INCH-POUND

MIL-DTL-2212J(SH)
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SUPERSEDING
MIL-DTL-2212H(SH)
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DETAIL SPECIFICATION

CONTACTORS AND CONTROLLERS, ELECTRIC MOTOR AC OR DC, AND ASSOCIATED SWITCHING DEVICES

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

1. SCOPE

1.1 Scope. This specification covers alternating current (AC) and direct current (DC) motor controllers and associated switching devices. Included are manual and magnetic controllers, controller parts, limit switches, pressure switches, temperature switches, selector switches, push-buttons, and similar devices used for control of electric motors. Semiconductor (solid-state) devices used as parts for magnetic controllers are included.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 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 cited in the solicitation or contract.

COMMERCIAL ITEM DESCRIPTIONS

A-A-55507	-	Clip, Electrical, Fuse General Requirements for
A-A-55507/1	-	Clip, Electrical, Fuse, 30 and 60 Ampere, for Fuse Diameters 1/4 Inch Thru 13/16 Inch
A-A-55518/2	-	Fuseholder, Block, 20 or 30 Amperes (A), 250 Volts (V) AC, 1 Through 12 Pole, Accommodates 3AG or 3AB Type Fuse Cartridges
A-A-55518/3	-	Fuseholder, Block, 30 Amperes (A), 250 Volts (V) AC, 1 Through 12 Pole, Accommodates 4AG or 4AB Type Fuse Cartridges
A-A-55518/4	-	Fuseholder, Block, 30 Amperes (A), 250 Volts (V) AC, 1 Through 12 Pole, Accommodates 5AG or 5AB Type Fuse Cartridges

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05M2, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

A-A-59125	-	Terminal Boards, Molded, Barrier Screw and Stud Types and Associated Accessories
A-A-59781	-	Light Emitting Diodes for Use as Indicator Lights

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-I-631	-	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid
MIL-S-901	-	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-E-917	-	Electric Power Equipment, Basic Requirements
MIL-E-2036	-	Enclosures for Electric and Electronic Equipment, Naval Shipboard
MIL-DTL-3661	-	Lampholders, Indicator Lights, Indicator Light Housings, and Indicator Light Lenses, General Specification for
MIL-L-3661/63	-	Lampholder, Lights, Indicator (Housing), Style LH96
MIL-L-3661/65	-	Lampholder, Lights, Indicator (Housing), Style LH98
MIL-PRF-8805	-	Switches and Switch Assemblies, Sensitive, Snap Action (Basic, Limit, Push Button and Toggle Switches), General Specification for
MIL-DTL-15109	-	Resistors and Rheostats, Naval Shipboard
MIL-PRF-15160	-	Fuses, Instrument, Power, and Telephone General Specification for
MIL-PRF-15160/60	-	Fuses, Instrument, Power, and Telephone (Nonindicating), Style F60
MIL-PRF-15160/61	-	Fuses, Instrument, Power, and Telephone (Nonindicating), Style F61
MIL-DTL-15291	-	Switches, Rotary, Snap Action and Detent/Spring Return Action, General Specification for
MIL-T-16315	-	Transformers, Power, Step-Down (Miscellaneous, Naval Shipboard Use)
MIL-DTL-16878	-	Wire, Electrical, Insulated, General Specification for
MIL-M-17059	-	Motors, 60-Cycle, Alternating-Current, Fractional H.P. (Shipboard Use)
MIL-M-17060	-	Motors, 60-Hertz, Alternating Current, Integral-Horsepower, Shipboard Use
MIL-S-18396	-	Switches, Meter and Control, Naval Shipboard
MIL-R-19523	-	Relays, Control
MIL-DTL-21604	-	Switches, Rotary, Multipole and Selector, General Specification for
MIL-PRF-24711	-	Switch, Proximity, Solid-State
MIL-PRF-32006	-	Programmable Controller, Naval Shipboard
MIL-PRF-32168	-	Variable Speed Drive System for Induction and Synchronous Machines

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-108	-	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-167-1	-	Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)

MIL-STD-202 - Electronic and Electrical Component Parts

MIL-STD-461 - Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

MIL-STD-740 - Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment

MIL-STD-740-1 - Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment

MIL-STD-740-2 - Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment

DOD-STD-1399-70-1 - Interface Standard for Shipboard Systems Section 070 - Part 1 D.C. Magnetic Field Environment (Metric)

MIL-STD-1399-300 - Interface Standard for Shipboard Systems Section 300A Electric Power, Alternating Current (Metric)

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-2036 - Electronic Equipment Specifications, Preparation of

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 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 of these documents are those cited in the solicitation or contract.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

804-1385850 - Piping, Instrument Pressure for All Service

(Copies of this document are available from the Commander, Naval Sea Systems Command, ATTN: SEA 05M2, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or by email at CommandStandards@navy.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM F1836M - Standard Specification for Stuffing Tubes, Nylon, and Packing Assemblies (Metric) (DoD adopted)

(Copies of this document are available from ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA 19428-2959 or online at www.astm.org.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1 - Industrial Controls and Systems: General Requirements (DoD adopted)

NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors and Overload Relays

ANSI/NEMA MW 1000 - Magnet Wire (DoD adopted)

(Copies of these documents are available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209 or online at www.nema.org.)

SAE INTERNATIONAL

SAE J1926/1 - Connectors for General Use and Fluid Power-Ports and Stud Ends with ISO 725 Threads and O-Ring Sealing-Part 1: Threaded Port with O-Ring Seal in Truncated Housing (DoD adopted)

(Copies of this document are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at www.sae.org.)

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

ANSI/TIA/EIA 232 - Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

(Copies of this document are available from the Telecommunications Industry Association, 2500 Wilson Blvd., Suite 300, Arlington, VA 22201-3834 or online at www.tiaonline.org.)

UNDERWRITERS LABORATORIES, INC. (UL)

UL 512 - Standard for Safety Fuseholders (DoD adopted)

(Copies of this document are available from COMM 2000, 1414 Brook Drive, Downers Grove, IL 60515 or online at www.ul.com.)

2.4 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 Qualification. Contactors, controllers, and associated switching devices (relays, switches, and so forth) furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.4, 6.6, Appendix A, and Appendix B).

3.2 Basic requirements. Unless otherwise specified herein, the equipment shall conform to the requirements of MIL-E-917 for the following items:

a. Materials (except cadmium plating, which is prohibited).
b. Electrical shock hazard.
c. Electrical creepage and clearance distances.
d. Threaded parts and fastening devices.
e. Electrical insulation.
f. Insulating procedures.
g. Wire, wiring methods, and marking.
h. Parts.
i. Processes.

3.3 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.4 Power.

3.4.1 AC controllers. AC controllers shall operate on Type I, 60-hertz (Hz) power as specified in MIL-STD-1399-300 and shall operate between 80 and 110 percent of rated voltage at the specified ambient temperature.

3.4.1.1 AC input. The AC input to the controller shall be the voltage and phase(s) specified (see 3.16.15.a and 6.2).

3.4.2 DC controllers.

3.4.2.1 Surface ships. DC controllers shall operate between 80 and 110 percent of rated voltage at the specified ambient temperature.

3.4.2.2 Submarines. DC controllers shall operate at the specified ambient temperature between 180 and 355 volts (V) (nominal 250 volts direct current (VDC)).

3.4.2.3 DC controllers with field rheostat. DC controllers having a motor speed adjustment by field rheostat exceeding a speed range of 1½ to 1 shall provide full field starting and field acceleration features.

3.5 Connection diagram and table of overload heaters and reactors. Each controller shall include a connection diagram, a schematic diagram, a description of operation, and a table of overload heaters, coils, and reactors (if used). The information shall be printed by a process that is nonfading, protected by transparent plastic, and secured inside of the enclosure. This information shall be of suitable size but not less than 8.5 inches by 11 inches.

3.6 Duty. Unless otherwise specified (see 6.2), controllers shall be constructed for continuous duty and general purpose service. For special duty such as jogging or plugging, constant horsepower multi-speed motors, lighting or transformer loads, special ratings may be required as specified (see 6.2).

3.7 Circuit arrangement. Controllers shall operate on an ungrounded system. Each controller shall be electrically independent, except for interlocks, and will normally derive its power from the same source as the controlled device. A fault in one controller shall not disable any other controller. Current transformer secondaries shall be grounded to the controller enclosure. Main line fuses, disconnects or circuit breakers shall not be provided as part of the controller. Contacts shall not be connected in parallel to obtain higher current carrying capacity. Unless otherwise specified (see 6.2), control circuits shall be the same voltage as the power circuit. Line contacts of one contactor shall not be used to maintain power to another contactor unless tests, in accordance with 4.6.5, have been made to ensure that a shock will not cause the maintained contactor to drop out. Multi-speed and reversing controllers shall be arranged so that speed and direction changes are effected by a single operation. It shall not be possible for a motor to be in a different mode of operation than indicated by the associated switching device's identification plate. Multi-speed and reversing controllers shall use electrical and mechanical interlocks in their operations to preclude any short circuit condition. When timing relays are used to bypass safety switches during the starting period, the circuit shall be wired so that an opening in the relay circuit will prevent starting of the motor. The stop device of a controller shall be so connected that the controlled device will be de-energized and can be started again only upon actuating the start device. When the circuit arrangement incorporates ten or more control or timing relays, a programmable logic controller (PLC) shall be considered.

3.8 Reduced voltage controllers. Reduced voltage controllers shall provide closed circuit transition.

3.9 Load isolation. If specified (see 6.2), opening of the line contactors shall isolate all portions of the load from the line except control circuits and the incoming power terminals. A discharge circuit shall be provided for shunt field winding DC controllers.

3.10 Remote device circuits. Control circuit leads from controllers to remote devices shall be protected against damage from short circuits. Leads wired in series with current limiting parts, such as coils and resistors, which are located within the enclosure will be considered to be adequately protected. Leads not protected by current limiting parts within the enclosure shall be fused. When specified (see 6.2), remote indicating and monitoring circuits shall be independently fused so that a short circuit in these circuits will not prevent the controller from performing its function. When fuses larger than 10-ampere capacity are required, 15-or 20-ampere fuses shall be used as appropriate. Fuses that are used in conjunction with step-down transformers shall be sized based on the transformer or wiring capacity, whichever is smaller.

3.11 Overload protection. Overload protection shall be provided for the motor during starting and running conditions. Resetting, if not automatic, shall be accomplished by means external to the enclosure. When two single-pole relays are used with three-phase motors, resetting of the two relays shall be accomplished by a single button. Automatic reset overload relays shall not be used with controllers arranged for low voltage release (LVR). When an overload protection system requires external power, the power source shall be the motor power line or the motor control circuit. Overload protection shall not be provided in DC controllers for submarine service; however, provision shall be made for wiring to an over-speed trip module, if required (see 6.2).

3.12 Ambient temperature ratings. The ambient temperature rating for the motor controllers shall be in accordance with 3.12.1. The ambient temperature rating for the contactor and associated switching devices shall be in accordance with 3.12.1 and 3.12.2, as specified (see 6.2).

3.12.1 Rating 50 degrees Celsius (°C). The rating of the motor controllers, contactors, and associated switching devices shall be based on an ambient temperature of 50 °C for those installations where the maximum normal operating temperature of the surrounding atmosphere or other cooling medium is 50 °C or less. Motor controllers constructed for use in a 50 °C ambient temperature shall withstand exposure to an ambient temperature of 70 °C without damage.

3.12.2 Rating 65 degrees Celsius (°C). The rating of the contactors and associated switching devices shall be based on an ambient temperature of 65 °C for those installations where the maximum normal operating temperature of the surrounding atmosphere or other cooling medium is 65 °C or less but more than 50 °C. Contactors and associated switching devices constructed for use in a 65 °C ambient temperature shall withstand exposure to an ambient temperature of 85 °C without damage.

3.13 Wiring. Permanent internal wiring shall be copper wire or bus bar. The size, stranding, and insulation of wire, and the dimensions, insulation, and spacing of bus bars shall be mechanically and electrically suited to the application. Hook-up and lead wire shall be as specified in MIL-DTL-16878 or commercially similar UL listed types as approved by NAVSEA. Polyvinylchloride (PVC) insulation shall not be used. Magnet wire shall conform to ANSI/NEMA MW 1000. Wires connecting to resistors or Class H coils, and wires otherwise exposed to heat shall have a minimum temperature rating of 125 °C. The minimum temperature rating for all other wires shall be 105 °C. The minimum wire size shall be AWG 14, except that AWG 16 may be used for connections to local switches and that, at a minimum, AWG 22 may be used for all connections to the PLCs and selected solder connected devices as appropriate for device termination.

3.13.1 External cable connections. When the number of external control circuit conductors entering a controller is 12 or less, direct connection may be to the internal connection points. When more than 12 external control circuit conductors are required, connections shall be made to terminal boards located within the enclosure near the cable entrance. External power circuit conductors may be wired directly to the internal connection points. Terminal boards and direct connection points shall be accessible from the front of the enclosure. Circuitous routing of conductors shall be avoided.

3.14 Mounting. Parts mounted on panels shall be replaceable without removing the panel.

3.15 Endurance. Endurance requirements for manual controllers, contactors, switches, relays (except relays conforming to MIL-R-19523) and overload relays shall consist of the electrical and mechanical operations, as shown in table I. Control relays qualified under MIL-R-19523 shall not be considered for further qualification under this specification. A device will have failed the endurance test if at any point during the test specified in 4.6.2 the device fails to function mechanically or electrically (failure to make, carry, or break the load), there is welding of contacts, or at the conclusion thereof, the device fails to operate as required to pass the examination and general operation test specified in 4.5.

TABLE I. Endurance requirements.

Item	No. of operations [1/]	Percent of rated current		At percent rated voltage	Power-factor (lagging)
		Make	Break		
Manual controllers (AC)	25,000	600	100	100	1
Manual controllers (AC)	50	600	600	110	0.4 to 0.5
Manual controllers (AC)	25,000	Mechanical operations			
Manual controllers (DC)	25,000	400	100	100	
Manual controllers (DC)	50	400	400	110	
Manual controllers (DC)	25,000	Mechanical operations			
Contactors (AC):					
Size 0 through 5	50,000	600	100	100	1
Size 6	25,000	600	100	100	1
Size 7	12,500	600	100	100	1
Size 0 through 6	50	600	600	110	0.4 to 0.5
Size 7	25	600	600	110	0.4 to 0.5
Size 0 through 4	1,000,000	Mechanical operations			
Size 5 and 6	300,000	Mechanical operations			
Size 7	100,000	Mechanical operations			
Contactors (DC):					
Size 0 through 6	25,000	400	100	100	
Size 0 through 6	50	400	400	110	
Relays (except overload and relays conforming to MIL-R-19523)					
	AC – same requirements as for Size 0 AC contactors				
	DC – same requirements as for Size 0 DC contactors				
Switches	50,000	100	100	100	
	50	150	150	100	
	50,000	Mechanical operations			
Overload relays	500	100	100	100	1

NOTE:

[1/] One operation means one electrical make and break for each set of contacts.

3.16 Detail requirements.

3.16.1 Manual controllers. Size 1 manual controllers shall be arranged so that the overload device is defeated by holding down the start button. Emergency run features shall not be provided on Size 0 manual controllers.

3.16.2 Interlocks. Mechanical and electrical interlocks shall be provided between reversing or speed selection contactors to eliminate the possibility of a short circuit resulting from simultaneous closing of contactors.

3.16.3 Emergency run. When specified (see 6.2), magnetic controllers shall be provided with a means of defeating the overload relay for emergency running. This feature may be combined with the overload relay reset, or obtained with a separate push-button. Manual operation of the emergency run switch shall be required for the duration of the emergency. Emergency run shall not be combined with the start push-button.

3.16.4 Local transfer. When specified (see 6.2), controllers that are intended for use with remote switches shall have a local and remote selector switch. This local and remote selector switch will disconnect the remote control wiring and allow local control. This switch shall prevent a damaged remote switch or defective wiring from disabling the controller. Generally, a local and remote selector switch is required only for vital functions such as steering and fire pump control. In addition, newer controllers utilizing an electronic overload relay and communication module may be operated via a communication bus and may not employ a local/remote selector switch.

3.16.5 Contactors and relays. Coils shall be encapsulated as specified in MIL-E-917. Coil leads shall terminate at screw terminals. Contactor coils shall be readily replaceable. Contacts shall be of simple and rugged construction. Contactor contacts shall be easily replaceable. Contacts, other than sliding contacts, used in control circuits, shall not be plated, except with silver. Electrodeposited gold is permitted on control circuit contacts where arc voltages and currents are not exceeded. Springs shall be constructed to ensure the proper functioning of the relays and contactors. Springs shall not be stressed beyond their fatigue limits. The design shall be such that springs are not depended upon to carry current. All bolts, nuts, and screws used for mechanical connections shall be secured by split ring (helical spring) or external tooth lockwashers, locknuts, or double nuts. All electrical connections utilizing hex nut fasteners shall employ split ring lockwashers to maintain contact pressure and prevent loosening during vibration, shock, and thermal cycling. When the terminal mounting and wire connection is common, a captive fastener shall be used to prevent the terminal capscrew and screw from rotating when attaching or removing the wire lug. The contact assembly, as well as other current carrying parts of time delay relays, may be plated with electrodeposited gold for corrosion resistance purposes. Mating armature faces shall not be plated, painted, or coated in any manner that will interfere with correct electrical operation. Contactors and relays shall meet the endurance requirements specified in table I. The design of each contactor and relay shall incorporate EMI and arcing suppression devices, if required (see 6.2).

3.16.5.1 Relays. Relays shall conform to this specification except that control relays may be in accordance with MIL-R-19523, endurance Class A or B, shock Class I or II. MIL-R-19523 relays shall meet the applicable requirements of this specification. Electronic overload relay and associated communication devices shall have a communication port to support the network communication option as specified (see 6.2). The communication port shall be bidirectional communication for programming and monitoring. The overload relay communication protocol(s) shall meet ANSI/TIA/EIA 232 or ANSI standard communication protocol requirements. The network communication link shall provide status parameters of the overload device including those specified (see 6.2).

3.16.5.2 Time delay relays. Time delay relays shall be electromechanical, solid-state with electromechanical relay output, or solid-state with solid-state output. Setpoint repeatability at constant operating conditions shall be ±15 percent for electromechanical types, ±2 percent for solid-state knob adjustable and fixed RC types, and ±0.2 percent for solid-state discrete switch and fixed digital circuitry types. The reset time shall be 75 milliseconds maximum. Time delay relays shall meet the endurance requirements of table I.

3.16.6 Overload protection. General purpose overload relays shall be used to protect continuous duty, intermittent duty, and varying duty constant speed or multi-speed AC motors constructed in accordance with MIL-M-17059 or MIL-M-17060. Overload relays shall have tripping characteristics falling within the acceptable band shown on figure 1. When tripped at 150 percent of rated current in an ambient temperature of 20 °C to 30 °C, overload relays shall be re-settable within 2 minutes after tripping. Overload relays shall be constructed to trip within 3 hours when carrying rated relay current. The overload relay ultimate trip current rating shall be 115 to 125

percent of the motor identification plate current. The overload relay rating for magnetic controllers shall change not more than 3 percent for each 10 °C change in ambient temperature in the range between 20 °C and 70 °C. For manual controllers, the rating of the overload relay shall change not more than 5 percent for each 10 °C change in ambient temperature in the range between 20 °C and 70 °C. When specified (see 6.2), direct temperature sensing overload protection systems shall be used to protect variable speed motors (either variable voltage or variable voltage and frequency control systems) and motors where the duty cycle may be worsened by operator control or by operational mode which exceeds motor thermal limits because of mechanical or electrical characteristics of the motor or its load. Overload protection systems using temperature sensing devices in the motor winding shall be compatible with the temperature sensors. This system shall energize an alarm or de-energize the motor control. The system shall be fail safe. Overload relays shall be calibrated for operation at the 50 °C ambient temperature. Overload relays shall meet the endurance requirements specified in table I.

3.16.6.1 Electronic overload protection. Electronic overload relays can be used to protect motors described in 3.16.6. Electronic overload relays shall have tripping characteristics falling within the acceptable band shown on figure 1. Where overload values might exceed the limits of figure 1 adjustment and settings for the electronic overload relay shall be in accordance with the manufacturer technical guidance. Electronic overload relays shall include but not be limited to the following protection features unless otherwise specified (see 6.2):

a. Setup password protection
b. Low voltage protection (LVP)
c. Low voltage release (LVR)
d. Over current
e. Under current
f. Low voltage
g. High voltage
h. Single phasing
i. Voltage unbalance
j. Current unbalance
k. Phase reversal

3.16.7 Switches. Switches shall conform to the applicable specifications MIL-DTL-15291, MIL-S-18396, and MIL-DTL-21604 or applicable requirements of this specification. Endurance requirements of switches shall be as specified in table I. Each position of manual switches, other than spring return switches, shall have definite positioning that can be felt by the operator. Switch identification plates shall clearly indicate each position. Switches shall be mountable in any position.

3.16.7.1 Pressure switches. Pressure and differential pressure switches shall have the following features:

a. Vibration test shall be in accordance with 3.17.2.3 and 4.6.4.2.
b. Shock test shall be in accordance with 3.17.3.3 and 4.6.5.3.
c. Pressure connection shall be 7/16-20, female port, per SAE J1926/1.
d. Pressure switches shall be electromechanical unless otherwise approved by the contracting activity.
e. Electromechanical pressure sensing element to be diaphragm, bellows, or piston types (bourdon tubes not acceptable).
f. Pressure ranges and differentials specified by manufacturer.
g. Pressure switches shall withstand a pressure of at least three times the maximum operating pressure, but no longer need to be operational.
h. When specified (see 6.2), pressure switches shall be supplied with ambient pressure compensation.

3.16.7.1.1 Designations. Designations shall be assigned as specified (see 6.2) and listed in the format below:

*M2212-	-	A	-	1	-	A	-	A	-	1	-	1	-	1
R-Type		Circuit		Range		Cut In & Differential		Sensing Element		Voltage		Dimension		Pressure Switch Range

3.16.7.1.1.1 Type. The pressure switch type shall be designated by the single letter symbol as follows:

R - Pressure, regular

D - Pressure, differential

3.16.7.1.1.2 Circuit. The pressure switch circuit shall be designated by the single letter symbol as follows:

A - S.P.S.T. - single pole, single throw

B - S.P.D.T. - single pole, double throw

C - D.P.S.T. - double pole, single throw (2 normally open (NO) or 2 normally closed (NC))

C'- D.P.S.T. - double pole, single throw (1 NO and 1 NC)

D - D.P.D.T. - double pole, double throw (2 NO and 2 NC and 2 common terminals)

D'- D.P.D.T. - double pole, double throw (4 NC and 2 common terminals)

D"- D.P.D.T. - double pole, double throw (4 NO and 2 common terminals)

3.16.7.1.1.3 Ranges. Each standard pressure switch range and its maximum pressure shall be specified by the designator in tables II and III.

3.16.7.1.1.4 Cut in and differential. The pressure switch cut in and differential shall be designated by the single letter symbol as follows:

A - High close

B - High wide

C - Low close

D - Low wide

3.16.7.1.1.5 Sensing element. The pressure switch sensing element shall be one of the following components depending on the type of operation of the switch:

A - Bellows

B - Diaphragm

C - Piston

3.16.7.1.1.6 Voltage. The pressure switch voltage shall be designated by the single number symbol as follows:

1 - 440 VAC

2 - 115 VAC

3 - 230 VDC

4 - 115 VDC

3.16.7.1.1.7 Dimensions. The pressure switch dimensions shall be designated by a single letter symbol as follows:

1 - For regular switch:

Mounting hole separation distance: $2\frac{13}{32}$ inches with the space between left-side mounting hole and the housing edge as $1\frac{3}{16} + \frac{1}{8}$ inch and the space between the left-side mounting hole and the lower mounting hole is $3\frac{9}{32}$ inches vertically and $\frac{21}{32}$ inch horizontally, hole to hole tolerance is $\pm\frac{1}{32}$ inches.

Switch box housing (maximum): $3\frac{5}{16}$ inches (height) x $5\frac{1}{4}$ inches (width) x $5\frac{3}{16}$ inches (depth).

Sensor housing (maximum): 3⅞ inches

2 - For differential switch:
Mounting hole separation distance: 5¼ inches
Switch box housing (maximum): 3⅝ inches (height) x 5¼ inches (width) x 5⅜ inches (depth).
Sensor housing (maximum): 3⅞ inches

3 - Special (Other than the standard dimensions for regular switch)

4 - Special (Other than the standard dimensions for differential switch)

TABLE II. Range for pressure switches. 1/, 8/

Designator	Adjustment operating/working pressure range 1/	Maximum proof pressure 2/ (pound per square inch)	Maximum allowable variation from setting (plus or minus)	Optimum differential	Connection for pressure supply
1	15 to 28 inches mercury	5	6/	4/, 5/, 7/	3/
2	1 to 15 lb/in^2	80	6/	4/, 5/, 7/	3/
3	15 to 50 lb/in^2	125	6/	4/, 5/, 7/	3/
4	50 to 150 lb/in^2	200	6/	4/, 5/, 7/	3/
5	100 to 300 lb/in^2	400	6/	4/, 5/, 7/	3/
6	300 to 900 lb/in^2	900	6/	4/, 5/, 7/	3/
7	500 to 1500 lb/in^2	2000	6/	4/, 5/, 7/	3/
8	1000 to 5000 lb/in^2	5100	6/	4/, 5/, 7/	3/
9	Special (other than a standard range)				

NOTES:

1/ Unless otherwise specified (see 6.2), for pressure switches, the ranges to be specified are the operating pressure range and the resetting differential are relative to gauge pressure.

2/ Unless otherwise specified (see 6.2), is in gauge pressure.

3/ Unless otherwise specified (see 6.2), type of connection shall be in accordance with NAVSEA Drawing 804-1385850 that is, a mechanical threaded connection. Straight threads shall be standard for all new construction.

4/ Manufacturer's name and part number shall be given on the identification plate by which to obtain from manufacturer all the information for which headings are given in this table.

5/ Shall be as specified (see 6.2).

6/ Repeatability of all switches shall be within 1 percent of the maximum proof pressure for all switches rated for 200 PSI and above and within 0.5 percent of the maximum proof pressure for all others. Repeatability, plus operator error, plus gauge error equals maximum allowable variation from setting (tolerance).

7/ Differentials (make or break) will vary widely due to applications. Switch capabilities shall be as specified (see 6.2).

8/ If required, ambient pressure compensation (absolute pressure switch) shall be as specified (see 6.2).

TABLE III. Range for differential pressure switches. 1/

Designator	Adjustment operating/working pressure range 1/	Maximum proof pressure 2/ (pound per square inch)	Maximum allowable variation from setting (plus or minus)	Optimum differential	Connection for pressure supply
1	0.3 to 3 lb/in^2	5	6/	4/, 5/, 7/	3/
2	5 to 30 lb/in^2	80	6/	4/, 5/, 7/	3/
3	10 to 70 lb/in^2	125	6/	4/, 5/, 7/	3/
4	20 to 150 lb/in^2	200	6/	4/, 5/, 7/	3/
5	25 to 250 lb/in^2	400	6/	4/, 5/, 7/	3/
6	100 to 800 lb/in^2	900	6/	4/, 5/, 7/	3/
7	200 to 1300 lb/in^2	2000	6/	4/, 5/, 7/	3/
8	Special (other than a standard range)				

NOTES:

1/ Unless otherwise specified (see 6.2), for differential pressure switches, the ranges to be specified are the operating pressure range and the resetting differential are relative to pressure difference.

2/ Unless otherwise specified (see 6.2), is in gauge pressure.

3/ Unless otherwise specified (see 6.2), type of connection shall be in accordance with NAVSEA Drawing 804-1385850 that is, a mechanical threaded connection. Straight threads shall be standard for all new construction.

4/ Manufacturer's name and part number shall be given on the identification plate by which to obtain from manufacturer all the information for which headings are given in this table.

5/ Shall be as specified (see 6.2).

6/ Repeatability of all switches shall be within 1 percent of the maximum proof pressure for all switches rated for 200 PSI and above and within 0.5 percent of the maximum proof pressure for all others. Repeatability, plus operator error, plus gauge error equals maximum allowable variation from setting (tolerance).

7/ Differentials (make or break) will vary widely due to applications. Switch capabilities shall be as specified (see 6.2).

3.16.7.2 Temperature switches. Temperature switches shall have the following features:

a. Vibration test shall be in accordance with 3.17.2.4 and 4.6.4.3.
b. Shock test shall be in accordance with 3.17.3.4 and 4.6.5.4.
c. Temperature switches shall be electromechanical unless otherwise approved by the contracting activity.
d. Electromechanical temperature sensing element to be diaphragm and bellows.
e. Sensing bulb and capillary tube dimensions may differ as applicable.
f. Temperature ranges and differentials specified by manufacturer.
g. Sensing bulbs of temperature control shall be mounted in the position specified by the manufacturer.

3.16.7.2.1 Designations. Designations shall be assigned as specified (see 6.2) and listed in the format below for temperature switches:

M2212-	-	A	-	1	-	A	-	A	-	1	-	3	-	S	-	A	-	1
A Bulb Type		Circuit		Range		Cut In & Diff.		Sensing Element		Voltage		Conn. Tube Length		Bulb Size		Dimension		Temp. Switch Range

3.16.7.2.1.1 Bulb type. The temperature switch bulb type shall be designated by the single letter symbol as follows:

A - Cross ambient (warmer or colder than ambient)

B - Colder than ambient

C - Warmer than ambient

3.16.7.2.1.2 Circuit. The temperature switch circuit shall be designated by the single letter symbol as follows:

A - S.P.S.T. - single pole, single throw

B - S.P.D.T. - single pole, double throw

C - D.P.S.T. - double pole, single throw (2 NO or 2 NC)

C'- D.P.S.T. - double pole, single throw (1 NO and 1 NC)

D - D.P.D.T. - double pole, double throw (2 NO and 2 NC and 2 common terminals)

D'- D.P.D.T. - double pole, double throw (4 NC and 2 common terminals)

D"- D.P.D.T. - double pole, double throw (4 NO and 2 common terminals)

3.16.7.2.1.3 Ranges. Each standard temperature switch range and its maximum temperature shall be specified by the designator in table IV.

3.16.7.2.1.4 Cut in and differential. The temperature switch cut in and differential shall be designated by the single letter symbol as follows:

A - High close

B - High wide

C - Low close

D - Low wide

3.16.7.2.1.5 Sensing element. The temperature switch sensing element shall be one of the following components depending on the type of operation of the switch:

A - Remote (capillary tube)

B - Direct

C - Direct back angle for horizontal mounting

3.16.7.2.1.6 Voltage. The temperature switch voltage shall be designated by the single number symbol as follows:

1 - 440 VAC

2 - 115 VAC

3 - 230 VDC

4 - 115 VDC

3.16.7.2.1.7 Connection tube length. The temperature switch connection tube length shall be multiples of 5 feet.

3.16.7.2.1.8 Bulb size. The temperature switch bulb size shall be designated by the single letter symbol:

A - (⅜" x 3")

B - (11/16" x 3⅝")

C - (11/16" x 8¼")

D - (11/16" x 12")

E - (1⅛" x 6½")

F - (1⅛" x 14½")

G - (1⅛" x 30")

H - (11/16" x 3")

I - (11/16" x 4⅜")

N - Special (specified size other than a standard size)

3.16.7.2.1.9 Dimensions. The temperature switch dimensions shall be designated by a single letter symbol as follows:

A - For temperature switch:

Mounting hole separation distance: 2 13/32 inches with the space between left-side mounting hole and the housing edge as 1 3/16 + ⅛ inch and the space between the left-side mounting hole and the lower mounting hole is 3 9/32 inches vertically and 2 1/32 inch horizontally, hole to hole tolerance is ±1/32 inch.

Switch box housing (maximum): 3 5/16 inches (height) x 5¼ inches (width) x 5 3/16 inches (depth).

Direct sensor housing (maximum): 2½ inches.

Remote sensor housing (maximum): 5 inches.

B - Special (Other than the standard dimensions)

TABLE IV. Range for temperature switches.

Designator	Operating temperature range (°F)	Maximum proof temperature 1/ (°F)	Maximum allowable variation from setting (°F)	Optimum differential
1	-20 to 0	-	4/	2/, 3/, 5/
2	0 to 50	-	4/	2/, 3/, 5/
3	30 to 90	120	4/	2/, 3/, 5/
4	90 to 150	190	4/	2/, 3/, 5/
5	140 to 200	240	4/	2/, 3/, 5/
6	190 to 240	270	4/	2/, 3/, 5/
7	230 to 280	310	4/	2/, 3/, 5/
8	260 to 320	350	4/	2/, 3/, 5/
9	290 to 360	380	4/	2/, 3/, 5/
10	300 to 400	430	4/	2/, 3/, 5/

TABLE IV. Range for temperature switches - Continued.

Designator	Operating temperature range (°F)	Maximum proof temperature 1/ (°F)	Maximum allowable variation from setting (°F)	Optimum differential
11	375 to 480	500	4/	2/, 3/, 5/
12	Special (other than a standard range)			

NOTES:

1/ Maximum proof temperature is temperature at which the performance in the operating range will not be disturbed and shall exceed the maximum operating temperature.

2/ The manufacturer's name and part number shall be given on the identification plate by which to obtain from manufacturer all the information for which headings are given in this table.

3/ Shall be as specified (see 6.2).

4/ Repeatability of switches shall be within ±0.5 °F at the top of a range and ±1.5 °F at the bottom of a range, assuming controlled test conditions at a temperature change rate of 1 °F per minute in liquid with standard switch construction. Optional construction for applications will affect repeatability. Switches with optional construction shall have a repeatability within ±2 °F at the top of a range and ±5 °F at the bottom of a range in most cases. Switches with optional construction shall be marked with their repeatabilities. Repeatability, plus operator error, plus gauge error equals maximum allowable variation from setting (tolerance).

5/ Differentials (Make or Break) will vary widely due to applications. Switch capabilities shall be as specified (see 6.2).

3.16.7.3 Mechanical limit switches. Mechanical limit switches shall conform to this specification. Where practical, the switch assemblies utilized shall be in accordance with MIL-PRF-8805. Operational and design characteristics shall be as specified (see 6.2) and shall include:

a. Actuation configuration (roller, plunger, rod, lever, linkage, and so forth).

b. Operating force in pounds (lbs) or torque in inch-pounds (in/lbs).

c. Operator travel to actuate switch (inches or degrees).

d. Total operator travel (inches or degrees).

e. Operator reset travel (inches or degrees).

f. Electrical rating.

3.16.7.4 Solid-state proximity switches. Solid-state proximity shall conform to MIL-PRF-24711. Operational and design characteristics shall be as specified (see 6.2) and shall include:

a. Operating principle (inductive, hall effect, reed, and so forth).

b. Target description (ferrous metal, nonferrous metal, magnet, and so forth).

c. Target dimensions.

d. Sensing range (inches) and characteristic operational curve for slide-by and head-on modes.

e. Output switch type (electromechanical relay or solid-state switch).

f. Input and output electrical characteristics. Solid-state output switches data shall include leakage current, voltage drop, and all restrictive data.

3.16.7.5 Solid-state photoelectric switches. Solid-state photoelectric switches shall be of the modulated Light Emitting Diode (LED) operational configuration and shall conform to this specification. Operational and design characteristics shall be as specified (see 6.2) and shall include:

a. Operational mode (light or dark operated or selectable).

b. Scanning technique (direct or reflective).

c. Scanning range (inches) and characteristic operational curve.

d. Input and output electrical characteristics. Solid-state output switches data shall include leakage current, voltage drop, and all restrictive data.

3.16.8 Transformers. Control circuit transformers shall be rated and shall conform to MIL-T-16315. Devices powered by the transformer shall operate satisfactorily from Type I power and shall meet the operational requirements of this specification. Autotransformers shall be used only for reduced-voltage starting of motors.

3.16.9 Programmable logic controllers (PLC). When specified (see 6.2), a PLC shall be installed within the motor controller enclosure and shall perform normal programmed functions without operator interface. The PLC shall be in accordance with MIL-PRF-32006.

3.16.10 Variable speed drives (VSD). When specified (see 6.2), a VSD can be utilized to provide reduce voltage motor starting capability or variable speed motor control. The VSD shall be in accordance with MIL-PRF-32168.

3.16.11 Space heaters. When specified (see 6.2), controllers and switches in watertight or submersible enclosures with an enclosed volume larger than 150 cubic inches (in^3) shall be provided with space heaters to prevent condensation.

3.16.12 Indicator lights. If indicator lights are required, AC indicator lights shall conform to MIL-DTL-3661; MIL-L-3661/65 for 450-V service and 120-V service, or shall be a type satisfactory to NAVSEA. DC indicator lights shall conform to MIL-L-3661/63 or shall be a type satisfactory to NAVSEA. LED indicator lights that meet the requirements of A-A-59781 may be utilized provided the LED indicator lights have been subjected to all qualification requirements for the controller.

3.16.12.1 Indicating light colors. Indicating lights, when required, shall have the following colors (see 6.2):

a. Motor running: Green

b. Power available: White

3.16.13 Fuses and fuseholders. Fuses shall conform to Style F60 of MIL-PRF-15160 and MIL-PRF-15160/60. Existing controller designs may continue use of Style F61 fuses of MIL-PRF-15160/61. Fuseholders and associated clips shall be in accordance with A-A-55507, A-A-55507/1, A-A-55518/2, A-A-55518/3, A-A-55518/4, and UL512; all fuse clips shall be copper-clad steel type (material designation F) or silver-plated beryllium copper type (material designation N). The fuse type designation specified in MIL-PRF-15160 shall be permanently marked adjacent to each fuse block or fuseholder when space permits; otherwise, it shall be permanently marked in a conspicuous location.

3.16.14 Resistors and rheostats. Resistors and rheostats shall be in accordance with MIL-DTL-15109.

3.16.15 Controller characteristics. The following characteristics of controllers shall be as specified (see 6.2):

a. Voltage rating: (see 6.2)
   115 VAC, single-phase
   440 VAC, single-phase
   115 VAC, three-phase
   440 VAC, three-phase
   115 VDC
   230 VDC
   250 VDC (nominal) range 180 to 355 V, submarine service

b. Current rating: Current rating shall be as required by the applicable motor size specified in 3.16.16 (see 6.2).

c. Manual controllers: (see 6.2)
Type: Across-the-line
Protection: Overload relay
Function: Motor starting (low voltage release effect (LVRE))

d. Magnetic controllers: (see 6.2)
Type: Across-the-line
(1) single-speed
(2) multi-speed
Reduced voltage:
(1) Autotransformer
(2) Primary resistor
(3) Primary reactor
(4) Resistor (DC)
(5) Wye delta
Protection: LVP
LVR
Overload relay
Temperature sensor actuated
Function: Motor starting
Motor starting and reversing
Motor starting and speed regulation
Motor starting and speed selection
Motor starting, reversing, and speed selection
Miscellaneous

e. Switches: (see 6.2)

Type:	Manual	Automatic
	Push-button	Pressure
	Rotary selector	Thermostatic
	Drum	Limit
	Float	Proximity
		Photoelectric

Function: Usually to actuate a magnetic controller
Location: Local
Remote

3.16.16 Horsepower (hp) ratings. Controllers shall be provided in the sizes, and shall conform to the applicable horsepower and current rating, shown in tables V and VI.

TABLE V. Hp rating for DC contactors and controllers. (see 6.2)

Hp ratings of reduced-voltage magnetic controllers			
Size of controller	Continuous rating (amperes)	115 V hp rating	230 V hp rating (250 V nom)
1	25	3	5
2	50	5	10
3	100	10	25
4	150	20	40
5	300	40	75
6	600	75	150
7	900	110	225
Hp rating of full-voltage magnetic controllers			
Size of controller	Continuous rating (amperes)	Hp at	
		115 V	230 V
0	15	1	1
1	25	1½	2

TABLE VI. Hp rating for AC contactors and controllers. (see 6.2)

Rating of polyphase single-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty			
Size of controller	Continuous current rating (amperes)	Three-phase hp at	
		115 V	440 V
0	18	2	5
1	27	3	10
2	45	7½	25
3	90	15	50
4	135	30	100
5	270	--	200
6	540	--	400
7	810	--	600
Ratings for single-phase, full-voltage magnetic controllers for nonplugging and nonjogging duty			
Size of controller	Continuous current rating (amperes)	Single-phase hp at 115 V	
0	18	1	
1	27	2	
2	45	3	
Ratings of polyphase reduced-voltage, general purpose, reversing or nonreversing magnetic controllers			
Size of controller	Continuous current rating (amperes)	Three-phase hp at	
		115 V	440 V
1	27	3	10
2	45	7½	25
3	90	15	50
4	135	30	100
5	270	--	200
6	540	--	400
7	810	--	600

TABLE VI. Hp rating for AC contactors and controllers - Continued. (see 6.2)

Ratings for single-phase, reduced-voltage, general purpose, reversing or nonreversing magnetic controllers			
Size of controller	Continuous current rating (amperes)	Single-phase hp at 115 V	
1	27	2	
2	45	3	

Ratings of manual controllers for single-speed and multi-speed motors				
Size of controller	Three-phase 115 V	Single-phase		Continuous current rating amperes
		440 V	115 V	
0	1½	2	1	15
1	3	7½	1½	25

Ratings for wye-delta magnetic controllers for nonreversing, nonjogging duty for open or closed-circuit transition		
Size of controller	Continuous current rating (amperes)	Three-phase hp at 440 V
1	47	15
2	78	40
3	156	75
4	233	150
5	467	300
6	935	700
7	1400	1000

Ratings for nonreversing, nonjogging, reduced-voltage, polyphase magnetic controllers for motors for partwinding starting		
Size of controller	Continuous current rating (amperes)	Three-phase hp at 440 V
1	54	20
2	90	50
3	180	100
4	270	200
5	540	400

TABLE VI. Hp rating for AC contactors and controllers - Continued. (see 6.2)

Ratings for multi-speed, magnetic controllers for nonplugging and nonjogging duty for constant-horsepower motors			
Size of controller	Continuous current rating (amperes)	Three-phase hp at	
		115 V	440 V
0	18	1	3
1	27	2	7½
2	45	---	20
3	90	---	40
4	135	---	75
5	270	---	150
6	540	---	300
7	810	---	450

3.16.17 Enclosures. Enclosures shall be in accordance with MIL-E-2036 and MIL-STD-108. The enclosure shall be one of the following types, as specified (see 6.2):

a. Dripproof (45 degrees)
b. Watertight
c. Submersible (15 feet)
d. Explosion-proof (Class 1, Group D)
e. Splashproof

3.16.17.1 Special provisions for enclosures. If the degree of enclosure is not specified, dripproof (45 degrees) enclosures shall be used for controllers, and watertight enclosures shall be used for associated switching devices. Watertight and submersible enclosures larger than 60 in^3 shall have a moisture drain in the bottom. The opening shall be closed with a ¼-inch pipe plug. Enclosures shall be constructed so that all necessary cables can be brought into either the top or bottom. Enclosures larger than 4 ft^3 shall have removable cable entrance plates. Each enclosure shall be constructed to support itself and its parts when deck or bulkhead mounted. Fans shall not be used. Enclosures shall be constructed to allow cable entrance by one of the following methods:

a. Stuffing tube in accordance with ASTM F1836M.
b. Female National Taper Pipe Thread (NPT).

3.16.17.2 Large enclosures. Enclosures larger than 1.5 ft^3, except explosion-proof enclosures, shall have hinged doors. Doors wider than 18 inches shall be removable, and the removal shall require not more than 18 inches of free space in front of the enclosure. Doors on dripproof enclosures shall be secured by captive thumb screws or other fasteners with all parts captive. Doors on watertight and submersible enclosures shall be secured by captive screws.

3.16.17.3 Small enclosures. Enclosures 1.5 ft^3 and smaller may have hingeless removable covers provided that no electrical devices are mounted on the cover.

3.16.17.4 Plastic enclosures. Plastic enclosures shall have any penetration of the enclosure completely insulated from possible electrical contact with internal conductors.

3.16.17.5 Aluminum enclosures. Aluminum enclosures shall have any penetration of the enclosure completely insulated from possible electrical contact with internal conductors.

3.16.17.6 Basic dimensional limits. Basic dimensional limits of the enclosures shall be in accordance with table VII.

TABLE VII. Basic dimensions of enclosures.

Across-the-line			
Size	Height (inches)	Width (inches)	Depth (inches)
0	30	30	10
1	30	30	10
2	30	30	10
3	30	30	10
4	30	30	10
5	40	40	15
6	50	40	25
7	50	40	25
Reduced-voltage			
0	45	35	15
1	45	35	15
2	45	35	15
3	45	35	15
4	65	35	30
5	95	40	30
6	95	50	30
7	95	50	30

3.16.18 Safety. Electrical safety shall be in accordance with the requirements of MIL-E-917.

3.16.19 Painting. Parts not constructed of corrosion-resisting material, or having a corrosion-resistant treatment as specified in MIL-E-917, shall be painted as specified therein. Touching-up is permitted for marks or scratches due to assembly, testing, or other handling.

3.16.20 Identification plates. Each controller shall have an identification plate containing the manufacturer's name, catalog number, national stock number (NSN), if specified (see 6.2), voltage, frequency, and maximum horsepower rating, and low noise, if applicable. Each associated switching device shall have identification containing sufficient information to identify and reorder the item with information available in the controller technical manual. Preferred location of the information is inside the enclosure of the controller and on the outside of switch housings. Identification plates shall be not less than 0.020 inch in thickness, and shall be brass, corrosion-resistant steel, or anodized aluminum marked by etching, engraving, stamping, or photo-processing. Etching,

engraving, or stamping shall be not less than 0.003 inch deep. Identification plates, when used for associated devices, shall be securely fastened to the device. Where metal fasteners are not used, adhesive backed metal (not less than 0.010 inch in thickness) on plastic film, Type G as specified in MIL-I-631 may be used. Items that cannot be provided with a plate, such as tubular ceramic resistors, may be marked by stamping with a permanent ink and covered by a protective coating that shall withstand the temperature characteristics the part will exhibit. Controllers and switches shall be permanently and clearly marked with an identification plate showing the function of each position subject to manual operation. Controllers having more than one source of power shall be provided with an identification plate warning stating "WARNING all power sources shall be disconnected before working on the controller." The word "WARNING" shall be established in accordance with MIL-E-917. The plate shall be mounted on the front of the enclosure. When the controlled device is protected by special circuitry in the controller, the identification of the associated sensor shall be clearly marked on an identification plate on the controller. Laser marking of nameplates may be applied.

3.16.21 Terminals and terminal boards. Power current carrying studs, screws, and other current carrying components of power connections shall be constructed of nonferrous materials. Control current carrying components or connections shall be constructed of either nonferrous materials or silver-plated ferrous materials. Where practical, terminal boards shall be in accordance with A-A-59125. Construction materials shall be durable and corrosion-resistant.

3.16.22 Equipment capacitance and EMI filters. Where EMI filters are required, line-to-line filters are preferred to line-to-ground filters (see 3.17.8). AC line-to-ground capacitance shall be in accordance with MIL-STD-1399-300 and MIL-STD-461.

3.17 Performance.

3.17.1 Temperature rise. When tested as specified in 4.6.1, temperature rises shall not exceed the values shown in table VIII. Coil rises shall be determined by the resistance method. All other rises shall be measured by thermocouple or thermometer.

TABLE VIII. Maximum temperature rise.

Part	Allowable temperature rise over ambient (°C)	
	50 °C ambient	65 °C ambient
Shunt coils:		
Class A insulation	60	45
Class B insulation	85	70
Class F insulation	110	95
Class H insulation	135	120
Series coils: Single layer		
Class A insulation	50	35
Class B insulation	70	55
Class F insulation	95	80
Class H insulation	120	105
Bare or enameled	65	50

TABLE VIII. Maximum temperature rise - Continued.

Part	Allowable temperature rise over ambient (°C)	
	50 °C ambient	65 °C ambient
Series coils: Multi layer		
Class A insulation	40	25
Class B insulation	60	45
Class F insulation	85	70
Class H insulation	110	95
Contacts	70	55
Terminal studs and bolted connections:		
Silver-plated	65	50
Not silver-plated	50	35

3.17.2 Vibration. Equipment shall withstand the vibration test specified in 4.6.4 without mechanical damage, contact chatter, transfer, or other electrical malfunctioning. Vibration test frequency shall be 4 to 33 Hz. Equipment which will be exposed to frequencies above 33 Hz shall be vibrated up through 50 Hz, unless otherwise specified (see 6.2). Equipment shall not fail to function in any operational mode, including energized and de-energized conditions, during the vibration. Pre- and post-test examination and general operation test shall verify equipment performance.

3.17.2.1 Resilient mounting. Controllers utilizing resilient mounts shall be vibration tested as specified in 4.6.4 and 4.6.5 with the resilient mounts installed as specified (see 6.2).

3.17.2.2 Time delay relays. Time delay relays shall maintain their set time delay and shall maintain the setpoint repeatability specified in 3.16.5.2 after vibration testing as specified in 4.6.4.1. Post-test reference measurement of setpoint repeatability and variation of indicated time delay shall conform to the requirements of 3.16.5.2.

3.17.2.3 Pressure switches. When operated during vibration as specified in 4.6.4.2, pressure switches shall maintain their setpoint and shall function properly with a setpoint repeatability within 3 times the stated repeatabilities specified in note 6 of tables II and III. State transfer shall be positive without contact chatter or hang-up. Post-test reference measurements shall conform to the requirements of 3.16.7.1, and shall verify retention of the pre-test established setpoint.

3.17.2.4 Temperature switches. When operated during vibration as specified in 4.6.4.3, temperature switches shall maintain their setpoint and shall function properly with a setpoint repeatability within 3 times the stated repeatabilities of note 4 of table IV. Post-test reference measurements shall conform to the requirements of 3.16.7.2 for setpoint repeatability and differential, and shall verify retention of the pre-test established setpoint.

3.17.3 Shock. Equipment shall withstand the high-impact shock test specified in 4.6.5 without change of operational state, mechanical or electrical damage, or electrical malfunction. Equipment shall not fail to function in any operational mode as a result of the shock test. Pre- and post-test examination and general operation test shall verify equipment performance. Contact performance during impact shall be as follows:

a. AC line contacts. When shock tested as specified in 4.6.5.1.1, closed line contacts of contactors may not open for more than 200 milliseconds. Open line contacts shall not close for more than 20 milliseconds.

b. DC line contacts. The closed line contacts of contactors shall not open for more than 500 milliseconds when shock tested as specified in 4.6.5.1.2. Open line contacts shall not close for more than 75 milliseconds.

c. Associated switching device contacts. Closed contacts may open, or open contacts may close, for a duration of not more than 10 milliseconds for all pressure and temperature switches as well as for timing relays that are designed for vital applications. Closed contacts may open, or open contacts may close for a duration of not more than 20 milliseconds for the other relays and switches designed for non-vital applications unless otherwise specified (see 6.2). The equipment shall not alter state when tested as specified in 4.6.5.1.3.

d. Auxiliary contacts. Closed contacts shall not open more than 20 milliseconds. Open contacts shall not close for more than 20 milliseconds unless otherwise specified (see 6.2). Test conditions shall be as specified in 4.6.5.1.3.

e. Assembled controller contacts. Assembled controllers utilizing components and devices qualified to this specification shall meet the contact performance requirements specified for the applicable line contacts. Other contacts shall be monitored for qualitative analysis only.

3.17.3.1 Overload relays. Overload relays shall not trip when carrying up to 85 percent of the ultimate tripping current.

3.17.3.2 Time delay relays. Time delay relays shall maintain their set time delay and shall maintain the setpoint repeatability specified in 3.16.5.2 after shock testing as specified in 4.6.5.2. Post-test reference measurements shall conform to the requirements of 3.16.5.2.

3.17.3.3 Pressure switches. Pressure switches shall withstand the tests specified in 4.6.5.3 without damage other than a shift in setpoint which shall not exceed 3 percent for the 18 blows. Post-test reference measurements shall conform to the requirements of 3.16.7.1.

3.17.3.4 Temperature switches. Temperature switches shall withstand the tests specified in 4.6.5.4 without damage other than a shift in setpoint which shall not exceed 3 percent for the 18 blows. Post-test reference measurements shall conform to the requirements of 3.16.7.2.

3.17.3.5 Resilient mounting. When the momentary opening of closed contacts, or the momentary closing of open contacts, of components within a controller as specified in 3.17.3 is not acceptable, resilient mounts may be utilized as approved by the contracting activity. Resilient mounts shall be helical cable (wire rope) type constructed of noncorrosive nonferrous materials (except fasteners) and shall meet the requirements of MIL-S-901, MIL-STD-167-1, and the salt spray test, Method 101D, 96 hours, of MIL-STD-202. Controllers with resilient mounts attached shall meet the requirements of 3.17.3 when shock tested as specified in 4.6.5 (see 6.2).

3.17.4 Insulation resistance. Insulation resistance shall be not less than 10 megohms when tested as specified in 4.6.7.

3.17.5 Dielectric. Controllers, contactors, and associated switching devices shall withstand the dielectric tests specified in 4.6.8 without electrical breakdown such as corona, flashover, spark over (surface discharge) or breakdown (puncture).

3.17.6 Terminal strength. The terminals of the contactors and control relays shall withstand the terminal strength requirements of MIL-STD-202 when tested as specified in 4.6.13.

3.17.7 Inclination. Controllers, contactors, and associated switching devices shall meet the following requirements for inclined operation when tested as specified in 4.6.6:

a. Surface ships. Equipment shall operate when permanently inclined in any direction at any angle up to 15 degrees from the normal operating position. Equipment shall be constructed to function without damage during

temporary inclinations such as produced by ship's rolling of 45 degrees in any direction from the normal operating position.

b. Submarines. Equipment shall operate when permanently inclined in any direction at any angle up to 30 degrees from the normal operating position. Equipment shall be constructed to function without damage during temporary inclinations such as produced by ship's rolling of 60 degrees in any direction from the normal operating position.

3.17.8 EMI. All electronically-based control circuit devices and associated switching devices shall meet the EMI requirements of MIL-STD-461 and DOD-STD-1399-70-1 for surface ship and submarine equipment when tested as specified in 4.6.14.

3.17.9 Pickup and dropout voltage. When tested as specified in 4.6.11, AC contactors and relays shall pull in (pickup and seal) below 80 percent and drop out above 10 percent of rated voltage. DC contactors and relays for surface ships shall pull in below 68 percent and drop out above 5 percent of rated voltage. Surface ship AC and DC contactors and relays shall operate between the pull in voltage and 110 percent of rated voltage. DC (250 V nominal) contactors and relays for submarines shall pull in below 160 VDC and drop out above 13 VDC. Submarine DC contactors and relays shall operate between the pull in voltage and the upper limit specified (see 3.4.2.2).

3.17.10 Noise. When specified (see 6.2), AC controllers for low noise applications shall meet the structureborne noise requirements for Type III equipment of MIL-STD-740 or if specified, MIL-STD-740-2, and airborne noise requirements for Grade A3 and A12 equipment of MIL-STD-740-1.

3.17.11 Electrical service conditions. Motor controllers and other solid-state switching devices, shall operate properly under the electrical service conditions specified herein.

3.17.11.1 Steady-state voltage and frequency. Equipment shall operate satisfactorily when tested as specified in 4.6.17.

3.17.11.2 Transient voltage and frequency. Equipment shall operate satisfactorily when tested as specified in 4.6.18.

3.17.11.3 Spike voltage. Equipment shall operate satisfactorily when tested as specified in 4.6.19.

3.17.11.4 Power interruption. Equipment shall operate satisfactorily when tested as specified in 4.6.20.

3.17.11.5 Leakage current. When tested as specified in 4.6.21, the leakage current shall be limited to 5 milliamperes (mA) root mean square (rms). Leakage current shall be determined using a solidly grounded power source. Equipment with EMI filters connected line-to-ground shall be balanced to ensure that the leakage current in the equipment ground does not exceed 5 mA.

3.17.11.6 Output leakage current. When tested as specified in 4.6.22, the OFF state leakage current in the output circuit of solid-state relays, contactors, and switching devices shall not exceed the values specified in table IX.

TABLE IX. Solid-state switch output leakage current values.

Solid-state switch current rating (amperes)	Output leakage current value	
	Auxiliary/control circuit contacts (milliamperes root mean square)	Main contacts (milliamperes root mean square)
Less than 25 A AC	5.0	10.0
25 A AC or more	10.0	25.0
All DC	0.1	NA

3.17.11.7 Output voltage drop. When solid-state switching devices are tested as specified in 4.6.23 the ON state output voltage drop shall not exceed the values specified in table X.

3.17.11.8 Voltage ramp rate. Equipment required to operate under the condition of voltage ramp (see 6.2) shall perform satisfactorily when tested as specified in 4.6.27.

TABLE X. Solid-state switch output voltage drop.

Solid-state switch voltage rating	Maximum ON state voltage drop (volts peak)
5-75 VDC	2.0
90-250 VDC	3.0
115/440 VAC	2.0
115 VAC 1/	4.0
440 VAC 1/	8.0

NOTE:
1/ Devices series connected with the load.

3.18 Workmanship. The motor controller, including all parts and accessories, shall be free from cracked or displaced parts, burrs, sharp edges, and other defects that will detrimentally affect life and serviceability. Particular attention shall be given to neatness and thoroughness of soldering, marking of parts and subassemblies, wiring, welding and brazing, plating, riveting, finishes, machine operations and screw assemblies.

4. VERIFICATION

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

a. Qualification inspection (see 4.3).

b. Conformance inspection (see 4.4).

4.2 Inspection conditions. Unless otherwise specified (see 6.2), all inspections shall be performed in accordance with the test conditions specified in MIL-E-917.

4.3 Qualification inspection. Qualification inspection shall be conducted at a laboratory satisfactory to the contracting activity. Qualification inspection shall consist of the examination and tests specified in table XI, and shall be conducted in the order specified in 4.3.2.

TABLE XI. Qualification inspection.

Inspection	Requirement	Test method
Examination and general operation 1/, 2/, 3/, 4/	3.2 through 3.14, 3.16, 3.18	4.5
Overload protection 1/, 2/	3.11	4.6.3
Effectiveness of enclosure 6/	3.16.17	4.6.9
Temperature rise 1/	3.17.1	4.6.1
Endurance 1/, 2/	3.15	4.6.2
Vibration 1/, 2/, 3/, 4/	3.17.2	4.6.4
Shock 1/, 2/, 3/, 4/	3.17.3	4.6.5
Insulation resistance 1/ 2/	3.17.4	4.6.7
Dielectric 1/, 2/, 4/	3.17.5	4.6.8
Terminal strength 1/, 2/	3.17.6	4.6.13
Inclination 1/, 2/, 3/	3.17.7	4.6.6
EMI 2/, 7/	3.17.8	4.6.14
Pickup and dropout voltage 1/, 2/, 4/	3.17.9	4.6.11
Voltage variation 4/	3.4.1, 3.4.2	4.6.12
Noise 7/	3.17.10	4.6.10
Steady-state voltage and frequency 2/	3.17.11.1	4.6.17
Transient voltage and frequency 2/	3.17.11.2	4.6.18
Spike voltage 2/	3.17.11.3	4.6.19
Power interruption 2/	3.17.11.4	4.6.20
Leakage current 2/	3.17.11.5	4.6.21
Output leakage current 2/	3.17.11.6	4.6.22
Output voltage drop 2/	3.17.11.7	4.6.23
Voltage ramp rate 7/, 8/	3.17.11.8	4.6.27
Relay setpoint repeatability 5/	3.16.5.2	4.6.15
Relay recycle time 5/	3.16.5.2	4.6.16
Switch setpoint repeatability 3/	3.16.7.1, 3.16.7.2	4.6.24
Mechanical interlock 1/, 4/	3.16.2	4.6.25

TABLE XI. Qualification inspection - Continued.

NOTES:

1/ Test applies for qualification of individual contactors and associated switching devices.

2/ Test applies for qualification of solid-state associated switching devices.

3/ Test applies for qualification of pressure and temperature switches.

4/ Test applies for qualification of controllers which are assembled with components qualified to this specification. Completely assembled nonreversing dripproof motor controller of each size for only the following basic types: Across-the-line (single-speed and two-speed); reduced voltage (autotransformer, primary resistor, primary reactor, wye-delta, and resistor).

5/ Test applies only to qualification of time delay relay.

6/ Test applies to any device with an enclosure.

7/ When required (see 6.2).

8/ Test applies to qualification of devices operated under the condition of voltage ramp.

4.3.1 Samples for qualifications. One to five samples of each type contactor, controller, or associated switching device, for which qualification is desired, shall be submitted for qualification testing.

4.3.2 Order of tests. Unless otherwise specified (see 6.2), the tests for general operation, effectiveness of enclosure, insulation resistance, dielectric, pickup and dropout, terminal strength, voltage variation, overload protection, and voltage ramp shall precede and follow shock and vibration tests. The endurance test shall precede the shock test.

4.3.3 Disposition of qualification units. Samples subjected to qualification inspection shall be considered consumed and nondeliverable as specified (see 6.2).

4.3.4 Failures. If a sample fails to pass qualification inspections, NAVSEA shall be notified. The manufacturer shall identify cause of failure and take corrective action on the materials, processes, or design as warranted. New test samples shall be manufactured in accordance with the corrective measures and submitted for retest, or the failed samples may be modified to incorporate the corrective measures and resubmitted for test. The corrected test samples shall then be subjected to all of the table XI qualification inspection tests.

4.4 Conformance inspection. Conformance inspection shall be as specified in table XII and be conducted in a 3-year interval.

4.4.1 Group A inspection. Each equipment provided shall be subjected to the Group A inspections specified in table XII. Equipment that fails any test may be corrected and retested. Any equipment so corrected or reworked shall be submitted to the contracting activity or its representative for approval before being accepted or installed in an assembled controller. Equipment so corrected shall be subjected to all of the Group A inspections.

4.4.2 Group B inspection. Group B inspections shall be conducted when, after initial qualification, changes in the basic construction or materials that would affect performance are made. Group B inspections may also be required if manufacturing facilities are changed or relocated. Inspections will include those qualification inspections of table XI as directed by NAVSEA.

TABLE XII. Conformance inspection.

Inspection	Requirement	Test method
Group A Inspection		
Examination and general operation 1/, 2/, 3/	3.2 through 3.14, 3.16, 3.18	4.5
Shock 1/, 2/, 4/, 5/	3.17.3	4.6.5
Insulation resistance 1/, 2/	3.17.4	4.6.7
Dielectric 1/, 2/, 3/	3.17.5	4.6.8
Pickup and dropout voltage 1/, 2/, 3/	3.17.9	4.6.11
Voltage variation 3/	3.4.1, 3.4.2	4.6.12
Noise 6/	3.17.10	4.6.10
Voltage ramp rate 6/, 7/	3.17.11.8	4.6.27
Relay setpoint repeatability 4/	3.16.5.2	4.6.15
Relay recycle time 4/	3.16.5.2	4.6.16

NOTES:

1/ Test applies for individual contactors and associated switching devices.

2/ Test applies for solid-state associated switching devices.

3/ Test applies for controllers which are assembled with components qualified to this specification. Completely assembled nonreversing dripproof motor controller of each size for only the following basic types: Across-the-line (single- and two-speed); reduced voltage (autotransformer, primary resistor, primary reactor, wye-delta, and resistor).

4/ Test applies only to time delay relays.

5/ Test applies for pressure and temperature switches.

6/ When required (see 6.2).

7/ Test applies to qualification of devices operated under the condition of voltage ramp.

TABLE XIII. Routine inspection.

Inspection	Requirement	Test method
Examination and general operation 1/, 2/, 4/	3.2 through 3.14, 3.16, 3.18	4.5
Dielectric 1/, 2/, 4/	3.17.5	4.6.8
Pickup and dropout voltage 1/, 2/, 4/	3.17.9	4.6.11
Noise 3/	3.17.10	4.6.10
Voltage ramp rate 3/, 5/	3.17.11.8	4.6.27

NOTES:

1/ Test applies for individual contactors and associated switching devices.

2/ Test applies for solid-state associated switching devices.

3/ When required (see 6.2).

4/ Test applies for all motor controllers.

5/ Test applies to qualification of devices operated under the condition of voltage ramp.

4.4.3 Failures. If any equipment fails to pass Group A or Group B inspections, the Government contract office shall be notified. The contractor shall identify the cause of failure and take corrective action on the materials or processes, or both, as warranted, and on all units of the products manufactured under essentially the same materials and processes. Shipment of the product shall not be initiated until corrective action has been taken. After corrective action has been taken, Group A or Group B inspection (all tests and examinations or the test which the original sample failed, at the option of the Government contract office) shall be repeated on another sample unit. Final acceptance and shipment shall be withheld until the Group A or Group B inspections have shown that corrective action was successful. Samples which have satisfactorily passed the examination and tests may be applied as part of the quantity specified if approved by the contracting activity.

4.4.4 Routine inspection. The routine inspection specified in table XIII shall be performed on each equipment furnished (100 percent inspection) including each component of a motor controller that consists of several parts.

4.5 Examination and general operation. Equipment shall be examined to determine that the material, safety to operating personnel, and construction are in accordance with the requirements of this specification without disassembling the unit in such a manner that its performance, durability, or appearance would be affected. The general operation shall include energizing and operating the equipment to ascertain that the required operating features of the unit function properly. In particular, it shall be determined that the required sequence of operation has been attained and that the protective devices, as applicable, operate as required. External devices shall be simulated as necessary to perform operational tests. Specific electrical loads are not required but at least one set of each type of contact on every device shall be monitored by suitable means (voltage recorder, ohmmeter, indicator light, and so forth) to check the opening and closing performance. For qualification and conformance testing of solid-state devices that are programmable and have networking-interfacing capabilities, the following additional requirements are included:

a. Test and demonstrate all executable commands and status requests for all installed network interface protocols (see 3.16.5.1 and 3.16.6).

b. Test and demonstrate the operation of all inputs and outputs via both local and network protocol commands as appropriate for all configurations the device is capable of being configured (i.e., single-speed, multi-speed, reversing, etc.).

c. Test and demonstrate all configuration types to which the device is capable of being configured (i.e., single-speed, multi-speed, reversing, etc.).

d. Test and demonstrate proper operation of the LVP and LVR modes for all available configurations.

e. Demonstrate ability to display firmware version locally or via network interface if applicable.

f. Demonstrate password protection configuration feature, if installed.

4.6 Tests. All tests will be conducted at an ambient temperature range between 10 °C and 40 °C except for the temperature rise test, and pickup and dropout voltage tests for qualification and conformance inspections.

4.6.1 Temperature rise. Temperature rise tests shall be performed for conformance inspection on the first production run only. Temperature rise tests are not required on subsequent production runs unless a change is made in design. The test methods used and the precautions observed in conducting temperature rise tests shall be in accordance with NEMA ICS 1 and the following:

a. Temperature rise tests shall be made under conditions equivalent to normal operating conditions at rated voltage, frequency, and load, with the duty specified to determine that the rises specified in 3.17.1 are not exceeded.

b. Tests shall be made with equipment in its enclosure if enclosure is provided as part of the equipment.

c. The ambient temperature in the testing area shall vary not more than 10 °C during tests.

4.6.1.1 Reduced voltage controllers. Starting autotransformers, reactors, and resistors shall be tested to determine conformance to temperature rise limits specified in NEMA ICS 2.

4.6.2 Endurance. Endurance tests shall be conducted between 10 and 20 operating cycles per minute, except tests making and breaking 600 to 400 percent of rated current shall be conducted at 6 operating cycles per minute (closed 1 second, open 9 seconds). Tests making and breaking 600 to 400 percent of rated current, and where practical all other tests, shall be performed continuously without interruption. Tests breaking 100 percent rated current may be stopped and restarted for convenience provided each operational test period lasts a minimum of 6 hours. Mechanical operational tests may be stopped and restarted as necessary. Mechanical operational tests are not required for solid-state devices. A malfunction causing shutdown or out of specified limit performance during this period shall constitute a failure requiring corrective action. A failure has not occurred if malfunction can be attributed to external causes such as ambient temperature over the specified temperature, variation of input power parameters beyond specified limits, operator's error, and other unusual conditions. Equipment shall meet the requirements specified in 3.15. If a failure occurs during the run, the cause shall be determined and correction(s) made.

4.6.2.1 Restarting endurance test. Upon completion of corrective action after malfunction, the equipment shall be restarted from the first operation.

4.6.2.1.1 Termination of endurance run. In the event that an endurance run is incomplete after more than three failures have occurred during the test, the test shall not be continued unless approved by the contracting activity.

4.6.3 Overload protection. Overload relays shall be tested for tripping characteristics (see 4.6.3.1). Resetting time and temperature compensation shall be as specified in 3.16.6.

4.6.3.1 Tripping characteristics. Overload relays shall be tested in a 50 °C ambient at 110, 125, 150, 300, and 500 percent of rated current to determine that the tripping characteristic falls within the acceptable band shown on figure 1. Tests may be conducted at room ambient temperature if the appropriate temperature compensation correction factor for the deviation from specified ambient temperature (see 3.16.7.1.h) is applied as specified in 3.12. Relays shall be tested using the lowest, the highest, and a median rated heater or coil.

4.6.3.2 Special temperature sensing circuitry. Special circuitry for direct temperature sensing and protection of the controlled device shall be tested throughout its operating range with a sensor similar to that used in the protected device.

4.6.4 Vibration. Before vibration testing, an examination and general operation test shall be performed. The equipment shall then be subjected to the Type I vibration tests as specified in MIL-STD-167-1 for conformance to 3.17.2. Equipment shall be operated at nominal voltage and frequency during the tests and mounted in a fashion to simulate shipboard conditions, including sway bracing when required. During the variable frequency tests the equipment shall be operated in normal operational modes to verify that all features and devices are functioning correctly. During the endurance tests, the operational checks will be performed at 60-minute intervals. External devices shall be simulated as necessary to perform the operational checks. Specific electrical loads are not required but at least one set of each type of contact on every device shall be monitored by suitable means (voltage recorder,

ohmmeter, indicator light, and so forth) to check the opening and closing performance. When testing individual devices each set of contacts shall be monitored. For electronically-based control circuit devices and associated switching devices vibration testes shall be conducted with all inputs and outputs operating or powered and monitored to ensure they do not change state. After the vibration test, an examination and general operation test shall verify performance.

4.6.4.1 Time delay relays. Time delay relays shall be adjusted to any convenient setpoint for vibration testing. Performance shall conform to 3.17.2.2. Post test reference measurements shall verify that the set time delay has not changed and that setpoint repeatability and variation of the indicated time delay conform to 3.16.5.2.

4.6.4.2 Pressure switches. Pressure switch setpoints shall be adjusted to 50±5 percent of the range. Pressure switches shall be actuated at 5-Hz intervals (5, 10, 15, and so forth) during the test and shall perform as specified in 3.17.2.3. At each frequency of vibration pressure shall be applied to the pressure switch and shall be varied over the specified operational interval. Pressure switches with ranges less than or equal to 100 psig shall be operated between 10 percent above the setpoint and 10 percent below the reset point; pressure switches with ranges greater than 100 psig shall be operated between 5 percent above the setpoint and 5 percent below the reset point. Performance shall conform to 3.17.2.3. Post-test reference measurements without adjustments shall verify retention of the pre-test setpoint and conformance to the requirements of 3.16.7.1.

4.6.4.3 Temperature switches. Temperature switch setpoints shall be adjusted to 50±5 percent of the range. Temperature switches shall be actuated at 5-Hz intervals (5, 10 15, and so forth) during the test and shall perform as specified in 3.17.2.4. The temperature of the applied actuating medium need not be measured but should not exceed the switches maximum temperature. Hot air guns and vortex tubes are recommended. Post-test reference measurements without adjustments shall verify retention of the pre-test setpoint and conformance to the requirements of 3.16.7.2.

4.6.5 Shock. Shock tests shall be conducted in accordance with MIL-S-901 to determine conformance to 3.17.3. Tests shall be performed under light, medium, or heavy weight classifications, as required. Controllers, contactors, and electrically operated associated switching devices shall be shock tested in the de-energized and each of the normal energized conditions. Momentary contact associated switching devices such as push-button switches and spring return lever switches shall be tested in the normal position (not actuated). Other associated switching devices that may remain in more than one position shall be tested with contacts actuated and not actuated. Specific electrical tests (insulation resistance, dielectric and pickup and dropout) shall be made as necessary to determine satisfactory performance following the shock test. For controllers and associated switching devices mounted separately on the ships structure, MIL-S-901 bulkhead fixtures shall be used (Fixture 4A mounting for lightweight tests). For individual controller components, Fixture 6E of MIL-S-901 shall be used. Equipment shall be mounted on the shock machine in a manner simulating normal shipboard mounting. The following are definitions of failure:

a. Breaking or cracking of any part, including mounting bolts, or material around the mounting holes that will affect device function.

b. Failure to pass insulation resistance tests.

c. Failure to pass pickup and dropout tests for individual contactors and relays.

d. Failure to pass voltage variation tests for controllers.

e. Failure to pass dielectric test.

f. Failure to pass the visual examination shall be cause for rejection.

g. Appreciable distortion of any parts, including enclosure and framework.

h. Failure to meet the shock requirements specified in 3.17.3.

i. Any change of state of a controller, contactor, or associated switching device.

4.6.5.1 Contact monitoring. On shock tests of components, each contact shall be monitored. Assembled controllers shall have at least one contact set on each device monitored, including one line contact; the recorded data, with the exception of line contacts, shall be for qualitative determination of devices responsible for controller malfunction should it occur. The contacts of equipment undergoing shock tests shall be connected to the monitoring equipment specified in 4.6.5.1.1 through 4.6.5.1.3. For electronically-based control circuit devices and associated switching devices, shock tests shall be conducted with all inputs and outputs operating and monitored to ensure that they do not change state. Shock tests shall be repeated for each network protocol port that is available for the device. Network status and/or operational commands shall be continuously executed to the device to ensure that network communications are properly operating during the entire test.

4.6.5.1.1 Monitoring of AC line contacts. The line contacts of AC controllers and contactors shall be monitored as follows: Closed and open line contacts shall be monitored. Performance shall be as specified in 3.17.3.a.

4.6.5.1.2 Monitoring of DC line contacts. The line contacts of DC controllers and contactors shall be monitored as follows: Closed and open line contacts shall be monitored. Performance shall be as specified in 3.17.3.b.

4.6.5.1.3 Monitoring of auxiliary and associated switching device contacts. The auxiliary contacts of contactors and the contacts of associated switching devices, when testing individual devices or spare contact sets of devices within a controller, shall be monitored as follows: Closed and open contacts shall be monitored by oscillograph, FM tape recorder, or suitable digital data acquisition system. All equipment shall have a minimum frequency response and sampling rate of 2 kHz. Digital signal processing of acquired data shall be capable of producing suitable waveform plots with 0.5-millisecond minimum resolution, and for analysis purposes shall be able to expand contact events with graphical editing to determine voltage levels and time increments of the individual sample points. Performances shall be as respectively specified in 3.17.3.c and 3.17.3.d.

4.6.5.2 Time delay relays. Time delay relays shall be adjusted to any convenient setpoint for shock testing. After each blow time delay relays will be operated. The set time delay and the setpoint repeatability shall not change. Setpoint repeatability and variation of the indicated time delay shall conform to 3.16.5.2.

4.6.5.3 Pressure switches. Pressure switch setpoints shall be adjusted to 50±5 percent of the range. Nine hammer blows shall be applied with the test pressure slightly below the reset point and 9 hammer blows shall be applied with the test pressure slightly above the setpoint. Pressure switches with ranges less than or equal to 100 psig shall be tested at 10 percent above the setpoint and 10 percent below the reset point; pressure switches with ranges greater than 100 psig shall be tested at 5 percent above the setpoint and 5 percent below the reset point. After all eighteen blows, pressure shall be varied as necessary to cycle the switch at least three times; tested performance shall conform to 3.17.3.3. Performance shall meet the requirements of 3.16.7.1.

4.6.5.4 Temperature switches. Temperature switch setpoints shall be adjusted to 50±5 percent of the range. The sensing bulbs of the temperature switch shall be installed in a suitable mounting adapter possessing temperature control and monitoring capability. Nine hammer blows shall be applied with the temperature of the mounting adapter slightly below the reset point and nine hammer blows shall be applied with the temperature of the mounting adapter slightly above the setpoint. Temperature switches shall be tested at 15 percent above the setpoint and 15 percent below the reset point. After all eighteen blows, the temperature of the mounting adapter shall be varied as necessary to cycle the switch at least two times; tested performance shall conform to 3.17.3.4. Performance shall meet the requirements of 3.16.7.2.

4.6.5.5 Post shock tests and examinations. Upon completion of shock testing the following tests and examinations shall be performed:

a. Visual examination. Equipment shall be carefully examined to ascertain any mechanical damage. Equipment shall be disassembled as necessary to detect any damage.

b. Examination and general operation. An examination and general operation shall be performed as specified in 4.5. Equipment shall operate properly.

c. Insulation resistance. Insulation resistance shall be measured as specified in 4.6.7 and shall meet the requirements of 3.17.4.

d. Post shock dielectric. A dielectric test shall be conducted as specified in 4.6.8 except that the test voltage applied will be 65 percent of the specified value and will be applied for 5 seconds. Performance shall meet the requirements of 3.17.5.

e. Pickup and dropout voltage. When tested individually, contactors and relays, including time delay relays, shall be tested as specified in 4.6.11 except at ambient temperature between 10 °C and 40 °C and shall meet the requirements of 3.17.9.

f. Voltage variation. Controllers shall be tested as specified in 4.6.12 and shall meet the requirements of 3.4.1 and 3.4.2.

4.6.5.5.1 Time delay relays. Post-test reference measurements shall verify that the set time delay has not changed and that setpoint repeatability and variation of the indicated time delay conform to 3.16.5.2.

4.6.5.5.2 Pressure switches. Post-test reference measurements without adjustments shall verify retention of the pre-test setpoint and conformance to the requirements of 3.17.3.3.

4.6.5.5.3 Temperature switches. Post-test reference measurements without adjustments shall verify retention of the pre-test setpoint and conformance to the requirements of 3.17.3.4.

4.6.6 Inclination. Equipment shall pass an examination and general operation test as specified herein when inclined from the bulkhead mounted orientation to the following positions at the maximum angles specified in 3.17.7 (45 for surface ships and 60 for submarines). Tests shall be conducted at nominal voltage and frequency except where noted. Controllers shall be subjected to the voltage variation test specified in 4.6.12 at each of the four test positions. When tested individually, contactors and relays, including time delay relays, shall be subjected to the pickup and dropout test specified in 4.6.11 at each of the four test positions. Other devices as specified in 4.6.6.1 through 4.6.6.3 shall conform to the tests described herein and function in each of the following test positions:

a. 45 (60) degrees from vertical forward.

b. 45 (60) degrees from vertical backward.

c. 45 (60) degrees from vertical to the left.

d. 45 (60) degrees from vertical to the right.

4.6.6.1 Time delay relays. Time delay relays shall be adjusted to any convenient setpoint for inclination testing. At each position time delay relays will be operated. The set time delay shall not change and the setpoint repeatability and variation of the indicated time delay shall conform to 3.16.5.2.

4.6.6.2 Pressure switches. Pressure switch setpoints shall be adjusted to 50±5 percent of the range. At each position pressure shall be applied to the pressure switch and shall be varied between 10 percent above the setpoint and 10 percent below the reset point. Performance shall meet the requirements of 3.16.7.1.

4.6.6.3 Temperature switches. Temperature switch setpoints shall be adjusted to 50±5 percent of the range. Temperature switches shall be actuated at each position. Performance shall meet the requirements of 3.16.7.2.

4.6.7 Insulation resistance. The measuring instrument used shall have an open circuit voltage of 500 VDC ±10 percent. Measurement shall be made between all mutually insulated points and between insulated points and ground (see 3.17.4).

4.6.8 Dielectric. Dielectric tests shall be conducted in accordance with NEMA ICS 1 with a test voltage (rms) of 1000 V plus (2X nominal voltage rating) for controllers, contactors and all associated switching devices (see 3.17.5).

4.6.9 Effectiveness of enclosure. Enclosures shall be subjected to the applicable test conditions (see 6.2) specified in MIL-STD-108 to determine conformance to 3.16.17.

4.6.10 Noise, AC contactors and relays (if applicable). Noise tests shall be conducted to determine conformance to the requirements specified in 3.17.10. AC contactors and relays shall be noise tested in the operating mode.

4.6.11 Pickup and dropout voltage. Contactors and relays shall be connected to a voltage supply that can be varied from 0 to 110 percent of the rated voltage to determine pickup and dropout voltages. Performance shall be in accordance with 3.17.9. The pickup and dropout voltage test for qualification and conformance shall be conducted with the contactor or relay operating at maximum temperature, unless the tests are being performed as part of another test.

4.6.12 Voltage variation. Controllers shall be connected to a voltage supply that can be varied from 0 to 110 percent of the controller rated input voltage to determine conformance to 3.4.1 and 3.4.2. The controller shall not malfunction due to the input voltage varying between 80 and 110 percent of rated value. An examination and general operation test shall be performed at the low and high points to determine that the controller operates satisfactorily.

4.6.13 Terminal strength. The terminals of the contactors and control relays shall be tested in accordance with torque test Method 211A of MIL-STD-202 (see 3.17.6).

4.6.14 EMI. The emission and susceptibility tests (CE101, CE102, CS101, CS114, CS116, RE101, RE102, RS101, RS103) as required by MIL-STD-461 as specified in 3.17.8 of this document shall be performed to determine electromagnetic compliance (EMC). In addition, the following DOD-STD-1399-70-1 test shall be performed to simulate extreme magnetic conditions that can be present. The energized device shall be subjected to a high current field of 500 ampere/foot. The field shall be applied in each axis (top, bottom, left, right, front, and back). During testing, the device shall be constantly polled via the network interface and all input and outputs monitored. There shall be no error in the data stream or unexpected change in state of the device. (see 3.17.8)

4.6.15 Time delay setpoint repeatability. Time delay relays shall be set at 5, 20, 40, 60, 80, and 95 percent of their timing range. At each setting, the relay will be operated five times. Performance shall conform to the requirements of 3.16.5.2.

4.6.16 Recycle time of time delay relay. Time delay relay shall be set at 80 percent of their timing range and operated five times to establish an average reference time delay. To test the relay the control voltage shall be interrupted for 75 milliseconds and then restored. Performance shall be the average of at least 5 operations for each condition. Performance shall conform to 3.16.5.2.

a. Interruption immediately following the timing interval. The subsequent time delay shall be at least 90 percent of the reference time delay.

b. Interruption during (30 to 70 percent of the set time delay) timing. The subsequent time delay shall be at least 80 percent of the reference time delay.

4.6.17 Steady-state voltage and frequency tolerance test for solid-state devices. Equipment shall pass an examination and general operation test (see 4.5) in each of the conditions A through F as specified in table XIV. See MIL-STD-1399-300 for limits.

TABLE XIV. Steady-state voltage and frequency tolerance test for solid-state devices.

Condition	Voltage			Frequency		
	Lower limit	Normal	Upper limit	Lower limit	Normal	Upper limit
A (Reference measurement)		Nominal			6.0	
B	-5% (3 ph) -10% (1 ph)			58.2		
C			+5% (3 ph) +10% (1 ph)	58.2		
D			+5% (3 ph) +10% (1 ph)			61.8
E	-5% (3 ph) -10% (1 ph)					61.8
F	-10% (1 ph)				60	

4.6.18 Transient voltage and frequency tolerance and recovery test for solid-state devices. Equipment shall not malfunction or change state of operation when tested as specified in 4.6.18.1 through 4.6.18.2. Equipment shall be tested in both the energized and de-energized operational modes. Equipment with more than one energized operational mode shall be operated in the mode selected by the testing activity to be the most likely to be affected by the test conditions and the mode used predominantly in service. See MIL-STD-1399-300 for limits.

4.6.18.1 Transient voltage.

4.6.18.1.1 Upper limit. With the equipment operating at nominal frequency (60 Hz) and the upper limit of the steady-state voltage (+5 percent (three-phase), +10 percent (single-phase)), the voltage shall be increased to the maximum positive transient voltage (+20 percent) and then decreased back to the upper limit steady-state voltage in a two-second period (for example, for 440 V, three-phase, the voltage will be at 462 and the transient will be to 528).

4.6.18.1.2 Lower limit. With the equipment operating at nominal frequency (60 Hz) and the lower limit of the steady-state voltage (-5 percent (three-phase), -10 percent (single-phase)), the voltage shall be decreased to the maximum negative transient voltage (-20 percent) and then increased back to the lower limit steady-state voltage in a two-second period (for example, for 440 V, three-phase, the voltage will be at 418 and the transient will be to 352).

4.6.18.2 Transient frequency.

4.6.18.2.1 Upper limit. With the equipment operating at nominal voltage and the upper limit of the steady-state frequency, 61.8 Hz, the frequency shall be increased to the maximum positive transient frequency, 63.3 Hz, and then decreased back to the upper limit steady-state frequency in a two-second period.

4.6.18.2.2 Lower limit. With the equipment operating at nominal voltage and the lower limit of the steady-state frequency, 58.2 Hz, the frequency shall be decreased to the maximum negative transient frequency, 56.7 Hz, and then increased back to the lower limit steady-state frequency in a two-second period.

4.6.19 Spike voltage. Equipment shall be subjected to the voltage spike test as specified in MIL-STD-1399-300. Equipment shall not malfunction or change state of operation when tested as specified herein. Equipment shall be tested in both the energized and de-energized operational modes. Equipment with more than one energized operational mode shall be operated in the mode selected by the testing activity to be the most likely to be affected by the test conditions or the mode used predominantly in service.

4.6.20 Power interruption. Equipment shall be operated at nominal voltage and frequency. The total electrical input power shall be interrupted and reapplied in a randomly short period (less than 25 milliseconds). The equipment shall continue to operate properly. Equipment specified to continue operation during power interruptions greater than 1 second shall be then operated long enough to detect any performance degradation, the power shall be interrupted for a period of 30 seconds or the specified recycle time, and then reapplied. During these tests, and as a result of these tests, no damage or malfunction shall occur. Examination and general operation test shall confirm proper equipment performance upon completion of this test (see 4.5). Equipment with more than one energized operational mode the power interruption test shall be performed in each of the modes.

4.6.21 Leakage current. Assembled controllers and stand-alone devices shall be subjected to the leakage current tests specified in MIL-HDBK-2036 and shall meet the requirements of 3.17.11.5.

4.6.22 Output leakage current. Apply the rated voltage to the device under test and adjust the load to obtain the rated resistive current, ±5 percent. Place the device in the OFF-state and measure the output leakage current in each output circuit. The leakage current in the output circuits of solid-state switching devices shall not exceed the values specified in 3.17.11.6.

4.6.23 Output voltage drop. Apply the rated output voltage and rated frequency to the device under test. Place the device in the ON state (conducting) and adjust the load to obtain rated resistive current, ±5 percent. With a voltmeter or oscilloscope connected across the device output terminals, measure the output voltage drop (volts peak). The ON state output voltage drop of solid-state switching devices shall meet the requirements of 3.17.11.7 and not exceed the values listed in table X.

4.6.24 Pressure and temperature switch setpoint repeatability. Pressure switches shall be set to 5, 20, 40, 60, 80, and 95 percent of their pressure range; all setpoints shall be ±3 percent of range. At each setting the pressure switch will be operated five times. These readings shall be conducted before and after the endurance test. The last pre-endurance test setpoint for each setting shall be used as the first post-endurance test setpoint for that setting. Performance shall conform to the requirements of 3.16.7.1 and 3.16.7.2.

4.6.25 Mechanical interlock. Contactors and relays incorporating a mechanical interlocking feature (see 3.16.2) shall be subjected to the following tests. With one contactor and relay held in the energized position as specified, maximum operating voltage (see 3.4) shall be applied to the actuating coil of the opposing contactor and relay for 50 cycles. The operational cycle shall consist of 0.5 seconds ON and 2.5 seconds OFF. The specified 50 cycles of operation shall be applied under each of the following conditions:

a. The first contactor and relay being held in the energized position by applying maximum operating voltage to the device's actuating coil.

b. The second contactor and relay being held in the energized position by applying maximum operating voltage to the device's actuating coil.

c. The first contactor and relay being held in the energized position by mechanical means.

d. The second contactor and relay being held in the energized position by mechanical means.

4.6.26 Position sensing switch operational performance. Position sensing switches shall be operated at nominal voltage and frequency. Specific electrical loads are not required. Switches shall be actuated for a minimum of 5 operations at each checkpoint as specified:

a. Mechanical limit switches. Switches shall operate within the parameters specified in 3.16.7.3.b through 3.16.7.3.e for operating force, total operator travel, and operator reset travel.

b. Proximity switches. Proximity switches shall be actuated with the target moved in the slide-by configuration to verify a minimum of five different checkpoints on the characteristic curve. The checkpoints shall be spaced to represent 10 to 80 percent of the maximum sensing distance. The maximum sensing distance checkpoint shall be verified by head-on target movement along the sensor axial centerline. Performance shall be in accordance with the parameters specified in 3.16.7.4.c.

c. Photoelectric switches. Photoelectric switches shall be actuated by manipulating the receiver and reflector in a slide-by configuration to verify a minimum of five different checkpoints on the characteristic curve spaced to represent 10 to 80 percent of the specified maximum sensing distance. Performance shall be in accordance with the parameters specified in 3.16.7.5.c.

4.6.27 Voltage ramp operation. Equipment shall be tested to ensure correct operation for the specified voltage ramp rate. Equipment shall be tested at the minimum ramp rate and at a voltage step (0 – Max voltage instantaneously).

SSDC: 54 volts per second and voltage step

SSAC: 900 volts per second and voltage step

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.1 Intended use. Controllers, controller parts, and associated switching devices covered by this specification are intended for surface and submarine use. For special duty see 3.6.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Equipment with which associated (for example, pump, motor generator set and so forth).

c. Quantity required.

d. Duty and service requirements (see 3.6).

e. Control voltage, if other than that of the controlled device (see 3.7).

f. Motor field isolation (see 3.9).

g. Remote indicating and monitoring circuits is independently fused, if required (see 3.10).

h. Provision for wiring to an over-speed trip module, if required (see 3.11).

i. Ambient temperature and maximum permissible temperature rise (see 3.12 and table VIII).

j. Emergency run feature, if required (see 3.16.3).

k. Local transfer switch for vital function, if required (see 3.16.4).

l. Provision for EMI and arcing suppression, if required (see 3.16.5).

m. Solid-state switching devices network communication (see 3.16.5.1).

n. If embedded temperature detectors are used for overload protection (see 3.16.6).

o. Solid-state overload relay protection features other than as specified (see 3.16.6).

p. Ambient pressure compensations, if required (see 3.16.7.1.h).

q. Pressure and temperature switch designation required (see 3.16.7.1.1 and 3.16.7.2.1).

r. Pressure switch ranges, maximum proof pressure, and type of connection requirements (see tables II and III, notes 1, 2, and 3, respectively).

s. Optimum differential and switch capability requirements (see table II, notes 5 and 7, table III, notes 5 and 7, and table IV, notes 3 and 5).

t. Ambient pressure compensation requirements (see table II, note 8).

u. Programmable logic controller (PLC), if required (see 3.16.9).

v. Variable speed drive (VSD), if required (see 3.16.10).

w. Space heaters, if required (see 3.16.11).

x. When indicator lights are required (see 3.16.12.1).

y. Controller characteristics (see 3.16.15).

z. Voltage and phase rating (see 3.16.15.a).

aa. Special service for submarine (see 3.16.15.a).

bb. Current rating required (see 3.16.15.b).

cc. Operation (manual or magnetic), protective features and function (see 3.16.15.c and d).

dd. Location and type of switches (see 3.16.15.e).

ee. DC controllers, size, horsepower, current, and dimensions, as applicable (see tables V and VII).

ff. AC controllers, size, horsepower, current, and dimensions, as applicable (see tables VI and VII).

gg. Enclosure type (see 3.16.17).

hh. Requirements for inclusion of NSN on identification plate, if needed, and the NSN to be used (see 3.16.20).

ii. Maximum vibration frequency, if other than 33 Hz (see 3.17.2).

jj. Requirements for resilient mounting of equipment (see 3.17.2.1 and 3.17.3.5).

kk. Shock classification for associated switching devices other than specified (see 3.17.3.c and d).

ll. AC controllers for low noise, if required (see 3.17.10 and tables XI, XII, and XIII).

mm. Voltage ramp rate, if required (see 3.17.11.8).

nn. Inspection conditions, if other than those specified in MIL-E-917 (see 4.2).

oo. Disposition of sample units (see 4.3.3).

pp. Packaging requirements (see 5.1).

qq. Technical manual requirements (see 6.3).

rr. Provisioning requirements (see 6.5).

6.3 Technical manuals.. The requirement for technical manuals should be considered when this specification is applied on a contract. The technical manuals must be acquired under separate contract line item in the contract (see 6.2).

6.4 Special information concerning shockproofness. Users of this specification who design equipment or acquire controllers and associated switching devices should be aware of the extent of shockproofness of equipment listed on the Qualified Products List (QPL) No. 2212. It is the aim of this specification to provide equipment as shockproof as possible for Naval shipboard use; however, due to the nature of shock, 100 percent shockproofness is not possible in all cases. During shock, it is possible that the controller output power may be interrupted momentarily. It is also possible that associated switching devices may interrupt the circuit they are part of momentarily.

6.4.1 Limits on shock testing. Users of this specification who have the responsibility for acquisition of shockproof equipment for Naval shipboard use are requested to give careful consideration before requiring additional shock testing, which will stress the equipment and may cause unnoticed damage. If additional shock testing is deemed essential, then instruction should be issued to require careful post-shock examination by qualified personnel.

6.5 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified (see 6.2). 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 as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

6.6 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 2212 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Commander, Naval Sea Systems Command, ATTN: SEA 05M2, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil.

6.7 Definitions.

6.7.1 Across-the-line. Across-the-line signifies the connection of an apparatus directly across the main supply circuit.

6.7.2 Ambient temperature. Ambient temperature is the temperature of the medium surrounding an equipment.

6.7.3 Associated switching device. Associated switching devices are devices that are used in conjunction with the main line contactor(s) of a controller to control the operation of the connected load and may be mounted separately from the controller. These include control and overload relays, limit switches, push-button stations, pressure switches, selector switches, level switches, and others.

6.7.4 Automatic. Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence as, for example, a change in current strength, pressure, temperature, or mechanical configuration.

6.7.5 Contact chatter. Contact chatter is a transient condition characterized by the repetitive bouncing (make and break) of mating electrical contacts. Each contact bounce is usually denoted by transient voltage excursions equal to or greater than 90 percent of the applied circuit voltage.

6.7.6 Contactor. A contactor is a device for repeatedly establishing and interrupting an electric power circuit.

6.7.7 Contactor, magnetic. A magnetic contactor is a contactor actuated by electromagnetic means.

6.7.8 Contacts. Contacts are conducting parts which coact to complete or to interrupt a circuit.

6.7.9 Contacts, auxiliary. Auxiliary contacts of a switching device are contacts in addition to the main circuit contacts and function with the movement of the latter.

6.7.10 Contacts, line. Line contacts are contacts on a contactor or relay used solely for controlling the power to a motor or controlled device.

6.7.11 Contacts, normally open (NO) and normally closed (NC). Normally open and normally closed signify the position taken by contacts when the device is de-energized. The de-energized condition of a manual device is the off position.

6.7.12 Control circuit. The control circuit of a control apparatus or system is the circuit which carries the electrical signals directing the performance of the controller but does not carry the main circuit power.

6.7.13 Control relay. A control relay is a device for repeatedly establishing and interrupting an electric circuit. A control relay is usually employed to actuate other relays or contactors in the same or associated circuits.

6.7.14 Control-circuit transformer. A control-circuit transformer is a voltage transformer used to supply a voltage for operation of control devices.

6.7.15 Control, local. Local control or device is a control function or device which provides for initiation or change of a control function from within or directly upon the controller enclosure.

6.7.16 Control, remote. Remote control or device is a control function or device which provides for initiation or change of a control function from a remote point.

6.7.17 Control, three-wire. Three-wire control is a control function which utilizes a momentary contact pilot device and a holding circuit contact to provide undervoltage protection.

6.7.18 Control, two-wire. Two-wire control is a control function which utilizes a maintained contact pilot device to provide undervoltage release.

6.7.19 Controller, electric motor. An electric motor controller is a device or group of devices which governs, in some predetermined manner, the electric power to the motor. An electric motor controller is distinct functionally from a simple disconnecting device whose principal purpose in a motor circuit is to disconnect the circuit, together with the motor and its controller, from the power source.

6.7.20 Controller, full-magnetic. A full magnetic controller is an electric controller having all of its basic functions performed by devices which are operated by electromagnets. Basic functions usually refer to acceleration, retardation, line closing, reversing, and so forth.

6.7.21 Controller, manual. A manual controller is an electric controller having all of its basic functions performed by hand operated devices.

6.7.22 Corrosion-resistant. Corrosion-resistance means constructed, protected, or treated so that corrosion will not exceed specified limits under specified test conditions.

6.7.23 Disconnection. Disconnection is the opening of a sufficient number of conductors to prevent current flow.

6.7.24 Dripproof. Dripproof means constructed or protected so that falling dirt or drops of liquid will not interfere with the successful operation of the apparatus under specified test conditions.

6.7.25 Dropout, voltage or current. The dropout voltage or current of a magnetically operated device is the voltage or current at which the device will return to its de-energized position.

6.7.26 Duty of a controller. The duty of a controller is the specific function or functions for which it is constructed with respect to the operation of the motor. These include starting, speed control, reversing, stopping, and the frequency and length of time of operation.

6.7.27 Duty, continuous. Continuous duty is a requirement of service which demands operation at a substantially constant load for an indefinitely long time.

6.7.28 Duty, intermittent. Intermittent duty is a requirement of service which demands operation for alternate intervals of (1) load and no-load, or (2) load and rest, or (3) load, no-load and rest; with such alternate intervals being definitely specified.

6.7.29 Duty, varying. Varying duty is a requirement of service which demands operation at wide variations of loads and intervals of time.

6.7.30 Emergency run. Emergency run is a condition in which the protective devices that normally interrupt a control circuit are temporarily and manually overridden by some means, and cause the circuit function to be maintained.

6.7.31 Enclosure. An enclosure is a surrounding case designed to protect:

a. Personnel against accidental contact with the enclosed electrical devices, and

b. Internal devices against specified external conditions.

6.7.32 Equipment. Equipment, as used herein, means controllers, controller parts, and associated switching devices.

6.7.33 Failure of a control component or system. Failure is a state or condition in which a control component or system does not perform its essential functions when its ratings are not exceeded.

6.6.34 Features, distinctive. Distinctive features are exclusive elements which are characteristic of a particular design which are not common to other designs.

6.7.35 Fuse. A fuse is an overcurrent protective device with a circuit opening fusible member which is heated and severed by the passage of over-current through it.

6.7.36 Grounded parts. Grounded parts are parts which are connected in an intentionally grounded manner.

6.7.37 Input and output characteristics. Input devices accept signals from the process elements and translate them into signals which can be used within the controller. Output devices convert controller signals into external signals used to control the process.

6.7.38 Insulation. The temperature limits on which the ratings of electrical apparatus are based are largely determined by the character of the insulation materials used.

a. Insulation is considered to be impregnated when a substance provides a bond between components of the structure and a degree of filling and surface coverage sufficient to ensure adequate performance under the extremes of temperature, surface contamination (moisture, dirt, and so forth) and mechanical stress expected in service. The impregnant should not flow or deteriorate at operating temperatures so as to seriously affect performance in service.

b. The electrical and mechanical properties of the insulation should not be impaired by the prolonged application of the limiting insulation temperature permitted for the specific insulation class. The word “impaired” is used here in the sense of causing any change which could disqualify the insulating material for continuously performing its intended function, whether creepage spacing, mechanical support or dielectric barrier action.

6.7.39 Interlock. An interlock is a device actuated by the operation of some other device with which it is directly associated to govern succeeding operations of the same or allied devices. Interlocks may be either electrical or mechanical.

6.7.40 Isolation. Isolation is the opening of all conductors connecting to the power source.

6.7.41 Jog (inch). Jog (inch) is a control function which permits the momentary operation of a drive for the purpose of accomplishing a small movement of the driven machine.

6.7.42 Limit. Limit means that the designated quantity is controlled so that a prescribed boundary condition is not exceeded.

6.7.43 Limit, current. Current limit is a control function which prevents a current from exceeding its prescribed limits. Current limit values should be expressed as a percent of rated load value.

6.7.44 Low voltage protection (LVP). LVP is the effect of a device which, on the reduction or failure of voltage, causes and maintains the interruption of power to the main circuit until the circuit is restarted manually.

6.7.45 Low voltage release (LVR). LVR is the effect of a device which, on the reduction or failure of voltage, causes the interruption of power to the main circuit, but does not prevent the reestablishment of the main circuit on return of voltage.

6.7.46 Low voltage release effect (LVRE). LVRE is the effect of a device which remains unchanged on the reduction or failure of voltage and does not cause an interruption of power.

6.7.47 Maximum proof pressure. Upper pressure at which performance of switch in the operating range will not be disturbed and exceeds maximum operating pressure.

6.7.48 Noise. Noise is an unwanted signal.

6.7.49 Nonautomatic. Nonautomatic means that the implied action requires personal intervention for its control. As applied to electrical controllers, nonautomatic does not necessarily imply a manual controller, but only that personal intervention is required.

6.7.50 Nonreversing. Nonreversing is a control function which provides for operation in one direction only.

6.7.51 Nonventilated. Nonventilated means constructed to provide no intentional circulation of external air through the enclosure.

6.7.52 Open momentarily, or momentary opening. Where applied in this specification, these expressions mean that an interval of contact physical opening may occur during high impact shock.

6.7.53 Part. A part is an item provided as an integral part of a controller such as a contactor, relay, indicating light, or push-button.

6.7.54 Pickup and seal voltage. The pickup and seal voltage of a magnetically operated device is the minimum voltage at which the device moves from its de-energized into its fully energized position.

6.7.55 Pickup voltage or current. The pickup voltage or current of a magnetically operated device is the voltage or current at which the device starts to operate.

6.7.56 Programmable logic controller (PLC). A PLC is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input and output modules, various types of processes.

6.7.57 Protection, overload. Overload protection is the effect of a device operative on excessive current, but not necessarily on short circuit, to cause and maintain the interruption of current flow to the device governed.

6.7.58 Push-button. A push-button switch (push-button) is a master switch having a manually operable plunger or button for actuating the switch.

6.7.59 Push-button station. A push-button station is a unit assembly of one or more externally operable push-button switches, sometimes including other pilot devices such as indicating lights or selector switches, in an enclosure.

6.7.60 Rating of a controller. The rating of a controller is an arbitrary designation of an operating limit. It is based on the power governed and on the duty and service required. A rating is arbitrary in the sense that it must necessarily be established by definite fixed standards and cannot, therefore, indicate the safe operating limit under all conditions which may occur.

6.7.61 Rating, continuous. Continuous rating is the rating which defines the substantially constant load which can be carried for an indefinitely long time.

6.7.62 Rating, 8-hour (as applied to a magnetic contactor). The 8-hour rating of a magnetic contactor is the rating based on its ampere carrying capacity for 8 hours, starting with new clean contact surfaces, under conditions of free ventilation, with full rated voltage on the operating coil, and without causing any of the established limitations to be exceeded.

6.7.63 Reduced voltage. Reduced voltage is the characteristic of a controller where the full line voltage is not immediately impressed upon the apparatus, but is applied gradually or in stages by means such as resistors or autotransformers.

6.7.64 Relay, magnetic control. A magnetic control relay is a relay which is actuated by electromagnetic means. When not otherwise qualified, the term refers to a relay intended to be operated by the opening and closing of its coil circuit, and having contacts designed for energizing and deenergizing the coils of magnetic contactors or other magnetically operated devices.

6.7.65 Relay, magnetic overload. A magnetic overload relay is an overcurrent relay in which the electrical contacts are actuated by the electromagnetic force produced by the full or partial load current.

6.7.66 Relay, overload. An overload relay is an overcurrent relay which functions at a predetermined value of overcurrent to cause disconnection of the load from the power supply. An overload relay is intended to protect the load (for example, motor armature) of its controller, and does not necessarily protect itself.

6.7.67 Repeatability. Repeatability is the degree of correspondence between successive readings of the same transition when measured in the same manner. It is expressed as plus or minus deviations.

6.7.68 Reset. To reset means to restore a mechanism, storage, or device, to a prescribed state.

6.7.69 Reset, automatic. Automatic reset is a function which operates to automatically reestablish specific conditions.

6.7.70 Reset, manual. Manual reset is a function which requires a manual operation to reestablish specific conditions.

6.7.71 Resistance. Resistance is the (scaler) property of an electric circuit, or of any body, which may be used as part of an electric circuit.

Resistance determines, for a given current, the rate at which electric energy is converted into heat or radiant energy, and has a value such that the product of the resistance and the square of the current gives the rate of conversion of energy. In general, resistance is a function of the current, but the term is most commonly used in connection with circuits where the resistance is independent of the current.

6.7.72 Resistance starting. Resistance starting is a form of reduced voltage starting employing resistances which are short-circuited in one or more steps to complete the starting cycle.

6.7.73 Resistant (used as a suffix). Resistant, used as a suffix, means constructed, protected, or treated so that the apparatus will not be damaged when subjected to the specified material or conditions for a specified time.

6.7.74 Resistor. A resistor is a device used to introduce resistance into an electric circuit.

6.7.75 Reversing. Reversing is a control function which permits changing operation of the drive from one direction to the other.

6.7.76 Rheostat. A rheostat is an adjustable resistor constructed so that its resistance may be changed without opening the circuit in which it is connected.

6.7.77 Sensing element. Sensing element is a primary measuring device for detecting either the absolute or variable pressure or temperature.

6.7.78 Service of a controller. The service of a controller is the specific application in which the controller is to be used, for example:

a. General purpose.

b. Definite purpose:

(1) Crane and hoist.

(2) Elevator.

(3) Machine tool.

6.7.79 Starter. A starter is an electric controller for accelerating a motor from rest to normal speed. A starter is a device designed for starting a motor in either direction of rotation. If it includes the additional function of reversing, it should be designated a controller.

6.7.80 Starter, autotransformer. An autotransformer starter is a starter provided with an autotransformer which furnishes a reduced voltage for starting. It includes the necessary switching mechanism and is frequently called a compensator or autostarter.

6.7.81 Starter, part-winding. A part-winding starter is a starter which applies voltage successively to the partial; sections of the primary winding of an AC motor.

6.7.82 Starter, primary reactor. A primary reactor starter is a starter which includes a reactor connected in series with the primary winding of an induction motor to furnish reduced voltage for starting. It includes the necessary switching mechanism for cutting out the reactor and connecting the motor to the line.

6.7.83 Starter, primary resistor. A primary resistor starter is a starter which includes a resistor connected in series with the primary winding of an induction motor to furnish reduced voltage for starting. It includes the necessary switching mechanism for cutting out the resistor and connecting the motor to the line.

6.7.84 Submersible. Submersible means constructed to exclude water when submerged in water under specified test conditions of pressure and time.

6.7.85 Switch. A switch is a device for making, breaking, or changing the connections in an electric circuit.

6.7.86 Switch, cam-operated. A cam-operated switch is a switch in which the electrical contacts are opened and closed by a mechanical action of a cam or cams.

6.7.87 Switch, control cutout. A control cutout switch is a switch which interrupts and isolates the control circuit of an electric controller.

6.7.88 Switch, control-circuit limit. A control-circuit limit switch is a limit switch in which the contacts are connected only into the control circuit.

6.7.89 Switch, drum. A drum switch is a switch in which the electric contacts are made on segments or surfaces on the periphery of a rotating cylinder or sector, or by the operation of a rotating cam.

6.7.90 Switch, float. A float switch is a switch which is operated by a buoyant constituent part and is responsive to the level of liquid.

6.7.91 Switch, limit. A limit switch is a switch which is operated by some part or motion of a power-driven machine or equipment to alter the electrical circuit associated with the machine or equipment.

6.7.92 Switch, master (see also push-button). A master switch is a switch which dominates the operation of contactors, relays, or other remotely operated devices.

6.7.93 Switch, pressure. A pressure switch is a switch which is operated by a constituent part and is responsive to fluid (gas or liquid) pressure.

6.7.94 Switch, proximity. A proximity switch is a device which reacts to the proximity of an actuating means without physical contact or connection therewith.

6.7.95 Switch, selector. A selector switch is a manually operated, multiposition switch for selecting an alternative control circuit.

6.7.96 Switch, temperature. A temperature switch is a two-state (on-off) controller which is responsive to the temperature of a sensed medium.

6.7.97 Temperature rise. Temperature rise refers to the increase in temperature above ambient, measured in degrees Celsius, which will be reached by a device during its normal operation.

6.7.98 Temperature, ambient. Ambient temperature is the temperature of the medium such as air, water, or earth into which the heat of the equipment is dissipated. For self-ventilated equipment, the ambient temperature is the average temperature of the air in the immediate neighborhood of the equipment. For air or gas-cooled equipment with forced ventilation or secondary watercooling, the ambient temperature is taken as that of the in-going air or cooling gas. For self-ventilated enclosed (including oil-immersed) equipment considered as a complete unit, the ambient temperature is the average temperature of the air outside of the enclosure in the immediate neighborhood of the equipment.

6.7.99 Tests, dielectric. Dielectric tests are tests which consist of the application of a voltage higher than the rated voltage for a specified time for the purpose of determining the adequacy against breakdown of insulating materials and spacings under normal conditions.

6.7.100 Thermal cutout. A thermal cutout is an overcurrent protective device which contains a heater element in addition to and affecting a fusible member which opens the circuit.

6.7.101 Thermal protector (as applied to motors and generators). A thermal protector is a protective device which is intended for assembly as an integral part of the machine and which, when properly applied, protects the machine against dangerous overheating due to overload and, in a motor, failure to start.

6.7.102 Time delay. Time delay means that a time interval is purposely introduced in the performance of a function.

6.7.103 Transition, closed-circuit. Closed-circuit transition, as applied to reduced-voltage controllers, including star delta controllers, is a method of starting in which the power to the motor is not interrupted during the starting sequence.

6.7.104 Ultimate tripping current. Ultimate tripping current is the minimum value of continuously applied current that will cause an overload relay to operate (trip).

6.7.105 Ventilated. Ventilated means constructed to provide for the circulation of external air through the enclosure to remove heat, fumes, or vapors.

6.7.106 Watertight. Watertight means constructed to exclude water applied in the form of a hose stream under specified test conditions.

6.7.107 Waveform, output. Output waveform is the graphical representation of the output during one pulse interval.

6.7.108 When specified. A requirement for a function or item necessitated by the system design.

6.8 Subject term (key word) listing.

Relay

Switch, limit

Switch, pressure

Switch, selector

Switch, temperature

Transformers, AC and DC

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

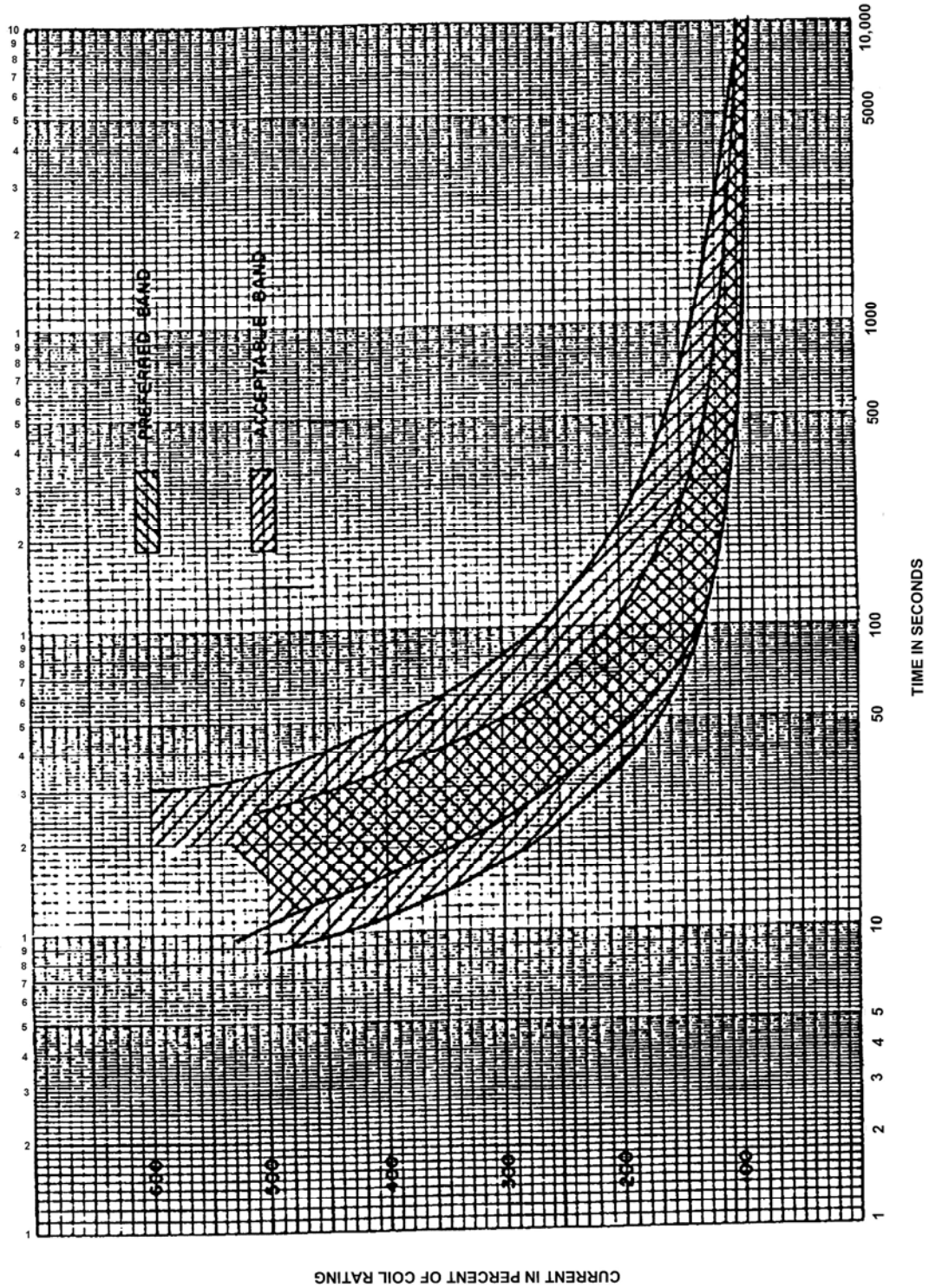


FIGURE 1. Time-current characteristic of overload relays.

TECHNICAL CONTENT REQUIREMENTS OF ENGINEERING DRAWINGS

A.1 SCOPE

A.1.1 Scope. This appendix provides requirements for the content of engineering drawings for contactors and controllers and associated switching devices. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

A.3 DRAWINGS

A.3.1 Technical content. Drawings must conform to MIL-T-31000. Figure A-1 is an example of a drawing. Drawings shall be prepared by the controller manufacturer and contain the following minimum data, as applicable:

a. List of material, listing the enclosure and all components. Each component shall show the description, quantity, material, material specification, company part or catalog number, and any supplementary descriptive.

b. List of repair parts, listing name of parts. Each part shall show piece number, quantity, and company part or catalog number.

c. Outline of the front and top views of the controller, supplying dimensions and essential details of the enclosure, including the size and quantity of the mounting bolts required.

d. Connection and schematic diagrams of the control circuit, including connections to associated switching devices and other remote devices. The rating of all fuses shall be indicated.

e. Description of operation of the controller.

f. Description of adjustments which can be made on the equipment, such as the range of time for a timing relay.

g. Table of overload heater or coil catalog numbers, with full load motor current ranges. Not applicable for solid-state overload relay.

h. Applicable current transformer data.

i. Applicable voltage and voltampere rating of control circuit transformers.

j. Table of applicable autotransformer or reactor information, containing turns, wire size and covering, coil insulation and impregnation and rating of taps.

k. Table of applicable resistor catalog numbers with corresponding step-by-step and overall resistances, continuous ampere ratings of each step and identification as to where used.

l. Applicable capacitor information, including type (paper or electrolytic) and microfarad and voltage rating.

m. Applicable rectifier information, including type (selenium or silicon) and current and voltage rating. For selenium rectifiers, the size and number of cells shall be indicated.

n. Descriptive information of the equipment which shall include: list of exceptions to this specification, rating, duty, type, ambient temperature, weight for controller and an unboxed set of repair parts, degree of enclosure, and shockproofness statement (see A.3.2).

o. Table of revisions including a brief description of each revision of the drawing.

p. Title block.

q. AWG wire sizes of all conductors and/or bus bar size shall be provided.

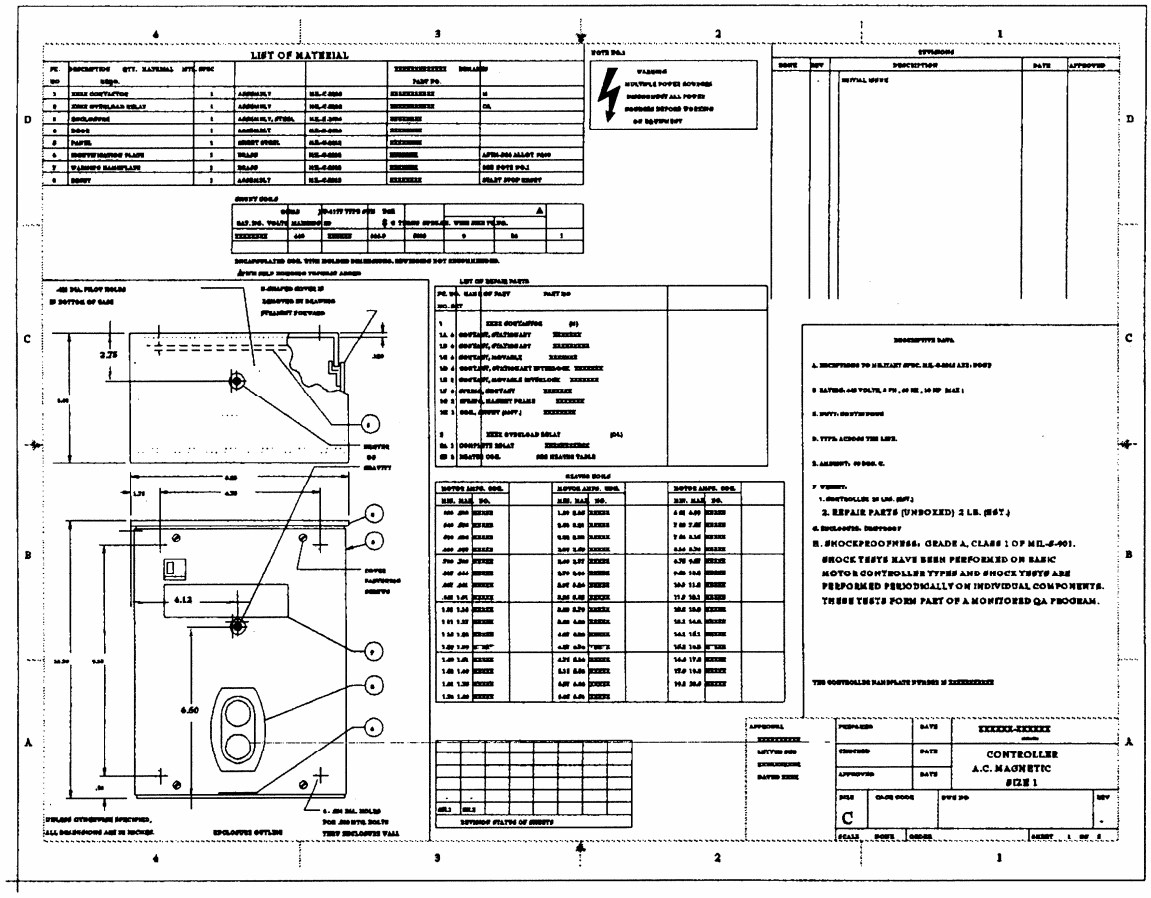
r. Safety ground straps shall be shown on controllers with hinged doors that contain electrical devices.

s. All parts shall be identified on the drawing.

t. Center of gravity.

A.3.2 Shockproofness statement:

SHOCKPROOFNESS: GRADE A, CLASS 1 OF MIL-S-901. SHOCK TESTS HAVE BEEN PERFORMED ON BASIC MOTOR CONTROLLER TYPES AND SHOCK TESTS ARE PERFORMED PERIODICALLY ON INDIVIDUAL COMPONENTS. THESE TESTS FORM PART OF A MONITORED QA PROGRAM.



NOTE: Dimensions are in inches.

FIGURE A-1. Sample motor controller drawing.

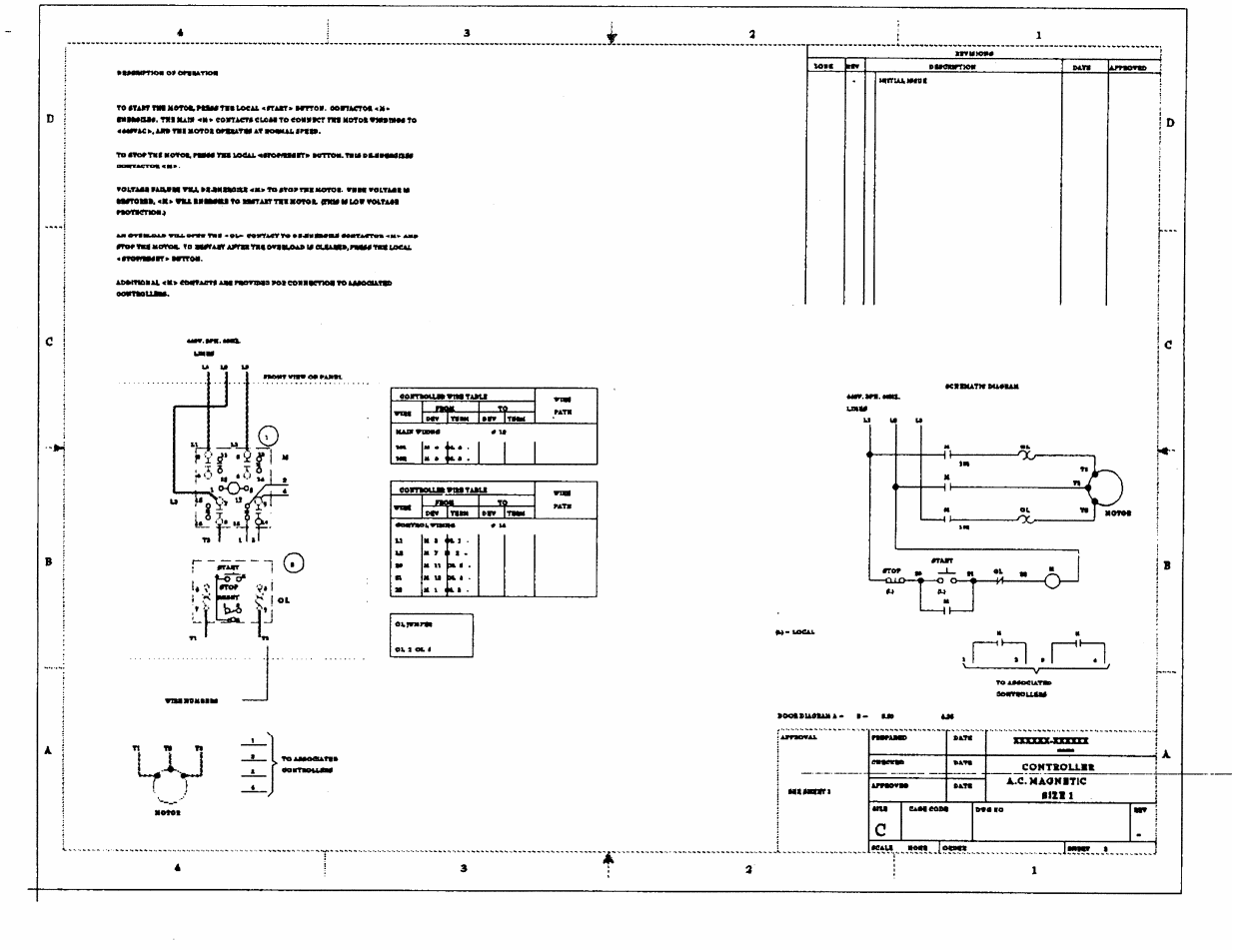


FIGURE A-1. Sample motor controller drawing - Continued.

TECHNICAL CONTENT REQUIREMENTS FOR CERTIFICATION DATA

B.1 SCOPE

B.1.1 Scope. The appendix details the certification requirements for contactors, controllers, and associated switching devices. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

B.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

B.3 PROCEDURE

B.3.1 Certification information. Certification information shall include the following:

a. Navy contract or Shipbuilder's order and item number.
b. Controller manufacturer's order and item number.
c. Master drawing numbers of the controller and all associated switching devices.
d. Catalog numbers of the controller and all associated switching devices.
e. Applicable specifications (including issue, amendment, and date).
f. Voltage, horsepower, and ampere rating of motor.
g. Drawing number of motor and other associated control devices.
h. Number and identification of ships involved.
i. Application on ship.
j. Quantity per ship.
k. List of repair parts (if repair parts are furnished on a per set basis).
l. Title block.
m. Size of overload.
n. Set point for temperature, pressure switches, timing relays, and other switching devices.

Custodian:
Navy – SH

Preparing Activity:
Navy – SH
(Project 6110-2006-001)

Review Activity:
DLA – GS

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.