandard parts shall conform to requirement 22 of MIL-STD-454.

3.8.3.3 Semiconductor devices. Semiconductor devices shall be chosen and applied in accordance with requirement 30 and microelectronic devices (ex) in accordance with requirement 64 of MIL-STD-454. Active semiconductor devices shall be made of silicon.

3.8.4 Motors. Industrial motors suitable for shipboard operation shall be used for hoisting, topping, rotating, and (if applicable) traveling operations as specified below and in 3.8.4.1, 3.8.4.2, or 3.8.4.3 as applicable.

(a) Service - Marine.
(b) Ambient temperature - 120°F.

(c) Enclosure - Drip-proof (inside machinery house) or totally enclosed (outside machinery house); force-ventilated if duty cycle computations indicate that cooling is necessary.
(d) Power - As required.
(e) Bearings - Ball.
(f) Insulation - Class B, class F, or class H. Allowable temperature rise limit corresponding to class B (70 degrees Celsius (°C) rise over 50°C ambient).
(g) Additional requirements - Motors shall be provided with over-temperature sensors and have facility to accept a replacement sensor without rewinding (see 3.7.2.3(j)). Neither silicone materials nor aluminum wire shall be used in the motors.

3.8.4.1 Motor requirements for EM and DE drive systems. For EM and DE drive

(a) Voltage - 500 volts direct current (Vdc) except certain crane travel motors (see 3.8.4.3).
(b) Duty - To meet reliability requirements (see 3.2.3.1).
(c) Type - DC industrial, suitable for crane operation with stepless speed control.
(d) Design - Shunt-wound with removable/replaceable commutator.
(e) Brakes - Electrical (see 3.8.5).

3.8.4.2 Motor retirements for crane base drive systems. Crane base drive systems (for portal and traveling cranes) with four or more motors shall have diagonal motor pairs wired electrically in series and rated at 250 Vdc.

3.8.4.3 Motor requirements for EH drive systems. For EH drive systems, HPU motors shall be ac industrial motors as follows:

(a) Voltage - 440 Vat, 3-phase, 60 Hz.
(b) Duty - Constant.
(c) Type - AC industrial, suitable for crane operation.
(d) Design - Squirrel-cage, induction, not to exceed 1800 r/rein.
(e) Brakes - Hydraulic (see 3.9.4).

3.8.5 Electric brakes. Brakes shall be provided for each hoist, topping, slew drive, and (if applicable) travel motor. A duplicate second brake capable of stopping and holding the rated load shall be furnished for each hoist and topping motor in the event of a main break failure. The brakes shall stop and hold the dynamic test load of 150 percent of rated load (or 125 percent if applicable - see 4.5.3 and 6.2); they shall hold the static test load of 200 percent of rated load (or 150 percent, if applicable - see 4.5.2 and 6.2) or 200 percent of motor rating or full-stall motor torque, whichever is larger. The brakes shall be interlocked with their respective electric motors so that they will set when the control is on neutral (except when in the float mode), when the motor is stopped, and if power fails. The brakes shall be in accordance with the following:

(a) Voltage - Vdc for shoe, Vac or Vdc for disc.
(b) Duty - To meet reliability requirements (see 3.2.3.1).
(c) Type - Disc or shoe, magnet-operated.
(d) Mounting - Bedplates.

(e) Enclosure - Drip-proof (inside machinery house) or watertight (outside machinery house).
(f) If two or more motors are used for crane rotation, each drive shall have a single brake. The brakes shall be sized such that they are capable of stopping and holding the rated load in the event of the failure of one brake. If a single drive is used, a duplicate brake shall be provided; each brake shall be capable of stopping and holding the rated load.
(g) For motors having duplicate brakes, the second brake control circuit shall include an adjustable time delay so that the brakes may be adjusted to set in sequence. A transfer switch shall be provided on the control console to enable periodic switching of designated braking function between both brake systems to distribute wear and to minimize corrosion (see 3.7.2.4(f)).
(h) Brakes shall be furnished with manual release levers; use of removable brake covers and portable brake release levers is acceptable.

3.8.6 Controllers for EM and DE drive systems. Controllers shall provide stepless variable speed for each motion independent of the load. Controllers shall provide power conversion from the 3-phase ac power to a static, stepless, adjustable voltage dc power for use with the dc shunt wound motors. Static reversing and regeneration shall be provided using a dual-power conversion. Motor field regulation that provides field weakening to obtain a fast speed at light load shall not be provided. Hoisting, topping, rotating, and (if applicable) traveling static controllers shall be in accordance with the following:

(a) Input voltage - 440 Vat, 3-phase, 60 Hz.
(b) Duty - See duty cycle specified for each motor.
(c) Current rating - Line input contractors shall be in accordance with NFMA ICS-2 specifications.
(d) Emergency run - Required to provide emergency operation by bypassing protective circuits.
(e) Operation - Phase control, static reversing.
(f) Function - Motor starting, reversing, speed control, and regenerative motor braking.
(g) Speed range - 5 percent to 100 percent of rated speed.
(h) Protection - Low-voltage protection (LVP) and overload protection. The overload protection system shall be compatible with the temperature sensors used in the motor winding. These circuits shall provide means for visual and audible indication of motor overheat condition (see 3.7.2.3(j)).
(i) Other data - Controllers shall also include the following features:

(1) Protection from phase reversal and power loss at the controller output.
(2) Phase sequence indicating lights.
(3) Self-protection from input voltage variation and transients up to 2500 volts, having a basic input level (BIL) wave shape as shown on the figure for spike voltage (short time transient) wave shape in MIL-STD-1399, section 300.
(4) Hoisting controller shall provide for operation with either the main or auxiliary hoist (if applicable).

3.8.6.1 Power module converters. Power module converters shall be capable of continuous duty at a minimum of 150 percent of the highest motor current-rating that will provide full-load torque at all speed points and at 300 percent of this rating for one minute.

3.8.6.2 Peak inverse voltage rating. Peak inverse voltage rating of semiconductor devices shall be not less than 150 percent of the working peak inverse voltage.

3.8.6.3 Power circuits. Power circuits shall be removable modules. Each module shall include a pair or group of main power thyristors with any complementary devices that may be required. Also, associated components shall be included, such as current-limiting, voltage-limiting, and heat-dissipating components that are necessary to ensure proper and reliable operation of the thyristors in the particular circuit.

3.8.6.4 Controller protection. Controllers shall protect themselves without damage to parts, modules, or drawers if a control circuit is shorted or opened.

3.8.6.5 Temperature requirements. Heaters shall be provided if required to keep controller temperatures from falling below 32°F (see 3.1.5.2). The temperature of a power module shall not exceed 212°F in a 120°F ambient temperature when delivering rated load.

3.8.6.6 Cooling. Controllers shall be cooled by ambient air at a maximum temperature of 120°F. Cabinets may be forced-air cooled. Panels with forced-air cooling shall use one or more ventilation fans. The fans, complete with motors, shall be mounted within the cabinet so that cooling air exhausts through the top below the dripshield in the front or back. An interlock shall be required to shut down the drive if the controller ventilation fan circuit should be broken.

3.8.6.7 Fault isolation requirements. Fault isolation for each module or drawer shall be provided so that a shorted or noncommutated power semiconductor shall not result in damage to any other part of the controller, except that a single fuse may blow or a circuit breaker may trip.

3.8.6.8 Firing circuit modules. Identical thyristor firing circuit modules shall be used throughout the controllers to the maximum extent possible. Firing circuits shall be designed for maximum noise immunity, utilizing decoupling, shielding, low impedance, twisted pair cables, reverse bias, and proper wiring layout .

3.8.6.9 Part identification. Supplementing other requirements for parts identification, vendor-furnished parts shall be identified in parts lists and drawings by part manufacturer's name, part number, and the controller manufacturer's part number.

3.9 Hydraulic requirements. Hydraulic components shall be in accordance with MIL-STD-2193. The hydraulic system shall be designed and arranged to facilitate flushing, air venting, and oil sampling. Means shall be provided for checking manufacturers' specified pressure settings in each hydraulic circuit. The hydraulic system shall incorporate overload protection devices to prevent

runaway operation in the event of hydraulic or electrical power loss. The hydraulic circuit shall not contain valves which allow the fluid to by-pass the hydraulic motor when the control is in the neutral position. When the motion is stopped (control in neutral position) the hydraulic motor shall act as a brake. Accumulators shall not be used.

3.9.1 Controller and control accessories. The HPU motor controller shall provide full voltage (across-the-line) for an HPU motor up to 150 hp. The HPU motor controller shall provide reduced voltage (auto-transformer) for an HPU motor exceeding 150 hp.

3.9.2 Servo controller. Drive systems shall use pump-mounted electro-hydraulic servo controllers which incorporate fail-safe mechanisms to return pumps to zero stroke if power is lost. If topping cylinders are used, topping speed shall be controlled by an electro-hydraulic servo valve. Topping controls shall incorporate fail-safe feature to stop boom motion if power is lost (see 3.1.1). Master switches shall be used in conjunction with servo controllers or servo valves to ensure that the speed of operation will remain constant through the load range of zero to full load.

3.9.3 Pumps and motors. Variable- and fixed-displacement axial-piston and radial-piston hydraulic pumps and motors shall be used in accordance with MIL-P-17869, Class 1. Motors shall be flange-mounted and shall have 30-degree involute splines in accordance with SAE J 744. If topping cylinders are used, the pump selected for the topping operation shall be pressure-compensated.

3.9.4 Hydraulic brakes. Brakes shall be provided for each hoist, topping, rotation, and (if applicable) travel drive. The brakes shall be able to stop and hold the dynamic test load of 150 percent of rated load (or 125 percent if applicable) (see 4.5.3 and 6.2), and shall hold the static test load of 200 percent of rated load (or 150 percent if applicable) (see 4.5.2 and 6.2). They shall be interlocked with their respective motors so that the brakes set when the control is in neutral (except when in the float mode (see 3.7.1)), when the motor is stopped, and if a power failure occurs, including the loss of hydraulic pressure. Brakes shall be as specified in 3.9.4.1 or 3.9.4.2.

3.9.4.1 Disc or shoe type brakes. If disc or shoe type brakes are used, they shall be mounted on the hydraulic motor and shall be spring-set and hydraulically released. They shall be flange mounted with 30-degree involute spline in accordance with SAE J 744. Each brake shall have a manually operated brake release pump with reservoir and isolation valve.

3.9.4.2 Band type brakes. If band brakes are used, they shall be mounted on the hoist drum. They shall be spring-set and hydraulically released. Band brakes shall meet the following requirements:

(a) The drum surface on which the band operates shall be nodular graphitic iron conforming to ASTM A 439-D2/D2C.
(b) The maximum coefficient of friction used in the brake design shall be 0.3. The liner material shall have nearly equal static and dynamic coefficients of friction.

(c) Moving components (band, pins, piston rods, and so forth) shall be constructed of CRES 316 or 17-4 PH steel as dictated by the strength requirements.
(d) Brake components (including drum) shall be designed for unlimited fatigue life when operating with 150 percent of rated load. The allowable stress range shall be as given in AISC S 326, appendix B.
(e) The brake liner material shall be acceptable for use in a saltwater atmosphere and shall not absorb water. The design of the brake shall be such that the liner pressure does not exceed 600 pounds per square inch (lb/in^2) under holding conditions. The allowable shear stress of the liner material shall be at least four times greater than the maximum shear stress seen in the liner.
(f) The liner material shall be fastened to the band by a combination of riveting and adhesive bonding. The shear strength of the bonding system shall be at least four times greater than the maximum shear stress at the joint.
(g) The brake band shall be removable without disassembly of the hoist drum.
(h) The brake shall be provided with a manually operated release pump, complete with reservoir and isolation valve.

3.9.5 Hydraulic fluid. Hydraulic fluid shall be in accordance with MIL-H-17672. Fluid operating temperatures shall be not greater than 160°F.

3.9.6 Hydraulic system. Maximum hydraulic system pressure shall be not greater than 3000 lb/in^2 under normal operating conditions. Relief valves shall be set 10 percent above the maximum pressure expected (plus or minus five percent) under all operating and test conditions. The hydraulic system shall incorporate a strainer in the pump suction line that is sized sufficiently to avoid cavitating. A commercially available filter housing that will accept the MIL-F-24402 filter element shall be used to provide the system filtration. Filter housing shall be provided with a drain and an indicator to alert personnel when the filter element needs changed.

3.9.7 Heater element. Each reservoir shall incorporate a heater element to facilitate operation in cold weather. The element shall have a maximum rating of 22 watts per square inch (W/in^2) and shall be thermostatically controlled with an on-off switch in the operator's cab (see 3.7.2.2(j)). Power to the heater shall be from the auxiliary services circuit (see 3.8.1).

3.9.8 Piping arrangement. Piping shall be arranged in a neat, orderly manner and with hydraulic lines kept as short as practicable to keep pressure losses to a minimum. Piping shall not obstruct visibility and access required to control, monitor, or adjust machinery and equipment. Hydraulic lines, 1/4-inch through 3/4-inch, shall incorporate short high-pressure flexible hose assemblies between rigid tubing and connecting pumps, motors, and manifolds to eliminate rupture and leakage caused by vibration of the rigid tubing. A manually operated, linkable bypass valve shall be provided for each hydraulic motor for inspection and maintenance purposes. The number of joints in piping systems shall be kept to a minimum through the maximum application of tube bends. The minimum radius for

all tube bends shall be five times the tube outer diameter. Where tube bends are not practical, butt-welded, socket-welded, or brazed joints shall be used to the maximum extent, with minimum use of flanged and similar takedown joints. Suction lines in the reservoir shall terminate at least 2 inches above the bottom of the reservoir. Drain lines shall permit the system to drain completely.

3.9.9 Tubing, cylinder, fittings, and clamps. Tubing and fittings shall be type 304L or 316L corrosion-resistant steel. The safety factor of tubing and (if applicable} cylinders, when subjected to maximum system pressure under normal operating conditions, shall be at least five. Clamps and similar support devices shall not be welded to the component or system being supported.

3.9.10 Connections. Tapered pipe thread connections, Teflon tape (or equivalent), and thread dope shall not be used. Takedown pipe connections shall be ANSI B16.5 flanges modified for O-ring face seals, except that connections to components may be straight-thread O-ring fittings in accordance with SAE J 514. Penetrations into the primary hydraulic systems for instruments and test points shall be straight-thread O-ring bosses conforming to SAE J 514. O-rings shall be in accordance with MIL-R-83248.

3.9.11 Vent and test valves. Vent and test valves in accordance with MIL-V-24695 and MIL-V-24695/1 shall be installed in each drive system. The number and locations of these valves shall provide for: (1) venting air from all system high points, (2) draining water from all system low points, (3) measuring hydraulic pressure upstream and downstream of major components, and (4) obtaining representative fluid samples for contamination analysis.

3.9.12 Hose requirements. Flexible hoses can be substituted for tubing in locations where unavoidable distortion of the supporting structure may occur. Hydraulic hoses shall be selected, fabricated, assembled, tested, and identified in accordance with NAVSEA S6430-AE-TED-010.

3.9.13 Flushing requirements. The system shall be flushed using hydraulic fluid in accordance with MIL-H-17672. Hydraulic components (pumps, motors, and valves) shall be removed from the system and replaced with temporary piping before flushing. Flushing shall be performed at flow rates which will provide a Reynolds number of at least 4,000 in every pipe of the circuit being flushed. Flushing will continue until the fluid meets NAS 1638, class 9 requirements, except that particle sizes in the 5 to 15 micrometer range shall meet class 10 requirements. Upon completion of flushing, the system shall be completely drained and the hydraulic components cleaned and reassembled into the system. The system shall then be refilled with fluid and run until the system meets the cleanliness requirements. Depending on the complexity of the system, additional drain-ando fill sequences may be required. Verification of cleanliness requirement will be according to the tests listed in 4.2.8.

3.10 Diesel requirements. If applicable (see 6.2), a diesel engine alternator or generator shall be provided to supply the electric power for all electric motors, auxiliary services, and controls as required by the crane design specifications. The diesel engine selected to meet these requirements shall be 4-cycle and shall be sized to provide efficient operation. The electric power generated shall conform to the shipboard power supply specified (see 3.1).

3.10.1 Components. The diesel engine shall include the following components:

(a) Air cleaner with replaceable paper element.
(b) Heavy-duty radiator.
(c) Regulating governor.
(d) Tachometer and hourmeter (see 3.7.2.3(o)).
(e) Lubricating oil pressure and water temperature sensors and gauges (see 3.7.2.3(p)).
(f) Low-fuel-pressure warning light, fuel gauge, low-fuel-level warning light, (see 3.7.2.3(m,n, and q)), and instructions for describing fueling method.
(g) Cold weather starting aid for O°F cold start.
(h) Drip pan.
(i) Emergency air-shut-off valve with switch in crane cab.
(j) Starter and batteries.
(k) Fuel tank.
(l) Emergency fuel-shut-off valve with remote lanyard pull and switch on control console.

3.10.2 Safety requirements. The diesel engine shall be provided with an overspeed trip device that is separate and distinct from the regulating governor to shut off the diesel if engine speed reaches 115 percent of full rated speed. Diesel engine components (filters, hoses) for fuel shall be positioned or shielded to avoid spray leakage of fuel onto hot engine parts or air intake.

3.10.3 Exhaust system. The exhaust system shall be equipped with a spark-arresting muffler conforming to the airborne noise criteria (see 3.1.5.4). Exhaust gases shall be piped to the outside of the engine enclosure and discharged in a direction away from the operator. The exhaust system shall be guarded to prevent contact by personnel during the performance of their normal duties.

3.10.4 Fuel tanks. Fuel tanks shall be sized to provide 24 hours of continuous operation at 30 percent power. They shall be equipped with filler necks and caps designed to prevent fuel from being contaminated by external sources. Removable caps, where fitted, shall be securely tethered to the filler. Drains shall be located on the bottom of the fuel. tank. A fuel gauge and sensors that determine when fuel level is at 10 gallons or less (see 3.7.2.3(m)), and when a low fuel pressure condition exists, shall be provided with read-outs on the control console.

3.11 Workmanship. Workmanship of component and assembly fabrication shall be of sufficiently high grade to enable the crane to operate satisfactorily, consistent with the other requirements of this specification. All components used in the assembly shall be sufficiently clean for the purpose of assembly and operation as applicable, welded parts shall be free of weld spatter, and soldered connections free of loose solder and excess flux. All parts shall be free of burrs and sharp or ragged edges.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows.

4.2.1 First article inspection. Unless otherwise specified, the first crane of an order shall be fully assembled and tested as specified in 4.5.1 through 4.5.8 at the contractor's facility. Lower hoist limits do not have to be demonstrated.

4.2.2 Quality conformance inspection. Quality conformance inspection shall consist of the examination specified in 4.4 and the tests specified in 4.5 through 4.5.10 (see 6.3).

4.2.2.1 Functional requirements. The contractor shall be responsible for ensuring that the entire crane system fits and functions properly when installed on board the ship by the Government, providing that proper installation procedures were followed. Prior to shipping, static controls shall be subjected to a burn-in test at the contractor's or control manufacturer's facility. Static controls shall be energized under a simulated 125 percent load condition and operated continuously for at least 24 hours to burn out as many marginal components as possible. Immediately following, static controls shall operate satisfactorily through all functional modes at 100 percent load condition for 1 hour.

4.3 Quality requirements. The contractor shall develop and maintain an inspection system in accordance with MIL-I-45208.

4.4 Examination. Each crane manufactured to this specification shall be examined for compliance with all nonoperating requirements specified herein before the crane is operated.

4.5 Load and performance tests. Unless otherwise specified, the first crane of an order shall be fully assembled and tested as specified in 4.5.1 through 4.5.8 at the contractor's facility. Lower hoist limits do not have to be demonstrated at the contractor's facility. After it is installed on board ship or floating drydock, each crane shall be tested as specified in 4.5.1 through 4.5.8 and in the following sequence. Tests will be conducted by the Government, assisted by the contractor. In the event of any equipment failure during testing, the crane shall be repaired by the contractor and completely retested.

4.5.1 No load operation test. A no-load operating test shall be conducted after the installation, the post installation inspection, and the crane operational checkout are completed. This test is conducted to determine if the crane is capable of safely operating through each specified functional mode. During the test, the crane shall be required to function through full operating ranges in all directions specified for the equipment. Operation of the travel limit switches, over-travel limit switches, emergency stop and)if applicable) emergency run switches, and limit switch recovery features shall be demonstrated. Specifically, the crane shall:

(a) Raise and lower load hooks through full range of travel at speeds varying from zero to maximum for five complete cycles. Two block limit switches and up-stop and down-stop limit switches on hoist drums shall be demonstrated satisfactorily. To conduct the two-block limit switch demonstration, it will require that the hoist up-stop limit switch be jumped.
(b) Top the boom through full range of motion from stow position to maximum for five complete cycles at speeds varying from zero to maximum. During one topping cycle, the boom shall be slowed to about 20 percent of maximum speed near top and bottom of travel and run into the boom-up and boom-down overtravel limit switches to demonstrate that the switches stop the boom. The up-stop, down-stop limit switches and boom stow, hoist stow switches shall be demonstrated.
(c) Rotate through full range of motion at varying speeds from zero to maximum for five complete cycles. Limit switches and overtravel limit switches shall be demonstrated (if applicable).
(d) On traveling base cranes, travel through full range of motion at varying speeds from zero to maximum for five complete cycles. Limit switches and overtravel limit switches shall be demonstrated.
(e) Demonstrate emergency stop and (if applicable) emergency run operation (see 3.7.2.4(a) and (b)).
(f) Demonstrate proper operation of the indicator lights and gauges, lights and accessory equipment (ventilators, fans, heaters, defrosters, and windshield wipers).
(g) Demonstrate simultaneous drive operation (see 3.1.1).
(h) Demonstrate compliance with noise level requirements (see 3.1.5.4).

4.5.2 Static load test. The crane shall be subjected to a static load test by suspending test loads equal to 200 percent of the rated and derated loads (see 3.1.3 and 6.2) on the main and (if applicable) auxiliary hoist hooks; 150 percent loads shall be used in lieu of 200 percent loads for cranes handling FBM's (see 6.2) or cranes intended for floating drydocks (see 6.2). Test loads shall not be applied to the hooks simultaneously. The crane shall not be operated with static test loads. Crane shall be:

(a) Positioned with hoist hooks outboard over pier or barge and extended to the rated range, and positioned to provide maximum protection to ship, equipment, and personnel in case of fialure. This test shall also be performed at the maximum outreach.
(b) Static load tested by suspending the test loads from the main and auxiliary hooks, in order, using an auxiliary crane to gradually apply the test loads, and to continue support if the crane should deform or fail.
(c) Required to support the static test load for a minimum of 10 minutes and until it can be determined that there is no evidence of deformation, brake slippage, or other damage.
(d) Inspected following the test to verify that there is no permanent set, deformation, or other damage to any part of the crane machinery, structure, rigging, or hoist hooks.

4.5.3 Dynamic load test. The crane shall be subjected to dynamic test by operating the crane through full ranges of motions and speeds with test loads of 150 percent of rated and derated loads (see 3.1.3 and 6.2) on the hooks; 125 percent load shall be used in lieu of 150 percent load for cranes handling FBM's (see 6.2) or cranes intended for floating drydocks (see 6.2). Main and (if applicable) auxiliary hoist test loads shall not be lifted or suspended simultaneously. The Government has the option of restricting the dynamic test to operations outboard and clear of the ship for safety purposes. The crane shall be:

(a) Exercised for 10 complete cycles at 50 percent of rated load and inspected for damage and rope twist.
(b) Positioned with hoist hooks outboard over pier or barge at rated outreach and repeated at maximum outreach, and positioned to provide maximum protection to ship, equipment, and personnel in case of failure.
(c) Dynamic load tested by lifting the main and auxiliary hoist test loads, in order, from position of rest on the barge or pier at slow speed until about 2 feet clear and then stopped for 5 minutes. Test loads shall be restarted and raised and lowered though full range of hoist travel at varying speeds from zero to maximum attainable in each direction. Test load shall be raised and lowered three times and stopped three times during lowering to test brake.
(d) Topped, rotated, and (if applicable) traveled through full ranges simultaneously with hoisting operation for three cycles each.

(e) Inspected during and after dynamic test to verify that brakes, controls, and machinery demonstrate satisfactory operation without excessive overheating, excessive noise, or excessive vibration. Drive motors shall not be overloaded more than 25 percent during this test condition (see 3.2.10).

4.5.4 Rated load test. The crane shall be subjected to rated load tests by operating the crane through full ranges of motions and speeds with rated and de-rated loads on the main and (if applicable) auxiliary hooks (not simultaneously). This test shall also serve as the reliability demonstration test (see 3.2.3.1). Accordingly, the 40-cycle testing (see 4.5.4(c)) shall be failure-free. The crane shall be:

(a) Positioned with hoist hooks outboard over pier or barge, at rated outreach and positioned to provide maximum protection to ship, equipment, and personnel in case of failure.
(b) Tested by lifting the rated and derated loads from position of rest and moved through complete ranges of hoisting, topping, rotating and (if applicable) travel at speeds varying from zero to maximum. Simultaneous operation shall be demonstrated.
(c) Tested a minimum of 40 complete cycles. Proper operation of controls, limit switches, and brakes shall be demonstrated during this test to ensure repeatability.
(d) Inspected to verify that brakes, controls, and machinery demonstrate satisfactory operation without overheating, excessive noise, or vibration.
(e) Demonstrated to have incorporated the fail-safe and hazard reduction features (see 3.1.1 and 3.2.1).

4.5.5 Airborne noise test. The noise levels (see 3-1.5.4) shall be measured in accordance with the methods given in ANSI S1.13 using a type 1 sound level meter (see 6.3). The interior noise level shall be measured at the operator's normal position. The exterior noise level shall be measured at locations directly in front and at both sides of the cab, at a distance of 25 feet from the centerline of the crane's rotation, and 6 feet above the deck.

4.5.6 Splashproof test. Machinery house and operator's cab shall be hose tested for being splashproof (see 3.3.2.1 and 3.3.2.2). The splashproof test shall be conducted using a 15-gal/min coarse nozzle spray that produces a 10-foot water head pressure. Water stream shall be sprayed at 6 feet and applied from all directions onto all exposed enclosure surfaces for a period of 5 minutes. Water within the enclosure shall be cause for rejection.

4.5.7 Paint test. Painted steel parts (see 3.2.8.9) shall be subjected to a tape test to verify cohesion and adhesion. Any paint damage caused by firmly applying and removing a 1-inch (minimum) wide strip of masking tape shall be cause for rejection. Masking tape used for this test shall be Minnesota Mining Company, Code No. 250, or equal.

4.5.8 Maintainability examination. A maintainability examination shall be conducted on the crane to demonstrate the ability (a) to replace complete assemblies and subassemblies with a minimum disassembly of parts, and (b) to completely drain gearboxes, replace filters, arid reach all lubrication fittings. Inspection covers shall be removed to demonstrate that adequate openings have been provided so that periodic maintenance can be performed.

4.5.9 Flushing test (if amicable). The test method for determining particulate contamination shall be in accordance with SAE ARP 598 or with an automatic particle counter capable of being calibrated in accordance with ANSI B93.28. The system cleanliness requirements are as specified in 3.9.13.

4.5.10 Shock test. If shock requirements are invoked (see 6.2), the contractor may be required to perform shock tests on the crane or on the crane machinery in the stowed position prior to installation on the ship to verify compliance with 3.1.5.3.

4.6 Methods of inspection.

4.6.1 Welding inspection. Crane machinery and structures shall be inspected in accordance with MIL-STD-278 as specified for class M machinery. Welds shall be inspected visually regardless of other testing performed. radiographic testing shall be done on at least 10 percent of all full-penetration welds in the primary load path and on 100 percent of critical full-penetration welds (see 6.6(d)). Ultrasonic testing may be substituted when radiographic testing is not feasible. Liquid penetrant or magnetic particle testing shall be done on at least 10 percent of all fillet welds in the primary load path (see 6.6(n)) and on 100 percent of critical fillet welds and welds which are totally enclosed or inaccessible (which cannot be checked later). Critical welds and welds in the primary load path which will be tested shall be identified on the preliminary and final drawings. If more than one area requires weld repair as a result of the inspection, the sample size shall be increased by another 10 percent. This procedure shall be continued until this condition is not exceeded. Minor defects, which can be removed mechanically without infringing on the design thickness, are not considered defects -requiring weld repair.

4.6.2 Packaging inspection. Sample packages and packs, and the inspection of the preservation, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisitions. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.9.)

5.1 Preservation. Preservation shall be level A or commercial, as specified (see 6.2). Level A cleaning, drying, and preservation shall be in accordance with MIL-P-116 and MIL-M-3184. Use of vermiculite is approved for packaging liquid products. Commercial preservation shall be in accordance with ASTM D 3961.

5.1.1 Cushioning, filler, dunnage and wrapping material. The use of excelsior, newspaper, shredded paper (all types) and similar hydroscopic or non-neutral materials for application such as cushioning, filler, stuffing, and dunnage is prohibited. Materials selected for cushioning and wrapping shall have properties (characteristics) resistant to fire.

5.1.1.1 Packing. Packing shall be levels A, B, C, or commercial, as specified (see 6.2), in accordance with MIL-M-3184.

5.1.1.2 Special tools, cleaning, drying, and preservation. Cleaning/drying and preservation of the equipment, accessories and tools shall be in accordance with MIL-M-3184, and MIL-P-116.

5.1.1.3 Fire resistance. Cushioning, filler, dunnage, and wrapping materials selected, whenever available, shall exhibit improved performance for resistance to fire.

5.1.1.4 Marking. Marking shall be in accordance with MIL-STD-129 marking and additional special marking shall be in accordance with MIL-M-3184, except that descriptive details and plans-of a sample packed as specified in MIL-M-3184 are not required.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cranes described herein are intended for shipboard weapons handling, general cargo handling, and repair service. High impact shock requirements may be specified if crane is to be installed on a combatant ship where possibility of high impact shock environment exists.

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
(c) Type of crane required (see 3.1.1, 3.5.8, 3.7.2.1(c), 4.5.2, and 4.5.3).
(d) If an auxiliary hoist is required (see 3.1.1).
(e) If crane speed should be other than specified (see 3.1.2).
(f) Load capacity at maximum reach (see 3.1.3 and 3.5.8).
(g) Maximum crane weight (see 3.1.4).
(h) Unloaded and stowed position shock requirements, if required (see 3.1.5.3).
(i) Maximum stress for wind load while operating, loads due to list and trim, and acceleration due to roll and pitch (see 3.2.6.1).
(j) Wind load, ice load, loads due to acceleration from ship motions, and loads due to shock for stowed condition (see 3.2.6.3).
(k) Will crane handle FBM's or be suitable for floating dry dock (see 3.2.10, 4.5.2, and 4.5.3).

(l) Radius, reach, and lift requirements for crane (see 3.3).
(m) Whether existing rails will be used (if so, provide their cross-sectional description) (see 3.3.1).
(n) Interface and envelope of kingpost or pedestal base or width and height clearance of portal base (see 3.3.1.1).
(o) Rotational limits of crane (see 3.3.1.4.2, 3.3.4, 3.6.1.5, and 3.8.2.5).
(p) Base travel distance between positive stops (see 3.3.1.4.3).
(q) If aircraft warning lights will be installed on crane (see 3.3.3.4 and 3.3.3.4.3).
(r) Rack and pinion requirements (see 3.3.4).
(s) Sheave and rope diameter ratio (see 3.5.4 and 3.5.6).
(t) Up-stop limit distance of main hook and (if specified) auxiliary hook (see 3.6.1.1).
(u) Two-block limit distance of main hook and (if specified) auxiliary hook (see 3.6.1.2).
(v) Minimum reach and rated reach (see 3.6.1.3).
(w) Hoist selector switch, main and auxiliary (see 3.7.2.1).
(x) Rated load, if applicable (see 3.8.5, 3.9.4, 4.5.2, and 4.5.3).
(y) Whether diesel engine alternator shall be provided (see 3.10).
(z) List requirement (see 4.5.2).
(aa) Shock requirements (if applicable) (see 4.5.10).
(bb) Levels of preservation and packing (see 5.1 and 5.1.1.1).
(cc) Any additional requirements that may be peculiar to the crane being acquired.

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
3.1, 3.6 and appendix A	DI-GDRQ-80650	Design data and calculation	-----
3.1 and appendix B	DI-MISC-80678	Certification data/ report	-----
3.1 and appendix C	DI-DRPR-80651	Engineering drawings	-----
3.1	DI-MGMT-80893	Contractor engineering and technical services (CETS) report	-----
3.2.2	DI-R-7085A	Failure mode, effects, and criticality analysis report	-----
3.2.2	UDI-A-23083A	Report/minutes, record of meeting	-----

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
3.2.2.1	DI-SAFT-80101	System safety hazard analysis report	
3.2.3.2	UDI-R-23567	Maintainability prediction/report	
4.2.2	DI-T-2072	Reports, test	

The above DID's were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL) , must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Technical manuals. The requirement for technical manuals should be considered when this specification is applied on a contract. If technical manuals are required, military specifications and standards that have been cleared and listed in DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL) must be listed on a separate Contract Data Requirements List (DD Form 1423), which is included as an exhibit to the contract. The technical manuals must be acquired under separate contract line item in the contract.

6.5 Engineering services. Services of the contractor's engineering staff should be available upon request to provide engineering and technical service as follows:

(a) Assist the installing activity in preparing the crane for installation and installing it in the ship.
(b) Provide technical assistance for corrective action in case of unexpected problems.
(c) Assist in inspection and test of crane after installation.
(d) Participate in technical meetings.
(e) Assist the ship's crew in becoming familiar with crane operation.

A maximum of 20 man-days per crane will be allowed.

6.6 Terminology and definitions. Terms used in this specification that require definitions are included below:

(a) A-frame. The structural portion, exclusive of the boom, above the rotation platform on the crane.
(b) Auxiliary services. Any function of the crane not directly related to the load handling operation.
(c) Base. The portion of the supporting structure immediately below the rotating structure of the crane.
(d) Critical weld. A critical weld is one whose failure would cause a catastrophic failure of the crane (loss of load) or injury to personnel.
(e) Dead load. Dead load is the load due to the weights of the structural and machinery components of the crane itself.
(f) Desire load. Design load for any component is the load acting on the component due to the rated load, wind load, and any applicable dead loads as increased by dynamic motions of the ship and the crane.

(g) Equipment failure. Equipment failure occurs when the crane fails to start, ceases to function, or when its performance degrades below the requirements of this specification.

(h) Factor of safety. Unless otherwise noted, the factor of safety shall be defined as the material yield stress divided by the actual stress in the part.

(i) Fail-safe operation. A design requirement in which failure of the operating power source or power operated drive mechanism shall not jeopardize the safety of personnel, the load being handled, or the crane unit.

(j) Float mode operation. A mode of operation when the brake is released without changing the position of the load. The load can then be moved at minimum speed in either direction of travel. When in this mode, the brake will not set with the master switch in the neutral position.

(k) Length of fall. The distance (feet) measured from the centerline of the stationary sheave on the boom to the centerline of the sheave in the traveling block.

(l) Mast. A vertical structural member that provides the center of stability for the rotating structure. The mast is either mounted over the kingpost or is an extension of the pedestal or kingpost.

(m) Momentary contact switch. A switch with contacts that are spring returned to the original or "off" position. The "on" position is maintained only as long as the switch is held in the depressed (or rotated) position.

(n) Primary load path. The primary load path is defined as the components between the. hoist block and the hoist drum which in some way support the lifted load. For example: the boom and the mast.

(o) Rated load. Rated load is the maximum weight that the crane shall handle on the hook during normal operations.

(P) Rated reach. Rated reach is the maximum reach of the crane at which it is still capable of lifting the rated load. Beyond this point, the load rating will decrease.

(q) Special tools. Special tools are defined as those not listed in the Federal Supply Catalog. (Copies of this catalog may be found in the office of the Defense Contract Management Area Operations (DCMAO)).

(r) Tail swing. Tail swing is the radius of the circle in which the crane, excluding the boom, is free to rotate.

6.7 FMECA design review. As part of the FMECA, the contractor should conduct a design review between his personnel and Government representatives. This review will primarily involve a discussion of the FMECA and the contractor's recommendations for improving the equipment (see 3.2.2).

6.8 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract.

6.8.1 When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

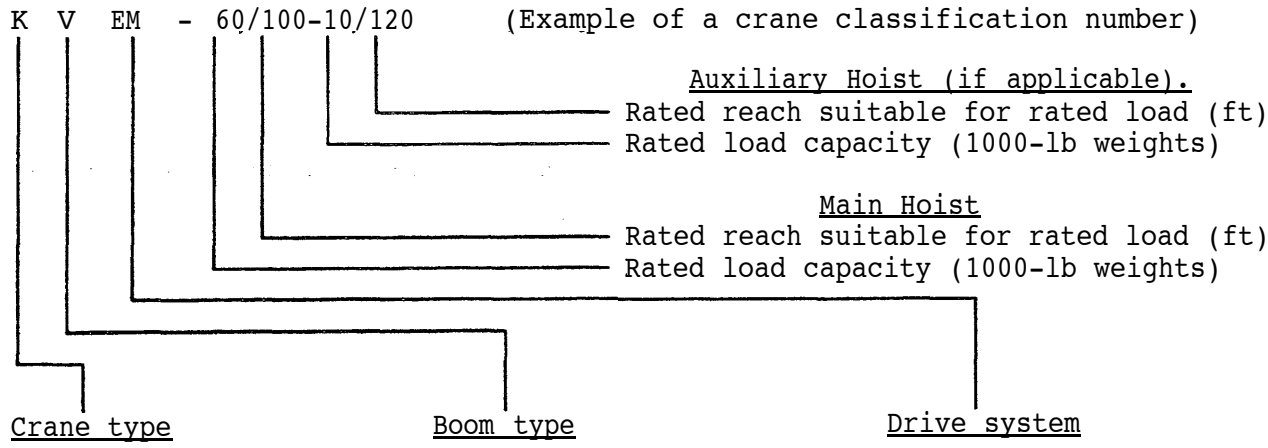
6.8.2 Interim spare parts. Interim spare parts required for the crane type ordered should be provided as indicated below. These parts along with a listing of their manufacturer's part number should be packed in one crate. Quantities shown should be provided for each type and size of the components used on the crane.

Component	Quantity	Crane type
* Printed circuit board assembly	2	All
* Firing pulse generator assembly	2	EM, EH
* Power assembly	2	EM, EH, DE
Rectifier	1	EM, EH, DE
Relays	1	All
Resistor	2	All
Rheostat	1	All
Thyristor	3	EM, EH, DE
Potentiometer	1	All
Fuse	5	All
Bulb	3	All
Motor overload element	3	EM, EH, DE
Motor brush set	2	EM, EH, DE
Brake shoe lining set	2	All
Wiper blade	2	All
Gasket/O-ring/seal	6	All
Filter/filter element	6	All
Belt	2	DE, DH
Fuel filters for complete system	3	DE, DH
Oil filters	3	DE, DH
Air filters	3	DE, DH
Fuel nozzles or unit fuel injectors	1 set	DE, DH

* These components should be burned-in in accordance with 4.3.1.

6.9 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.10 Part or identifying number (PIN). The pin to be used for cranes acquired to this specification are created as follows:



K - Kingpost F - Fixed Reach (non-topping) EM - Electro-Mechanical
P - Pedestal V - Variable Reach (topping) EH - Electro-Hydraulic
O - Portal E - Extendible (Telescopic) DE - Diesel-Electric
T - Traveling DH - Diesel-Hydraulic

In the above example, the crane classification number identifies a kingpost-type crane having a variable reach boom and an electro-mechanical drive system. Its main hoist has a rated load capacity of 60,000 pounds at a rated reach of 100 feet and the auxiliary hoist has a rated capacity of 10,000 lb at a rated reach of 120 feet.

6.11 Supersession data. This specification combines the two previous military specifications, MIL-C-17933 and MIL-C-17949.

6.12 First article. When first article inspection is required, the contracting officer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first production items, a standard production item from the contractor's current- inventory (see 3.1.6), and the number of items to be tested as specified in 4.2.1. The contracting officer should also include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

APPENDIX A

DESIGN DATA AND CALCULATIONS TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the tecnical requirements that should be included in design data and calculations when required by the contract or order. This appendix is mandatory only when data item description DI-GDRQ-80650 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. DESIGN DATA AND CALCULATIONS

30.1 Desire data and calculation requirements. When required by the contract or order, design data and calculations content requirements shall include design calculations, force and moment diagrams, load acceleration, power calculation, deck reaction, weight and center of gravity, and stopping distance as follows:

(a) Desire calculation requirements. Design calculations shall be complete and show that under specified conditions the combined stress in any part does not exceed stress limits specified herein. A complete set of design calculations of crane structure, gears, bearings, shafts, keys, holding-down bolts, wire rope, and brakes shall be prepared. Calculations shall show maximum working loads, stresses, bearing pressures, and deck reactions. Calculations shall be complete and in such form that they may be reviewed easily. A list.ing of all assumptions used in generating the calculations shall be furnished. Sources of formulas and definitions of symbols shall be included. Calculations shall include diagrams and sketches when needed for clarity.

(b) Force and moment diagrams. Force and moment diagrams or a complete record of internal forces, obtained from analysis of the boom, mast and kingpost (if applicable) under maximum design loads shall be included. An analysis using a recognized digital computer solution is acceptable.

(c) Load acceleration requirements. Calculations shall be provided for determining the acceleration loads due to the dynamic motions of the crane (see 3.2.6.1(f)).

(d) Power calculation requirements. Power calculations for determining the sizes of motors, hydraulic pumps (if applicable), brakes, and (if applicable) diesel engine shall be prepared.

(e) Deck reaction requirements. The contractor shall determine deck reactions and deck interface requirements. The Government will be responsible for the design of the supporting deck structure.

(f) Weight and center of gravity requirements. The contractor shall prepare and maintain a record of weight and center of gravity of major assemblies. Calculated total weight of the crane and location of center of gravity shall be included.

(g) Stopping distance requirements. For topping, rotation, and (if applicable) traveling operations with rated load at rated speed conditions, the contractor shall determine the required stopping distance for the crane after tripping the operational limit switch , then the overtravel limit switch. The contractor shall locate positive stop devices just beyond stopping distance to ensure the maximum limit of travel (specified operational limits plus stopping distance) is not exceeded (see 3.6).

APPENDIX B

CERTIFICATION DATA\REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the technical requirements that should be included in certification data reports when required by the contract or order. This appendix is mandatory only when data item description DI-MISC-80678 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. CERTIFICATION DATA

30.1 Certification sheet. When required by the contract or order, the contractor shall prepare certification sheets for the items listed below:

(a) Load blocks and hooks (see 3.5.5).
(b) Steel (including results of nil-ductility and Charpy impact tests (see 3.2.8.2.1).
(c) High strength bolts (see 3.2.7.4).

Certification sheets shall contain sufficiency information to trace material to manufacturer's lot number, indicate minimum strength characteristics, and indicate if it is suitable for its intended purpose. Test data from any shop tests performed in accordance with the data ordering documents included in the contract or order (see 6.3) shall be included.

APPENDIX C

ENGINEERING DRAWINGS TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the technical requirements that should be included on drawings when required by the contract or order. This appendix is mandatory only when data item description DI-DRPR-80651 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. DRAWINGS

30.1 Drawing content. When required by the contract or order, the contractor shall prepare layout drawings, arrangement drawings, mounting interface drawings, electrical interface drawings, and assembly and detail drawings with integral parts list in accordance with the data ordering document. Contractor's format, identifiers, and numbering shall be used. Assembly drawings shall identify items in the crane to the piece part level. Drawings shall provide sufficient information to completely identify all parts for provisioning purposes. Drawing shall also specify the following when required:

(a) Critical welds and welds in the load bearing path (see 3.2.7.2).
(b) Where materials of identical or equal quality can be identified by more than one specification or standard, drawings shall reference only one such source.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-C-24769(SH)	1992 MARCH 16

3. DOCUMENT TITLE
Crane, Rotating Shipboard

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code)	
Technical Engineer: Mr. Tom Nodeem, NAVSEA 56W3	(1) Commercial (703) 602-9393	(2) AUTOVON 332-9393
c. ADDRESS (Include Zip Code) Commander, Naval Sea Systems Command (55Z3) Department of the Navy Washington, DC 20362-5101	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	