INCH-POUND
MIL-DTL-16036M(SH)
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SUPERSEDING
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27 January 2006

DETAIL SPECIFICATION

SWITCHGEAR, POWER, LOW VOLTAGE, NAVAL SHIPBOARD

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05S, 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 https://assist.dla.mil.

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

1. SCOPE

1.1 Scope. This specification covers the requirements for electrical power dead-front, deck-mounted, low voltage switchgear for Naval shipboard use.

1.2 Classification.

1.2.1 Types. Switchgear covered by this specification are of the following types:

a. Type I - Ship's service power switchgear group for ships with alternating current (AC) power.

b. Type II - Emergency switchgear group for ships with AC power.

c. Type III - Ship's service power switchgear group for ships with direct current (DC) power.

1.3 Part or identifying number (PIN).

M	**16036**	**-**	**X**
Prefix for Military Specification	Specification Number		Type (see code below)

Type Code	
Type	Code
I	A
II	B
III	C

Examples: M16036-A
M16036-B
M16036-C

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.

FEDERAL SPECIFICATIONS

TT-C-490 - Chemical Conversion Coatings and Pretreatments for Metallic Substrates (Base for Organic Coatings)

TT-P-645 - Primer, Paint, Zinc-Molybdate, Alkyd Type

COMMERCIAL ITEM DESCRIPTIONS

A-A-208	-	Ink, Marking, Stencil, Opaque (Porous and Non-Porous Surfaces)
A-A-59125	-	Terminal Boards, Molded, Barrier Screw and Stud Types and Associated Accessories
A-A-59125/2	-	Terminal Boards, Molded, Barrier Screw Type, Class 38TB
A-A-59125/9	-	Terminal Boards, Molded, Barrier Stud Type, Class 3TB
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-DTL-1222	-	Studs, Bolts, Screws and Nuts for Applications Where a High Degree of Reliability is Required; General Specification for
MIL-I-1361	-	Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers
MIL-R-2033	-	Relays-Power, Electrical Specialty, Induction Type, Naval Shipboard Use
MIL-DTL-2212	-	Contactors and Controllers, Electric Motor AC or DC, and Associated Switching Devices
MIL-R-2729	-	Regulator-Exciter Systems, Voltage, A.C. Generator, Naval Shipboard Use
MIL-I-3158	-	Insulation Tape, Electrical Glass-Fiber (Resin-Filled): and Cord, Fibrous-Glass
MIL-DTL-3661	-	Lampholders, Indicator Lights, Indicator Light Housing, and Indicator Light Lenses, General Specification for
MIL-L-3661/38	-	Housing, Indicator-Light, Style LH80
MIL-L-3661/62	-	Lampholder, Lights, Indicator (Housing), Style LH95 (for D.C. Applications)
MIL-L-3661/63	-	Lampholder, Lights, Indicator (Housing), Style LH96
MIL-L-3661/64	-	Lampholder, Lights, Indicator (Housing), Style LH97
MIL-L-3661/65	-	Lampholder, Lights, Indicator (Housing), Style LH98
MIL-DTL-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-PRF-6855	-	Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes, General Specification for
MIL-C-11796	-	Corrosion Preventive Compound, Petrolatum Hot Application
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-P-15024/5	-	Plates, Identification
MIL-DTL-15090	-	Enamel, Equipment, Light Gray (Navy Formula No. 111)

MIL-T-15108	-	Transformers, Power, Step-Down, Single-Phase, 60-Hertz, 1-Kilovoltampere Approximate Minimum Rating, Dry Type, Naval Shipboard
MIL-DTL-15109	-	Resistors and Rheostats, Naval Shipboard
MIL-PRF-15160	-	Fuses, Instrument, Power, and Telephone General Specification for
MIL-T-15377	-	Temperature Monitor Equipment Naval Shipboard
MIL-DTL-16034	-	Meters, Electrical-Indicating (Switchboard and Portable Types), General Specification for
MIL-I-16103	-	Indicator, Phase Sequence, Switchboard and Panel
MIL-S-16104	-	Synchroscope
MIL-M-16125	-	Meters, Electrical, Frequency
MIL-T-16315	-	Transformers, Power, Step-Down (Miscellaneous, Naval Shipboard Use)
MIL-T-16366	-	Terminals, Electrical Lug and Conductor Splices, Crimp-Style
MIL-DTL-17361	-	Circuit Breakers Types AQB/NQB, Air, Electric, Low Voltage, Insulated Housing (Shipboard Use), General Specification for
MIL-DTL-17587	-	Circuit Breakers, ACB, Low Voltage, Electric Power, Air, Removable Construction, General Specification for
MIL-C-17588	-	Circuit Breakers (Automatic-ALB-1) and Switch, Toggle (Circuit Breaker, Non-Automatic-NLB-1) Air, Insulated Housing, 125 Volts and Below, A.C. and D.C., (Naval Shipboard Use)
MIL-PRF-17773	-	Switches, Bus Transfer, Electric Power, Automatic and Manual
MIL-DTL-18240	-	Fastener Element, Self-Locking, Threaded Fastener, 250 °F Maximum
MIL-S-18396	-	Switches, Meter and Control, Naval Shipboard
MIL-W-19088	-	Wattmeters, Switchboard Type, 4-1/2 Inch
MIL-PRF-19207	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating, General Specification for
MIL-PRF-19207/1	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Types FHL10U and FHL10G
MIL-PRF-19207/2	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Types FHL11U and FHL11G
MIL-PRF-19207/3	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Types FHL12U and FHL12G
MIL-PRF-19207/5	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL14G
MIL-PRF-19207/21	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Non-EMI/RFI Shielded and EMI/RFI Shielded, Type FHL32W and Type FHL32WS
MIL-PRF-19207/22	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL33W
MIL-PRF-19207/23	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL34W
MIL-PRF-19207/24	-	Fuseholders, Extractor Post Type, Blown Fuse Indicating, Non-EMI/RFI Shielded and EMI/RFI Shielded, Type FHL35W and Type FHL35WS

MIL-R-19523	-	Relays, Control
MIL-DTL-21604	-	Switches, Rotary, Multipole and Selector; General Specification for
MIL-DTL-21604/5	-	Switch, Rotary, Multipole and Selector, 10 Ampere, Style JR
MIL-E-22118	-	Enamel, Electrical-Insulating
MIL-V-23151	-	Voltmeter, Expanded Scale Switchboard Type (Naval Shipboard Use)
MIL-M-23167	-	Meter, Frequency, Expanded Scale Switchboard Type (Naval Shipboard Use)
MIL-S-24188	-	Synchronizing Control Equipment, 60 Cycles, 450 Volts, Naval Shipboard
MIL-M-24350	-	Monitors, Reverse Power and Power-Sensing, Electrical Power (Naval Shipboard Use) (Metric)
MIL-I-24391	-	Insulation Tape, Electrical, Plastic Pressure-Sensitive
MIL-DTL-24552	-	Terminals and Seals, Plugs and Switch, Casualty Power Systems, Receptacle Type, General Specification for
MIL-DTL-24552/1	-	Terminals and Seals, Plugs and Switch, Casualty Power, Receptacle Type, Back Connected 200 Ampere, 450-Volt, Alternating Current, Three-Phase, Symbol No. 1046
MIL-DTL-24552/2	-	Terminals and Seals, Plugs and Switch, Casualty Power, Receptacle Type, Upper and Lower Riser, 200-Ampere, 450-Volt, Alternating Current, Three-Phase, Symbol No. 1047
MIL-R-24563	-	Relay, Alternating Current, Power-Sensing
MIL-PRF-28750	-	Relays, Solid-State, General Specification for
MIL-DTL-28803	-	Display, Optoelectronic, Readouts, Back Lighted Segmented, General Specification for

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-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-1310	-	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility, Electromagnetic Pulse (EMP) Mitigation, and Safety
MIL-STD-1399-300	-	Electric Power, Alternating Current
MIL-STD-1474	-	Noise Limits
MIL-STD-2003-2	-	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Equipment)

MIL-STD-46855 - Human Engineering Requirements for Military Systems, Equipment, and Facilities

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-470 - Designing and Developing Maintainable Products and Systems, Volume I

(Copies of these documents are available are available online at http://quicksearch.dla.mil/ or https://assist.dla.mil.)

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.

CODE OF FEDERAL REGULATIONS

29 CFR1910 - Occupational Safety and Health Standards

(Copies of this document are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20401 or online at www.gpoaccess.gov/index.html.)

DEFENSE STANDARDIZATION PROGRAM OFFICE

SD-18 - Defense Standardization Program Guide for Part Requirements and Application

(Copies of this document are available from http://www.navsea.navy.mil/nswc/crane/sd18/default.aspx or to obtain a CD-ROM, send requests to Commander, Naval Surface Warfare Center – Crane Division, ATTN: Code 6056, Mr. Dan Quearry, Building 3334, 300 Highway 361, Crane, IN 45722-5001.)

MILITARY STANDARD DRAWINGS

MS17831 - Bus Disconnect Quick Opening Symbol 1484

MS17832 - Operating Wrench, Bus Disconnect Symbol 1485

(Copies of these documents are available online at http://quicksearch.dla.mil/ or https://assist.dla.mil.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9074-AR-GIB-010/278 - Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels

S9074-AQ-GIB-010/248 - Requirements for Welding and Brazing Procedure and Performance Qualification

S9086-CJ-STM-010 - NSTM Chapter 075, Fasteners

(Copies of these documents are available online at https://nll1.ahf.nmci.navy.mil. These publications can be located by searching the Navy Publications Index for the TMIN without the suffix.)

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.

ASME INTERNATIONAL

ASME Y14.38 - Abbreviations and Acronyms for Use on Drawings and Related Documents

(Copies of this document are available from ASME International, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 or online at www.asme.org.)

ASTM INTERNATIONAL

ASTM A131/A131M - Standard Specification for Structural Steel for Ships

ASTM A167	-	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	-	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A666	-	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM A1011/A1011M	-	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B36/B36M	-	Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
ASTM B98/B98M	-	Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes
ASTM B121/B121M	-	Standard Specification for Leaded Brass Plate, Sheet, Strip, and Rolled Bar
ASTM B127	-	Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip
ASTM B164	-	Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B187/B187M	-	Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
ASTM B209	-	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B221	-	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B371/B371M	-	Standard Specification for Copper-Zinc-Silicon Alloy Rod
ASTM B411/B411M	-	Standard Specification for Copper-Nickel-Silicon Alloy Rod and Bar
ASTM B564	-	Standard Specification for Nickel Alloy Forgings
ASTM B700	-	Standard Specification for Electrodeposited Coatings of Silver for Engineering Use
ASTM D709	-	Standard Specification for Laminated Thermosetting Materials

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE C37.20.1 - IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

(Copies of this document are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or online at www.ieee.org.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA HP 6 - Electrical and Electronic Silicone and Silicone Braided Insulated, Hook-Up Wire, Types S (600 V), ZHS (600 V), SS (1000 V), ZHSS (1000 V), and SSB Braided (1000 V)

(Copies of this document 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-AS7928 - Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For

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

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 2 - Hand Tool Cleaning

SSPC SP 3 - Power Tool Cleaning

(Copies of these documents are available from SSPC Publication Sales, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4656 or online at www.sspc.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, 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 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 General requirements.

3.2.1 Safety. The switchgear shall provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof. Equipment design for personnel safety shall be equal to or better than the appropriate requirements of the Occupational Safety and Health Act (OSHA) as identified in Title 29, Part 1910, of the Code of Federal Regulations (CFR). Except as required herein, safety shall be in accordance with MIL-E-917.

3.2.2 Accidental contact. The switchgear shall provide protection to personnel against accidental contact with voltages in excess of 30 volts root mean square (RMS) or DC with all removable panels in place and hinged doors closed.

3.2.3 Design life. All switchboards and switchboard equipment that are detailed in this specification shall have a minimum design life of not less than 30 years. Specific components not meeting this requirement shall be identified.

3.3 Detailed requirements.

3.3.1 Materials, parts, and process. Except as required herein, materials, parts, and processes (such as, but not limited to, prohibited materials, metals or coatings, threaded parts and fastening devices, electrical insulation, soldering, and brazing) shall be in accordance with MIL-E-917. When a requirement of MIL-E-917 conflicts with a requirement of this specification, the requirements of this specification shall govern.

3.3.1.1 Switchgear groups. Whether or not specifically mentioned for the various units, switchgear groups shall be complete with all devices required to accomplish the function specified hereinafter.

3.3.1.2 Cadmium. Elemental cadmium shall not be present in any component of the final product.

3.3.1.3 Mercury. Mercury shall not be used in any process of manufacture or test of switchgear and its components.

3.3.1.4 Polyvinyl chloride (PVC). PVC material shall not be used. Unless otherwise specified (see 6.2), PVC use will be allowed only if it is a part of or integral to the leads of a component or as a constituent or integrated element of a component.

3.3.1.5 Chemical conversion coatings. Chemical conversion coatings may be used as a protective coating for aluminum frame and aluminum components internal to the switchboard. Coatings may also be used as a preparation for the paint process. Electrically conductive Class 3 coating may be used in grounding. When used, coatings shall meet requirements of MIL-DTL-5541, visually discernible color.

3.3.2 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.

3.3.3 Component derating. Components shall be derated in accordance with applicable paragraphs of this specification. SD-18 may be used as a derating guideline.

3.4 Construction. Unless otherwise specified (see 6.2), the equipment shall conform to the general requirements of MIL-E-917 and be designed for operation, maintenance, and repair by the 5th through the 95th percentile user as described in MIL-STD-46855. Whether or not specifically mentioned for the various units, switchgear groups shall be complete with all devices required to accomplish the functions specified herein.

3.4.1 Ship's service power switchgear group (see 6.3.12) for ships having AC power.

3.4.1.1 AC generator control unit for switchgear groups having an electric plant control panel (EPCP) or having both an EPCP and an electric plant control console (EPCC). (see figure 1 for a typical one-line diagram) The following shall be mounted on or within the unit:

a. One generator circuit breaker.

b. One control power transformer (450/120 volts), connected to generator side of circuit breaker, for generator circuit breaker and governor motor control circuits, if required.

c. Potential transformers for metering and relaying, electric governor, and synchronizing, in number as required.

d. Current transformers for metering and relaying and for electric governor, in number as required. Protective device when metering is remote.

e. One current transformer with protective device for remote metering, where remote metering is required.

f. Dead-front fuse panel for fusing of the potential and control transformer primary circuits and any control circuits extending outside of the section. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

g. Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers as specified (see 6.2). Equipment shall be furnished with the generators.

h. One circuit breaker (see 3.12), Type AQB-A or AQB-LF, 250-ampere frame size. The casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kilowatts or greater, two casualty power circuit breakers shall be furnished.

i. One casualty power terminal, back-connected type, conforming to MIL-DTL-24552, connected through the AQB-A or AQB-LF circuit breaker, item (h). When the generator capacity is 500 kilowatts or greater, two casualty power terminals, back-connected type, shall be furnished.

j. One reverse power relay, conforming to MIL-M-24350, to prevent the generator from motoring on the bus after loss of driving power from the prime mover.

k. One indicator light (blue) to indicate that the generator circuit breaker is closed.

l. One generator running and voltage available auxiliary relay for control of associated indicator lights.

m. Space, mounting, and wiring for the electric governor equipment, if required (see 6.2). Equipment shall be furnished with the generator set.

3.4.1.1.1 AC generator control unit for switchgear groups on ships provided with a centralized machinery control system including an EPCC, but not an EPCP. The following shall be mounted within the unit:

a. One generator circuit breaker, electrically-operated.

b. One control power transformer (450/120 volts), connected to generator side of generator circuit breaker, for generator breaker and governor motor control circuits, if required.

c. Potential transformer for metering and relaying, electric governor, and synchronizing, in number as required.

d. Current transformers, for metering and relaying, and for electric governor, in number as required. Protective device when metering is remote.

e. One current transformer with protective device for remote metering.

f. Dead-front fuse panel for fusing of the potential and control transformer primary circuits and any control circuits extending outside of the section. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

g. Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers as specified (see 6.2). Equipment shall be furnished with the generators.

h. Relays for remote control of the generator circuit breaker. Relays shall be energized from EPCC power.

i. Load sensing relays in accordance with MIL-R-24563 or MIL-M-24350 to sense generator overload and activate the load shedding system, if required (see 6.2).

j. One Type AQB-A or AQB-LF circuit breaker (see 3.12), instantaneous element only, for power supply to the pump supplying cooling (sea) water to the generator diesel or gas turbine prime mover. Circuit breaker shall be connected on the generator side of the generator circuit breaker. A red warning instruction plate shall be provided stating that the circuit breaker shall always be in the closed position when the gas turbine or diesel are set up for starting.

k. One circuit breaker (see 3.12), Type AQB-A or AQB-LF, 250-ampere frame size. Casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kilowatts or greater, two casualty power circuit breakers shall be furnished.

l. One casualty power terminal, back-connected type, conforming to MIL-DTL-24552 connected through the AQB-A or AQB-LF circuit breaker, item (k). When the generator capacity is 500 kilowatts or greater, two casualty power terminals, back-connected type, shall be furnished.

m. One reverse power relay, conforming to MIL-M-24350, to prevent the generator from motoring on the bus after loss of driving power from prime mover.

n. One generator running and voltage available auxiliary relay for control of associated indicator lights. This relay is not required when a supervisory control system (SCS) is incorporated in the EPCC, and the signal can be derived from generator voltage and speed signals.

o. Space, mounting, and wiring for the electric governor equipment, if required (see 6.2). Equipment shall be furnished with the generator set.

p. One Type I synchronizing system for each switchgear group. The synchronizing control system may be mounted in the bus tie unit instead of the generator control unit.

q. One Type II automatic paralleling device, if required (see 6.2). The automatic paralleling system may be mounted in the bus tie unit instead of the generator control unit.

3.4.1.1.1.1 Front panel. The following shall be mounted on the front panel of the generator unit:

a. One AC ammeter for reading one phase of generator current.

b. One AC voltmeter with transfer switch for reading one phase of generator potential, one phase of each bus tie voltage, and one phase of shore power voltage for switchgear group containing shore power connection.

c. One polyphase wattmeter for reading generator output.

d. One frequency meter with transfer switch for reading frequency of generator and each bus tie frequency and shore power for switchgear group containing shore power connection.

e. One control switch for control of the generator circuit breaker.

f. Control switches as required (see 6.2) in conjunction with the governor speed regulation of the generator prime mover.

g. One local/remote control transfer switch for the purpose of transferring control from the local station to the EPCC. Monitoring and indicating circuits shall not be transferred except as noted below. Circuits transferred by this switch shall include:

(1) Generator starting and stopping. Remote generator starting shall be transferred by the switch. Remote generator stopping shall be locked out when the switch is in the local position. Local stopping and remote emergency stopping shall be effective regardless of the position of the switch.

(2) Generator output voltage control.

(3) Prime mover governor manual control.

(4) Voltage regulator mode selection.

(5) Governor mode selection.

(6) Circuit breaker control of all circuit breakers which are controlled at the EPCC. This shall include control of the synchronizing control system. Local automatic protection such as reverse power protection shall remain operative regardless of the position of the local/remote transfer switch.

(7) Elements of the generator green light circuit which are duplicated locally and at the EPCC.

(8) Local/remote transfer switch position indication.

h. Local/remote transfer switch position indicator light (white).

i. One control switch with indicator light (white) for control of the generator space heaters when provided with the generator as specified (see 6.2).

j. Control switches, rheostats, and similar equipment that is designed for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted and operated from the front panel as specified (see 6.2).

k. For installation in which a bus tie unit is not provided, one set of three ground indicator lights (clear) with a control switch to indicate ground on the main bus or its connected feeders.

l. One synchroscope and one set of synchronizing lights (clear) with selector switch for synchronizing with the main bus, the main bus with the bus tie circuit, and the bus tie with shore power switchgear group containing shore power connection.

(1) For synchronizing monitor devices (Type I) and automatic paralleling devices (Type II):

(a) System selector switch for selecting the system to be paralleled. This switch may be combined with the synchroscope selector switch.

(b) An indicator light (white) to indicate that the synchronizing control system is energized.

(2) For synchronizing monitor devices the following applies:

(a) Synchronizing control monitor operating mode selector switch having Operating, Test, and Off positions.

(3) For automatic paralleling devices the following applies:

(a) One operating mode selector switch having Automatic, Manual Permissive, Test, and Off positions.

(b) One pushbutton control switch for initiation of the automatic paralleling operation.

(c) An indicator light (red) to indicate that the synchronizing control equipment is unable to close the circuit breaker when in the automatic mode.

(d) A pushbutton to interrupt the automatic paralleling cycle to completion of paralleling.

(e) Indicating devices as required by MIL-S-24188.

m. Test receptacles with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary winding of metering current transformers so that only the meters are electrically removed from the circuit.

n. One temperature indicator with select switch and accessories, when temperature detectors are provided with the generator as specified (see 6.2).

o. One indicator light (blue) to indicate that the generator circuit breaker is closed.

p. One AC ammeter for each casualty power terminal furnished for reading one phase of casualty power current.

3.4.1.1.2 AC bus tie unit for switchgear groups on ships provided with a centralized machinery control system including an EPCC, but not an EPCP. The following shall be mounted within the unit:

a. One electrically-operated bus tie circuit breaker.

b. One feeder circuit breaker.

c. Necessary disconnecting devices for performing isolating functions as may be required (see 6.2).

d. Potential transformers, for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.

e. One current transformer for metering the current interchange through the bus tie circuit breaker.

f. Dead-front fuse panel for fusing the potential and control power transformer primary circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

g. Transfer relays to automatically transfer the source of circuit breaker closing power between the switchboard bus and bus tie.

h. Relays for remote control of the bus tie circuit breaker. Relays shall be energized from EPCC power.

Bus tie units of the switchgear group containing the shore power connection shall be designated as a “bus tie and shore power unit”. In addition, this unit shall substitute item (i) for the feeder circuit breaker, and items (j), (k), and (l) as follows shall be added:

i. Circuit breakers, Type AQB-LF, motor operated, 400-ampere frame size, to be furnished on only one bus tie unit of any switchgear group. One shall be provided for each shore power receptacle. Shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker. Where more than four circuit breakers are required, a separate switchgear unit may be provided.

j. Current transformers for metering the total shore power current.

k. Potential transformers for metering and synchronizing, in number as required.

l. Relays for remote control of the shore power circuit breaker motor operators. Motor operators shall be controlled from the local switchboard.

3.4.1.1.2.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

a. One control switch for control of the bus tie circuit breaker.

b. Indicator lights (blue) to show the closed position of the bus tie circuit breaker and the Type ACB (see 3.12) feeder circuit breaker.

c. One set of three ground indicator lights (clear) with a control switch to indicate ground conditions on the main bus or any of its connected feeders.

d. One AC ammeter for indicating the bus tie current.

e. One zero neutral wattmeter for reading bus tie power and direction of power flow.

3.4.1.1.2.2 Bus tie and shore power unit. When this unit is designated a bus tie and shore power unit, the following additional devices shall be mounted on the front panel of the unit:

a. One shore power circuit breaker control switch for operating all shore power circuit breakers simultaneously.

b. One indicator light (white) per shore power receptacle to indicate the shore power feeder is energized. One indicator light (white) to indicate the bus feeder is energized. These indicator lights shall be mounted near the shore power circuit breakers.

c. Indicator lights (blue) to indicate that each shore power circuit breaker is closed.

d. One switchboard type phase sequence indicator with a multiposition selector switch for use in checking phase rotation and orientation of shore power connections (see figure 2). Two indicator lights (green) to indicate phase orientation.

e. One transfer switch for use with the generator unit frequency meter for reading the frequency of the bus tie circuit and shore power.

f. One reference selector switch for use in checking phase orientation of shore power connections.

g. One AC ammeter for reading shore power current.

h. For shore power switchboard units with more than four shore power breakers installed, one multiposition selector switch to allow one of a selected number of different shore power receptacles to act as the master circuit. Necessary devices, including potential transformers, shall be provided on this receptacle circuit for metering and synchronizing of shore power and the switchboard bus across the shore power breakers.

3.4.1.2 AC generator control unit for switchgear groups not having an EPCP or an EPCC. (see figure 3 for a typical one-line diagram) Devices listed in 3.4.1.1, except item (l), shall be mounted on or within the unit.

3.4.1.2.1 Front panel. The following devices shall be mounted on the front panel of the generator unit:

a. One AC ammeter for reading one phase of generator current.

b. One AC voltmeter with transfer switch for reading one phase of generator potential, one phase of each bus tie voltage, and one phase of shore power voltage for switchgear group containing shore power connection.

c. One polyphase wattmeter for reading generator output.

d. One frequency meter for reading the frequency of the generator.

e. One control switch for control of the generator circuit breaker where an electrically-operated breaker is used.

f. Control switches, rheostats, and similar devices, as required (see 6.2) in conjunction with the governor speed regulation of the generator prime mover.

g. One transfer switch to transfer the governor control from the local control switch to the remote control switch on the AC bus tie unit (or control unit) of the control switchgear group. It shall also control the lamp [see 3.4.1.4.1(c)] on the bus tie unit or control unit to indicate when the remote switch is in control. This shall be provided only when the unit has control of a remote generator.

h. One control switch with indicator light (white) for control of the generator space heaters when provided with the generator as specified (see 6.2).

i. Control switches, rheostats, and similar equipment that is for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted and operated from the front panel (see 6.2).

j. For installations in which a bus tie unit is not provided, one set of three indicator lights (clear) with a control switch, to indicate ground conditions on the main bus or any of its feeders, shall be mounted on the front panel of the generator unit.

k. One synchroscope and one set of synchronizing lights (clear) with transfer switch for synchronizing the generator with the main bus, and the main bus with the bus tie circuit, and the bus tie with shore power for switchgear group containing shore power connection mounted and operated from the front panel.

l. One Type I synchronizing control equipment shall be provided for each single or two generator switchgroup. The synchronizing control monitor may be mounted in the bus tie unit instead of the generator control unit.

m. One Type II automatic paralleling device, if required (see 6.2). The automatic paralleling device may be mounted in the bus tie unit instead of the generator control unit.

n. Test receptacles with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary winding of metering current transformers, so that only the meters are electrically removed from the secondary circuit.

o. One temperature indicator with selector switch and accessories, when temperature detectors are provided with the generator as specified (see 6.2).

3.4.1.3 AC bus tie unit for switchgear groups having an EPCP, or having both an EPCP and EPCC. The following shall be mounted within the unit:

a. One bus tie circuit breaker.

b. One feeder circuit breaker.

c. Necessary disconnecting devices for performing isolation functions as may be required (see 6.2).

d. Potential transformers, for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.

e. One current transformer for metering the current interchange through the bus tie circuit breaker.

f. Dead-front fuse panel for fusing the potential and control power transformer primary circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

g. Indicator light (blue) to show the closed position of the bus tie and feeder circuit breaker.

Bus tie units of the switchgear group containing the shore power connection shall be designated as a “bus tie and shore power unit”. In addition, this unit shall substitute item (h) for the feeder circuit breaker, and add items (i) and (j) below:

h. Circuit breakers, Type AQB-LF, electrically-operated, 400-ampere frame size shall be furnished on only one bus tie unit of any switchgear group. One shall be provided for each shore power receptacle. The shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker. Where more than four circuit breakers are required, a separate switchgear unit may be provided.

i. Current transformers for metering the total shore power current.

j. Potential transformers for metering and synchronizing, in number as required.

3.4.1.4 AC bus tie unit for switchgear groups not having an EPCP or EPCC. The following shall be mounted within the unit:

a. One bus tie circuit breaker.

b. One feeder circuit breaker.

c. Necessary disconnecting devices for performing switching functions as may be required.

d. Potential transformers for metering and relaying, and for synchronizing, in number as required for the bus connections of the switchgear group.

e. Dead-front fuse panel for fusing the control circuits fed from the control power bus. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

f. Dead-front fuse panel for fusing the potential and control power transformer primary circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

3.4.1.4.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

a. One polyphase wattmeter, calibrated to indicate the three-phase power output of remote ship’s service generator.

b. One AC ammeter for indicating the current of remote ship’s service generator and from the shore power connection.

c. Remote control switches or rheostats, and indicator lights (white), as required, to control the speed of the prime movers of the remote generators. The control switch power shall be connected through the transfer switches [see 3.4.1.2.1(h)] on the generator units of the remote switchgear groups, and the indicating lamps shall be connected to indicate when the transfer of control is accomplished. This shall be provided when the unit has control of a remote generator.

d. One composite transfer switch for reading the power and current of each remote generator by means of (a) and (b) above and the shore power current by means of (b) above.

e. One control switch for control of the bus tie circuit breaker where an electrically-operated circuit breaker is used.

f. Indicator lights (blue) to show the closed position of the bus tie circuit breaker and the Type ACB feeder circuit breaker.

g. One frequency meter for reading the frequency of the bus tie circuit.

h. One transfer switch, with two white indicator lights, for connecting the switchboard control bus to the local 450-volt ship's service bus, or the 450-volt bus of the corresponding (forward or aft) emergency switchboard. Transfer may be accomplished automatically; however, in such cases one source of power shall be the local 450-volt ship's service bus and the second source shall be a 450-volt bus tie supply.

i. One set of three indicator lights (clear) with a control switch to indicate ground conditions on the main bus or any of its connected feeders.

j. One zero neutral wattmeter for reading bus tie power and direction of power flow.

3.4.1.4.2 Bus tie and shore power unit. One bus tie unit of the switchgear group containing the shore power connection shall be designated as a "bus tie and shore power unit". In addition to the devices specified in 3.4.1.4 and 3.4.1.4.1, this unit shall substitute item (a) for the feeder circuit breaker, and the additional items (b) through (h) shall be provided.

a. Circuit breakers, Type AQB-LF, electrically-operated, 400-ampere frame size shall be furnished on only one unit of the switchgear group. One shall be provided for each shore power receptacle. The shore power circuit shall be connected to the bus tie circuit so that power may be fed to either the local or remote switchboard through a bus tie circuit breaker.

b. One shore power circuit breaker control switch for operating all shore power circuit breakers simultaneously.

c. One indicator light (white) per shore power receptacle to indicate the shore power feeder is energized. One indicator light (white) to indicate the bus feeder is energized. These indicator lights shall be mounted near the shore power circuit breakers.

d. Indicator lights (blue) to indicate that each shore power circuit breaker is closed.

e. Current transformers for metering the total shore power current.

f. One switchboard type phase sequence indicator with a multiposition selector switch for use in checking phase rotation and orientation of shore power connections.

g. Potential transformers for metering and synchronizing, in number as required.

h. One transfer switch for use with item (g) of 3.4.1.4.1 for reading the frequency of the bus tie circuit and shore power (see figure 2).

i. One reference selector switch for use in checking phase orientation of shore power connections.

j. Two indicator lights (green) for use with (f) and (i) above.

k. For shore power switchboard units with more than four (4) shore power breakers installed, one multi-position selector switch to allow one of a selected number of different shore power receptacles to act as the master circuit. Necessary devices, including potential transformers, shall be provided on this receptacle circuit for metering and synchronizing of shore power and the switchboard bus across the shore power breakers.

3.4.1.5 Electric plant control panels.

3.4.1.5.1 Desk type EPCP (see 6.3.3). Desk type EPCP (see figure 4) shall be one of the following bench types:

a. A horizontal or inclined desk top for plant operation controls.

b. Inclined desk top for plant operation controls with apron section below.

Desk type EPCP shall have vertical panels for the mounting of instruments, displays, and associated controls. When specified (see 6.2), desk type EPCP for surface ships shall be provided with a chair that can be mounted so that it can be swung out of the way when not in use. Requirements for desk type EPCP shall be as specified (see 6.2).

3.4.1.5.1.1 Control switches. Control switches for the electrically-operated circuit breakers controlled from the EPCP shall be mounted on the desk top and arranged within convenient reach of the operator. Circuit breaker control switches and their corresponding switches in the mimic bus system shall be located so that their relative positions as to their locations on the EPCP are similar. Automatic voltage adjusting rheostats shall be mounted close to the meters being affected by their adjustment. Large equipment which requires infrequent personnel attention shall be located in the apron portion to conserve panel and desk space. The portion of the apron panel used for mounting the equipment shall not project beyond the front edge of the desktop. Space shall be provided for filing the reduced size drawing. Space shall be provided for the mounting of the interior communication (IC) equipment as specified (see 6.2).

3.4.1.5.2 Vertical EPCP. (see 6.3.13) Vertical EPCP shall be arranged to orient instruments, displays, and their associated controls near the top, other plant operation controls toward the middle, and larger, infrequently used equipment at the bottom. Requirements for vertical type EPCP shall be as specified (see 6.2).

3.4.1.5.3 Surface ship EPCP. The following shall be mounted on the EPCP for surface ships:

a. Control switches, rheostats, and similar equipment that is for panel mounting and is required in conjunction with the voltage regulator equipment mounted in the generator unit shall be mounted on and operated from the EPCP (see 6.2).

b. One AC ammeter for each local generator for reading one phase of generator current.

c. One AC voltmeter for each local generator for reading one phase of generator potential.

d. One AC voltmeter with transfer switch for reading single-phase voltage of the switchboard bus and of the bus tie feeders and shore power for switchgear groups containing shore power connection.

e. One polyphase wattmeter for reading generator output for each local generator.

f. One polyphase wattmeter with transfer switch to indicate the three-phase power output of the remote ship's service generator (shall be provided where a switchgear group is to have control of a remote generator or generators).

g. One temperature indicator with selector switch and accessories when temperature detectors are provided with the generator as specified (see 6.2).

h. One frequency meter for reading the frequency of the generator for each local generator. For units controlling two local generators, each frequency meter shall be provided with a transfer switch for reading the frequency of one generator and one bus tie circuit and shore power, in which case 3.4.1.5.3(i) shall be omitted.

i. One frequency meter with transfer switch for reading the frequency of the bus and of each bus tie circuit and shore power for switchgear group containing shore power connection. For units controlling two local generators, each frequency meter [see 3.4.1.5.3(h)] shall be provided with a transfer switch for reading the frequency of one generator and one bus tie circuit and shore power, in which case 3.4.1.5.3(i) shall be omitted.

j. One local control switch, or other control device as required, for control of the speed governor of the generator prime mover for each local generator.

k. One transfer switch to transfer the governor control of the generator prime mover from local control to the remote control on the master EPCP. It shall also control the indicator light on the master EPCP to indicate when the remote station is in control. This transfer switch shall be provided only on EPCPs for which remote control, item (l), is to be provided on the master EPCP.

l. One remote control switch or other remote control devices as required, and indicator light (white) to control the speed governor on the remote generator prime mover where the unit has control of a remote generator. Control power shall be connected through the transfer switch, item (k), of the remote EPCP, and the indicating light shall be energized when the transfer of control to the remote station is accomplished.

m. One control switch with circuit breaker closed indicator light (blue) for control of each local generator circuit breaker.

n. One control switch with circuit breaker closed indicator light (blue) for control of each bus tie circuit breaker.

o. One control switch with circuit breaker closed indicator light (blue) for control of each electrically-operated distribution circuit breaker.

p. One control switch with space heater on indicator light (white) for control of generator space heater (when provided with the generator) for each local generator when specified (see 6.2).

q. Test receptacle with test plugs for connecting portable instruments to the metering current and potential circuits. Removal of the receptacle protective cover shall automatically short circuit the secondary of metering current transformers, so that only the meters are electrically removed from the secondary circuit.

r. One transfer switch with two indicator lights (white) for connecting the switchboard control bus to the local 450-volt ship's service bus, or the 450-volt emergency supply. The transfer may be accomplished automatically; however, in such cases one source of power shall be the local 450-volt ship's service bus and the second source shall be a 450-volt bus tie supply.

s. One set of three ground indicator lights (clear) with a test switch to indicate ground conditions on the main bus.

t. Dead-front fuse panel for fusing the control circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

u. One mimic bus system (dark type) simulating the generator and bus tie connections shall be provided and shall consist of the following:

(1) Indicator lights (white) for each generator to indicate generator running and voltage available.

(2) Indicator lights (yellow) for each generator and bus tie circuit breaker.

(3) Single-pole, double-throw switches shall be provided for each circuit breaker light. These switches shall be combined with their respective yellow lights and so arranged that when the switch handle indication and the circuit breaker position (open or closed) are the same, the light shall be out. When the circuit breaker position and the switch handle indication are different, the light shall be lit. For indicator light power supply, see 3.11.7.

(4) Mimic bus material shall be 1/8 inch thick, 1/4 inch, 3/4 inch, or 1/2 inch wide, as specified (see 6.2). Mimic bus material shall be laminated plastic conforming to Grades ES-1, ES-2, or ES-3 of ASTM D709; aluminum alloy conforming to ASTM B209, alloy 5052; commercial brass conforming to ASTM B36/B36M and ASTM B121/B121M; corrosion resisting steel conforming to Type 316 of ASTM A167, ASTM A240/A240M, and ASTM A666; or nickel-copper alloy conforming to ASTM B127, ASTM B164, and ASTM B564.

v. One ammeter to indicate current in the bus tie.

w. One ammeter for each remote generator for reading one phase of generator current.

x. One shore power circuit breaker control switch for each shore power station to simultaneously operate all circuit breakers for that station. One indicator light (blue) for each shore power circuit breaker to indicate breaker closed. One indicator light (white) per shore power receptacle to indicate the shore power feeder energized. One indicator light (white) to indicate the bus feeder energized. These indicator lights shall be mounted near the shore power circuit breaker control switch.

y. One control switch with one blue and one white indicator light for each electrically-operated circuit breaker feeding an emergency switchboard.

z. One ammeter for reading the shore power current.

aa. One switchboard type phase sequence indicator with a multiposition selector switch, for use in checking phase rotation and orientation of shore power connections.

bb. One reference switch for use in checking phase orientation of shore power connections. Two indicator lights (green) to indicate phase orientation.

cc. One local/remote control transfer switch for the purpose of transferring control from the local station to the EPCC. Monitoring and indicating circuits shall not be transferred except as noted below. This is required only on ships provided with a centralized machinery control system including an EPCC when specified (see 6.2). Circuits transferred by this switch shall include:

(1) Generator starting and stopping. Remote generator starting shall be transferred by the switch. Remote generator stopping shall be locked out when the switch is in the local position. Local stopping and remote emergency stopping shall be effective regardless of the position of the switch.

(2) Generator output voltage control.

(3) Prime mover governor manual control.

(4) Voltage regulator mode selection.

(5) Governor mode selection.

(6) Circuit breaker control of all circuit breakers which are controlled at the EPCC. This shall include control of the synchronizing control system. Local automatic protection shall remain operative regardless of the position of the local/remote transfer switch.

(7) Elements of the generator green light circuit which are duplicated locally and at the EPCC.

(8) Local/remote transfer switch position indication on the EPCC.

dd. One synchroscope and one set of synchronizing lights (clear) with selector switch for synchronizing with the main bus, the main bus with the bus tie circuit, and the bus tie with shore power for switchgear group containing shore power connection. Where the switchgear group has control of two generators and two bus tie circuits, the synchroscope and synchronizing lights (clear) shall be connected for synchronizing either generator with the bus and the bus with either bus tie circuit.

(1) For synchronizing monitor devices (Type I) and automatic paralleling devices (Type II):

(a) System selector switch for selecting the system to be paralleled. This switch may be combined with the synchroscope selector switch.

(b) An indicator light (white) to indicate that the synchronizing control system is energized.

(2) For synchronizing monitor devices the following applies:

(a) Synchronizing control monitor operating mode selector switch having Operating, Test, and Off positions.

(3) For automatic paralleling devices the following applies:

(a) One operating mode selector switch having Automatic, Manual Permissive, Test, and Off positions.

(b) One pushbutton control switch for initiation of the automatic paralleling operation.

(c) An indicator light (red) to indicate that the synchronizing control equipment is unable to close the circuit breaker when in the automatic mode.

(d) A pushbutton to interrupt the automatic paralleling cycle to completion of paralleling.

(e) Indicating devices as required by MIL-S-24188.

3.4.1.5.4 Submarine EPCP. The following shall be mounted on submarine EPCPs:

a. For each ship's service turbine generator: items (a), (b), (e), (j), (m), (p), (q), and (z) of 3.4.1.5.3.

b. For each ship's service motor generator: items (a), (b), (m), and (p) of 3.4.1.5.3 and the following additional devices:

(1) Control switches, rheostats, and similar devices as required (see 6.2) in conjunction with speed regulating equipment.

(2) One control switch with indicator light (blue) for control of each motor circuit breaker.

(3) One ammeter, zero center scale, for reading DC current.

c. For a diesel generator:

(1) Control switches, rheostats, and similar equipment that are for panel mounting, and as required in conjunction with the voltage regulator equipment mounted in the generator unit, shall be mounted on and operated from the EPCP (see 6.2).

(2) One control switch with indicator light (blue) for control of the diesel generator circuit breaker.

(3) One AC ammeter for reading one phase of the generator current.

(4) One polyphase wattmeter for reading the generator power output.

(5) One control switch or other control devices as required, for control of the governor on the generator prime mover as specified (see 6.2).

d. For the battery:

(1) Two zero center scale DC ammeters, one high range and one low range, to measure battery charge and discharge currents.

(2) One battery float charge measuring device.

(3) One hydrogen detector remote indicator.

(4) One control switch with indicator light (blue) for control of each battery circuit breaker.

(5) One battery exhaust fan control switch with indicator light (green).

(6) One battery ventilation flow indicator.

(7) One control switch with ammeter to control and indicate operation of battery recirculating fans.

e. For the system:

(1) One synchroscope with synchronizing selector switch for synchronizing generators with the bus and the bus with bus tie circuits.

(2) Two frequency meters and two voltmeters connected through the synchronizing selector switch for reading frequency and voltage on each side of the point at which synchronizing is being performed.

(3) One DC voltmeter with selector switch for reading battery and DC bus voltages.

(4) One transfer switch with two indicator lights (white) for connecting the AC control bus to a 450-volt normal and alternate source of supply.

(5) One transfer switch with two indicator lights (white) for connecting the DC control bus to a normal and alternate DC supply.

(6) A direct reading ground detector.

(7) Dead-front fuse panel for fusing control circuit. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

(8) One mimic bus system simulating the generators, bus ties, shore power, and battery connections of the power system [see 3.4.1.5.3(u)].

(9) A transfer device with indicator light (white) shall be installed for supplying each DC control bus from either its respective motor generator DC bus or from the battery side of the battery circuit breaker.

(10) Test receptacles with test plugs shall be provided for connecting portable instruments to all metering and potential circuits on the EPCP. Removal of the receptacle protective cover shall automatically short circuit the secondaries of the metering current transformers so that only the meters are electrically removed from the secondary circuit.

3.4.1.5.5 400 Hertz EPCP for solid-state frequency changer systems. The following shall be mounted on the 400 Hertz EPCP:

a. One mimic bus system (dark type) simulating the frequency changer and bus tie connections shall be provided and shall consist of the following:

(1) Indicator lights (white) for each frequency changer to indicate frequency changer energized and voltage available.

(2) Indicator lights (yellow) for each frequency changer output contactor and bus tie circuit breaker.

(3) Single-pole, double-throw switch for each circuit breaker light. These switches shall be combined with their yellow lights and arranged so that when the switch handle indication and the circuit breaker position (open or closed) are the same, the light shall be out. When the circuit breaker position and the switch handle indication are different, the light shall be on. For indicator light power supply, see 3.11.7. Black mimic bus material shall be 1/8 inch thick, 1/4, 3/8, or 1/2 inch wide, as specified (see 6.2). Mimic bus materials shall be laminated plastic conforming to Grades ES-1, ES-2, or ES-3 of ASTM D709; aluminum alloy conforming to ASTM B209, alloy 5052; commercial brass conforming to ASTM B36/B36M and ASTM B121/B121M; corrosion-resisting steel conforming to Type 316 of ASTM A167, ASTM A240/A240M, and ASTM A666; or nickel-copper alloy conforming to ASTM B127, ASTM B164, and ASTM B564.

b. One current meter for reading one phase of each frequency changer output.

c. One pushbutton switch combination for actuating each frequency changer input contactor. One indicator light (white) to indicate that the unit is energized.

d. One control switch with indicator light (blue) for each frequency changer output contactor.

e. One control switch with indicator light (blue) for control of each 400 Hertz bus tie circuit breaker.

f. One remote control switch with indicator light (blue) for control of each applicable 400 Hertz distribution circuit breaker.

g. One set of three indicator lights (white) with a control switch to indicate ground conditions on the main 400 Hertz bus.

h. Solid-state frequency changer failure mode indicators as required (see 6.2).

3.4.1.6 ACB circuit breaker distribution unit. This unit shall provide for the distribution of power from the main bus as specified (see 6.2). The following shall be provided:

a. Circuit breakers having current rating and protective features as required.

b. Indicator lights (blue) mounted on the front panel adjacent to or on the circuit breaker escutcheon to indicate when each of the feeder circuit breakers is closed.

c. Control switches shall be provided for electrically-operated circuit breakers. Where the switchgear group has EPCP or EPCC, or both, these switches shall be located on the EPCP or EPCC, or both.

d. Necessary disconnecting devices for disconnecting cables between switchgear sections and performing other switching functions. NOTE: Where a circuit breaker supplies a feeder which may be energized from another source, such as the emergency switchgear group, an indicator light (white) shall be provided to indicate feeder is energized.

3.4.1.7 AQB circuit breaker distribution unit. This unit shall provide for the distribution of electric power or lighting supply (450/120 volts) through Type AQB circuit breakers as specified (see 6.2). Units receiving two sources of supply shall be provided with interlocked NQB or AQB circuit breakers. Where interlocked circuit breakers are installed, an indicator light (white) shall be provided for each power supply to indicate when power is available (see 3.4.4).

3.4.1.7.1 Spaces. Spaces for the future installation of circuit breakers shall be blanked off, with busing installed for the circuit breakers. Mounting blocks shall also be installed for AQB circuit breakers. Circuit breaker panel blanks shall be securely fastened in place so that the blanks or the fasteners shall not fall into the interior of the switchboard under any anticipated operating conditions. They may be constructed from conducting or nonconducting material.

3.4.1.8 ACB-AQB circuit breaker distribution unit. This unit shall provide for distribution of power through both ACB and AQB Types of circuit breakers as specified (see 6.2). It shall contain the devices listed in 3.4.1.6 through 3.4.1.7.1.

3.4.1.9 Load shedding. Distribution units of ship's service switchgear groups on ships provided with a centralized machinery control system including an EPCP or an EPCC, or both an EPCP and an EPCC, for which load shedding is required, shall contain a load shedding bus or buses segregated from the main bus by electrically-operated nonautomatic circuit breakers. Individual electrically-operated ship's service distribution circuit breakers shall also be operated by the load shedding system as specified. Each electrically-operated ship's service distribution circuit breaker not disconnected from the main bus by the load shedding system shall be provided with means for remote control from the EPCC or the EPCP. Relays energized from EPCC or the EPCP power shall be provided to activate the trip circuit of electrically-operated distribution circuit breakers. Shunt trip circuit of manually operated distribution circuit breakers shall be energized from EPCC or the EPCP power. The power sensing relay shall be in accordance with MIL-R-24563 or MIL-M-24350.

3.4.2 Emergency power switchgear groups for ships having AC power. Switchgear groups for controlling larger than 100 kilowatt generators shall employ a three-way Type ABT-4A (9) circuit breaker type bus transfer equipment and shall be constructed as sectionalized switchgear groups having a separate generator and bus transfer section, and feeder sections. For switchboards controlling emergency generators rated 100 kilowatt and less, the bus transfer equipment, Type ABT-4A (9) contactor type shall be used. When the contactor type unit is used, the switchboard shall be assembled with the AQB distribution units to form a single section (see figure 5 and figure 6). Bus transfer equipment shall be in accordance with MIL-PRF-17773.

3.4.2.1 AC emergency generator control and circuit breaker type bus transfer section. The following shall be mounted on or within the unit:

a. One Type ABT-4A (9) circuit breaker type, three-way, automatic bus transfer equipment having a current rating not less than the continuous rating of the emergency generator and the current rating of the feeders from the ship's service switchboards, as specified. Associated control switches, indicator lights, and relays for panel mounting shall be mounted on one of the front panels.

b. Necessary disconnecting devices for disconnecting cables between switchgear sections and performing other isolation functions.

c. Two potential transformers for metering and relaying.

d. One Type AQB-A or AQB-LF circuit breaker, instantaneous element only, for power supply to the pump supplying cooling (salt) water to the generator diesel as specified (see 6.2) connected to the generator side of the generator circuit breaker. A red warning plate shall be provided stating that the circuit breaker shall always be in the closed position when the diesel is set up for starting.

e. Two current transformers for metering and relaying.

f. One dead-front fuse panel for fusing the potential transformer primary circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

g. One circuit breaker Type AQB-A or AQB-LF, 250-ampere frame size. Casualty power circuit breaker shall be connected to the generator side of the generator circuit breaker. When the generator capacity is 500 kilowatts or greater, two casualty power circuit breakers shall be furnished.

h. One casualty power terminal, back-connected type conforming to MIL-DTL-24552 and MIL-DTL-24552/2, connected through the AQB-A or AQB-LF circuit breaker, item (g). When the generator capacity is 500 kilowatts or greater, casualty power terminals, back-connected type, shall be furnished.

3.4.2.1.1 Front panel. The following shall be mounted on the front of the panel:

a. One AC ammeter for reading one phase of generator current.

b. One AC voltmeter for reading one phase of generator potential.

c. One polyphase wattmeter for reading generator output.

d. One frequency meter for reading generator frequency.

e. Instruction plates containing complete operating instructions for the automatic equipment and a single line diagram of the main buses.

f. One set of three ground indicator lights (clear) with test switch to indicate ground conditions on the 450-volt emergency power bus.

g. One indicator light (green), so connected as to indicate when all manually operated control devices are set up for automatic operation. The applicable following functions and conditions shall be included to complete the green light circuit.

(1) Generator circuit breaker (closed) (when separated from bus transfer).

(2) Voltage regulator transfer switch (automatic position).

(3) Ship's service bus transfer equipment (set for automatic operation).

(4) Emergency bus transfer equipment (set for automatic operation).

(5) Diesel starting control circuits (set for automatic starting).

(6) Diesel starting air shut-off valve (open).

(7) Electrically-operated emergency bus unloader switch (if used, set for automatic operation).

(8) Diesel salt water cooling pump circuit breaker (closed).

(9) Circuit breaker reset switch closed (set for automatic operation).

h. Space, mounting, and wiring for the voltage regulator equipment, including associated current and potential transformers, and for the exciter field rheostat, all equipment to be furnished with the emergency generator. The control switches, rheostats, and similar equipment constructed for panel mounting shall be located for front-of-panel operation as specified (see 6.2).

i. Space, mounting, and wiring for equipment, for the control switches and interlocks, furnished with the bus transfer equipment. The control switches and similar equipment constructed for panel mounting shall be located for front-of-panel operation.

j. One temperature indicator with selector switch and accessories, when temperature detectors are provided with the generator as specified (see 6.2).

3.4.2.2 AC emergency generator control and contractor type bus transfer section. This unit shall be equivalent functionally to the section specified in 3.4.2.1. The devices shall be the same as required in 3.4.2.1 except that the following shall be provided in lieu of 3.4.2.1(a):

a. One generator circuit breaker, Type AQB-A, manually operated.

b. Two Type ABT-4A (9) contactor type bus transfer equipments having current ratings not less than the current rating of the feeders from the ship's service switchboards, as specified. One equipment shall be connected for selection of the ship's service supply, the second equipment shall be connected for transfer between ship's service supply and the emergency generator supply.

c. Four indicator lights (blue) to indicate closed positions of the contractors of the Type ABT-4A (9) bus transfer equipments. Indicator lights circuit shall be wired through auxiliary contacts provided in the bus transfer equipments.

d. Two indicator lights (white) to indicate that the ship's service power feeders are energized.

e. One Type NQB circuit breaker, connected to bypass the bus transfer equipment selecting between ship's service and emergency so that emergency generator power may be supplied to the ship's service switchboards when their generators are secured.

f. Two control switches, one for each bus transfer equipment, for selecting between manual and automatic control of the equipments.

g. One electrically-operated emergency bus unloader switch with control relay and current transformer. This switch shall be connected between the feeder for the steering power switchboard and the emergency bus to disconnect the emergency bus during periods of high current requirements by the steering gear auxiliaries when energized from the emergency generator. Equipment shall function to hold the unloader switch closed unless the demand on the steering power switchboard exceeds 150 percent of the full load current of two steering motors plus 100 percent of the full load current of all other steering gear auxiliaries, in which case the unloader switch shall open provided the power is being supplied by the emergency generator. This item shall be furnished only when specified (see 6.2).

3.4.3 Distribution units. Distribution units of the emergency switchgear group shall be in accordance with 3.4.1.6 through 3.4.1.9.

3.4.4 Load center (see 6.3.5) distribution sections. These sections shall be switchgear unit type of construction. Units comprising the section shall provide for distribution through Type ACB or AQB circuit breakers and shall be constructed in accordance with 3.4.1.6 through 3.4.1.9. Distribution units requiring two sources of supply shall be provided with interlocked NQB, AQB, or ACB circuit breakers. Where interlocked circuit breakers are installed, an indicator light shall be provided for each power supply to indicate when power is available.

3.4.4.1 Circuit breakers. Each load center distribution section shall be provided with two Type AQB-A or AQB-LF 250-ampere frame size circuit breakers for casualty power supply and two casualty power terminals back-connected type conforming to MIL-DTL-24552 and MIL-DTL-24552/1, connected through the Type AQB circuit breakers to the main bus.

3.4.5 Ship's service power switchgear group for DC ships.

3.4.5.1 DC generator control unit. Generator control unit shall contain the following:

a. One circuit breaker.

b. One DC voltmeter and switch for reading bus and generator voltage.

c. One DC ammeter with shunt for reading generator current.

d. One indicator light (blue) to show the closed position of the generator circuit breaker.

e. One set of two ground detector lights (clear) and one control switch for indication of ground conditions on DC bus or its connected feeders.

f. Space, mounting, and wiring for the generator field rheostat and operating mechanism to be furnished with the generator.

g. One reverse current relay to prevent the generator from motoring on the bus after loss of driving power from the prime mover (only when more than one generator is connected to the DC bus).

Lower section of the unit may be used for the mounting of distribution switches or circuit breakers where the utilization of this space will result in a saving in the overall size of the switchboard.

3.4.5.2 DC bus tie unit. The following shall be mounted within the unit:

a. One circuit breaker.

b. Necessary disconnecting devices for performing switching functions, as may be required.

c. Dead-front fuse panel for fusing control circuits. Dead-front fuseholders shall be of the type listed in 3.14.2.1 in accordance with MIL-PRF-19207.

d. Shunt for bus tie ammeter (in positive bus only).

3.4.5.2.1 Front panel. The following shall be mounted on the front panel of the bus tie unit:

a. One indicator light (blue) to indicate the closed position of the bus tie circuit breaker.

b. One ammeter with zero center scale for indicating current flow in the bus tie. The ammeter shall be connected to read to the right for current flowing from the bus to the bus tie.

c. Voltmeter with transfer switch for reading the voltage of the switchboard bus and of the bus tie.

Lower section of the unit may be used for the mounting of distribution switches or circuit breakers where the utilization of this space will result in a saving in the overall size of the switchboard.

3.4.5.2.2 Bus tie and shore power unit. Bus tie unit of the switchgear group containing the shore power connection shall be designated as a "bus tie and shore power unit". In addition to the equipment specified in 3.4.5.2 and 3.4.5.2.1, this unit shall have the following:

a. One shore power connection circuit breaker. The shore power circuit shall be connected to the bus tie circuit so that the power may be fed to either the local or remote switchboard through a bus tie circuit breaker. The ammeter shunt [see 3.4.5.2 (d)] shall be so located that it is in the circuit when feeding power to the local switchboard.

b. One indicator light (blue) to indicate the closed position of the shore connection circuit breaker.

c. One indicator light (white) to indicate when the shore connection feeder is energized.

d. One indicator light (white) to indicate when the bus tie feeder is energized.

e. Warning plate adjacent to the indicator lights for the shore connection and bus tie feeder stating "DO NOT CLOSE THIS CIRCUIT BREAKER WHEN THE BUS TIE CIRCUIT IS ENERGIZED".

3.4.5.2.3 ACB distribution circuit. For installations not requiring a bus tie unit, items (a), (b), and (c) of 3.4.5.2.2 shall be mounted on one of the ACB distribution circuit breaker units and the shore power circuit connected to the switchboard bus. In such instances, this unit shall be designated as "ACB distribution circuit breaker and shore power unit", and the following additional equipment shall be provided:

a. One indicator light (white) to indicate when the switchboard bus is energized.

b. Warning plate adjacent to the indicator lights to warn against closing the shore connection circuit breaker when the switchboard bus is energized.

3.4.5.3 DC, AQB circuit breaker distribution unit. Unit shall provide for the distribution of power or lighting through Type AQB, 250-volt, DC circuit breakers as specified (see 6.2).

3.5 Switchboard construction.

3.5.1 General construction methods. Each section of a switchgear group may be constructed using alternate methods of construction that differ from the traditional welded frame. Equivalent geometries shall be used to match the traditional welded frame dimensions and features given by this specification. The performance requirements of the switchgear sections shall be the same as traditional welded frame construction.

3.5.1.1 Standardized switchgear sections. (see 6.3.9) Each unit of a switchgear section shall be in accordance with the applicable unit shown on figure 7, figure 8, and figure 9 and applicable notes on the figure. Units shall be constructed with a self-supporting, box-like framework for support of the front panels, bus work, circuit breakers, and other devices to be included in the various units which constitute the section. Number and size of circuit breakers and overall dimensions of the unit shall be in accordance with figure 7, figure 8, and figure 9. Units shall be bolted together to form sections and shall be connected by transverse buses. Bus locations shall be as shown on figure 9, except where bus locations are not so specified, they shall be installed to suit the application. Each unit and enclosure shall be constructed to meet the requirements of MIL-STD-167-1 and MIL-S-901 (see 4.4.3.3 and 4.4.3.4).

3.5.1.2 Special switchgear sections. Each section of a switchgear group shall be constructed with a rigid, self-supporting, box-like framework for support of the front panels, bus work, circuit breakers, and other devices to be included in the various units which constitute the section. Framework for a section may be constructed as an integral frame for all units, joining the individual units by bolting and welding to form the section. Where each edge of the unit is formed by welding formed members, the ends joining to form a section shall be welded, including necessary intermediate welding of the joining members to add strength and rigidity to the section. When formed members are used for structural support, their strength shall be equivalent to that of structural members (angles, channels, and so forth) used for the same application. Each unit and enclosure shall be constructed to meet the requirements of MIL-STD-167-1 and MIL-S-901 (see 4.4.3.3 and 4.4.3.4).

3.5.2 Dimensions. Insofar as practicable, the grouping of the various units that comprise a switchgear group shall be such that the length of each section is approximately equal to the height; however, the length of a section shall not exceed 10 feet. In the arrangement of the devices to be located within the structure and the general design of the unit, particular attention shall be given to keeping the center of gravity of the unit as low as practicable.

3.5.3 Framework fabrication.

3.5.3.1 Standardized and special units. Framework shall be fabricated from angles, channels, or other structural shapes, or formed members. Each edge of each unit shall be formed by a length of a structural shape, formed member, or formed members welded to effect a continuous length. When formed members are used for structural support, their strength shall be equivalent to that of structural members (angles, channels, and so forth) used for the same application. Intermediate vertical supporting members shall be provided for the support of such heavy devices as circuit breakers and large disconnecting switches and shall be constructed using structural members welded to the bottom and top horizontal structural members. Gusset plates shall be continuously welded at the corners of the units in both lengthwise and lateral vertical panels so that each corner shall have a strength not less than the bending strength of the weakest adjoining vertical or horizontal member. Typical bottom corner construction is shown on figure 10.

3.5.4 Gusset plates. In the special case where the lengthwise gusset plates at the front of the unit interfere with devices, special consideration shall be given to the construction of the corner to provide maximum strength. Small gusset plates or L-shaped plates may be used in the above special case. A gusset plate shall not be less than 1/8-inch thick. Where the thickness of the gusset is less than 3/16 inch, the diagonal edge shall be bent to form a flange. Three-sided forged or formed and heat treated aluminum alloy gussets may be used on aluminum constructed switchboards. Typical gusset plates are shown on figure 11.

3.5.5 Framework assembly. Framework of each standardized unit or special section shall be stiffened to resist bending by the use of diagonal braces or welded sheets, but braces and sheets shall not be secured in such a manner as to restrict access to the front and rear of the units. The framework of each unit or section shall be fabricated by welding all members except those which must be disassembled for replacement of devices. In these cases, bolting shall be employed. Riveting shall not be used in the assembly. Interframe bolting of standardized units to form sections shall be in locations as shown on figure 8. The minimum size of bolt used for this purpose shall be of 1/2-inch diameter. Structural shapes that comprise the base members shall not be less than 1/4 inch thick and the horizontal flanges which are bolted to the foundation shall be not less than 2 inches wide. Members in the top of the frame of all switchboards shall have sufficient strength and rigidity for securing top braces. Braces shall not be considered as part of the switchboard.

3.5.6 Foundation channels. Foundation channels shall be supplied with complete switchboard section or sections.

3.5.6.1 Standardized units. (see 6.3.10) Foundation channels shall be drilled for the maximum number of mounting holes as shown on the floor plan (see figure 8) regardless of whether they are used for the original installation or not. Individual switchboard manufacturers may use all or any combination of these holes for mounting as long as the shock and vibration tests of 4.4.3.3 and 4.4.3.4 are met. Where the thickness of the frame member is less than 3/8 inch, a 1/4-inch thick reinforcing washer, approximately 2 inches square, shall be provided under each bolt head.

3.5.6.2 Special sections. The frame of each section shall be bolted directly to the channel by 3/4-inch diameter bolts conforming to MIL-DTL-1222. Bolt holes in channels shall be 0.813 (plus 0.010, minus 0.001) inch. The minimum number of holding-down bolts to be provided for a section shall be based on the total weight of the section, allowing 210 pounds for each 3/4-inch diameter bolt. No less than four bolts shall be provided per unit. Holding-down bolts shall be located as near the vertical frame members as practicable, but with no more than 3 inches horizontal separation between the vertical member and the center of the bolt hole. Where more than 12 bolts are required, two in each corner, and two adjacent in each intermediate vertical member, and the thickness of the frame member is less than 3/8 inch, a 1/4-inch thick reinforcing washer, approximately 2 inches square, shall be provided under each bolt head.

3.5.7 Side sheets. Ends of each standardized unit or special section shall be enclosed by solid sheets, at least 1/16 inch thick, welded to the switchboard framework, except where the arrangement of switchgear within the section is such as to require side access for maintenance, in which case the side sheet or a portion thereof shall be removable. Removable side sheets are not considered structural members. The side sheets shall be welded by intermittent welds, spot welds, or plug welds to the vertical and horizontal frame members. The gusset plates in the plane of the sheet may be omitted, provided the sheet is welded to the frame at the corners with the same length of welding that would normally be employed with a gusset plate. When gusset plates are omitted, plug welding shall be used only on the side sheets at the top corners of the frame. Side sheets shall be cut to provide for interconnecting bus bars and wiring, and insulating spacers shall be employed to close the openings. Location of cutouts for bus bars shall be as shown on figure 7 and figure 9 for standard units.

3.5.8 Compartmentation. Each unit shall be internally subdivided by barriers of either sheet metal, nonconductive material, or a combination of both to form separate compartments for the circuit breakers to isolate them from the bus work and cable connections and eliminate gaps between compartments. There shall be no gap between the barrier and top enclosure of the switchboard. The gap between the barrier and the horizontal plane at the bottom of the switchboard shall not exceed 3/8 inch. Gaps on any switchboard barrier sections not covered above shall not exceed 1/16 inch. If necessary, barriers may overlap. The ACB stationary component is acceptable as a rear barrier in an ACB compartment. The ACB stationary component (cradle) may have vents present in their design. Cradle vents do not invalidate the compartmentation requirement. For spraytight units, the barriers shall be perforated with 1/4-inch holes to allow for vertical flow of air. When barriers are installed, insulation distances shall be as specified in 3.6.2. A separate compartment shall be provided for each Type ACB circuit breaker, but all Type AQB circuit breakers on one unit may be in a common compartment. The compartments shall be constructed to prevent an arc or fault from spreading from one compartment to another or into the area occupied by the bus work. Bus disconnecting devices shall be located outside the circuit breaker compartment. Each Type ACB circuit breaker compartment shall be enclosed on the front by a removable panel section. On Type AQB circuit breaker compartments over 60 inches high, the front enclosure shall be made by two panels.

3.5.8.1 Compartmentation for switchgear equipped with arc fault detectors. Compartmentation for switchgear which utilizes Arc Fault Detection (AFD) shall be similar to that of 3.5.8 with the exception that the gap between the unit's internal subdivision barrier and the horizontal plane at the bottom of the switchboard shall not exceed 3/4 inch. All other gaps shall not exceed 3/16 inch.

3.5.9 Ventilation. Ventilation for compartments within a unit and for the unit itself shall be constructed, and the openings sized, so that the maximum internal temperature shall not exceed 167 °F (75 °C) when the unit is operated in an external ambient temperature of 122 °F (50 °C). Type ACB circuit breakers shall be vented through the front of the unit or through the rear of the unit. Components and wiring required to be installed in the units shall operate to rated capacity in the above internal, ambient temperature without performance degradation. Ventilating louvers and grill openings shall minimize the probability of entrance of solids and shall protect personnel against injury from electric arcs. An operating test of applicable controls and communication functions shall be performed at temperature stabilization to verify functionality at high temperatures.

3.5.9.1 Spray baffles. When spraytight units are specified, louvered or other type of ventilation openings shall have spray baffles to meet the requirements of 3.17.4, and these baffles shall be in accordance with figure 12 or an equivalent that meets the spraytight and thermal testing requirements (see 4.4.3.6).

3.5.9.2 Fans. Thermostatic fans may be added to the switchboard. When specified (see 6.2), fans shall meet the following requirements:

a. Fans shall activate only when the internal ambient temperature in a compartment exceeds 140 °F (60 °C).

b. Easily accessible, washable air filters shall be provided for intake fans.

c. Fans shall be disabled by operation of an appropriate maintenance switch.

d. When fans are installed, airborne and structureborne noise testing in accordance with MIL-STD-1474, Equipment Grade E and MIL-STD-740-2, Type IV shall be included in the first article test.

e. Fans shall be activated during selected first article tests as specified herein.

3.5.9.2.1 Fan monitoring system. A system shall monitor fans. The system shall have features for fan failure detection and fan failure alarms. The system shall have features for temperature monitoring and over-temperature alarms. Individual fuses shall be used for each fan. The alarms shall be visible from the front of the switchgear sections.

3.5.9.2.2 Fan shutdown during water mist. When water mist is specified, fans shall not be running during water mist events.

3.5.10 Vibration. Units of all switchgear groups shall be constructed to withstand the Type I vibration test as specified in MIL-STD-167-1 (see 4.4.3.4). The maximum frequency of vibration shall be as specified (see 6.2).

3.5.11 Materials. Switchboard structure may be either of steel or aluminum construction as specified (see 6.2). Steel conforming to ASTM A131/A131M shall be utilized in the fabrication of switchboard structures. Steel conforming to ASTM A1011/A1011M shall be used for plates and sheets. Aluminum alloy conforming to ASTM B221, alloy 5086-H111 or 6061-T6 shall be used for bars, rods, profiles, and tubes. Aluminum alloy conforming to ASTM B209, alloy 5052-H32 or 5086-H32 shall be used for plates and sheets. When aluminum components are subsequently bent, 50XX grades of aluminum shall be used.

3.5.12 Thread locking devices. Unless otherwise specified in the individual equipment specifications, locking devices shall be provided on the following basis for electrical connections and mechanical assemblies in all switchboards, switchgear units, and in all equipment. A visual method to check fastener looseness (such as torque check paint) shall be provided for fasteners not subject to periodic maintenance.

3.5.12.1 Electrical connections. Nuts, bolts, studs, and screws used for electrical connections shall be secured by means of a locking device, except that a locking device need not be provided where solderless types of connectors are used for conductors below 14 American Wire Gauge (AWG) [4000 circular roils (cmils)]. See 3.10 for bus bar connections.

3.5.12.2 Mechanical assemblies. Nuts, bolts, studs, and screws used for structural purposes shall be secured by means of an acceptable locking device where continuous satisfactory operation, under the shock, vibration, and heat conditions specified herein, or as specified in the individual equipment specifications, depends on maintaining tight connection of parts, or where a holding screw, nut, bolt, or component part could fall into the equipment. Anchor devices for thumbscrews (see figure 13) that are used to attach front and rear panels to the switchboard framing shall use hex head or counter-sunk head bolts and self-locking nuts, or button socket-head or flat socket-head, self-locking screws in tapped holes. Welding, brazing, or riveting shall not be used for anchor devices.

3.5.12.3 Acceptable locking devices. Unless specified in 3.5.12.4 or otherwise specified herein, any locking device rated for 250 °F or higher that performs successfully in first article testing shall be suitable for use with the following exceptions/caveats:

a. Self-locking nuts are the preferred method and shall be in accordance with applicable military specifications.

b. Castellated nuts with cotter pinning or safety wiring are not recommended for applications requiring accurate loads such as bus joints.

c. Toothed lockwashers may be used where the weight of the part does not exceed 2 ounces per screw, such as a terminal block.

d. Split ring lockwashers may be used where the weight of the part does not exceed 2 ounces per screw, such as a terminal block.

e. Non-liquid threadlocking adhesive may be used on any electrical joint except contact nuts and contact spacer nuts.

f. Bolt self-locking elements shall be in accordance with MIL-DTL-18240.

3.5.12.4 Prohibited locking devices. The following devices shall not be used for thread locking even in conjunction with a recommend locking device.

a. Nut and jam nut

b. Belleville washers (plain)

c. Clip-on types of nuts formed by stamping a thread-engaging impression in a flat piece of metal

d. Single-thread engaging nuts formed by stamping a thread-engaging impression in a flat piece of metal

e. Setscrews

f. Liquid threadlocking adhesive

3.5.13 Welding. Requirements for welding and allied processes shall be in accordance with S9074-AR-GIB-010/278 with the following exception. Welding practices in accordance with applicable American Welding Society (AWS) specifications may be used for welding applications not referenced in S9074-AR-GIB-010/278 provided they meet the vibration and shock tests of 4.4.3.3 and 4.4.3.4.

3.5.14 Mechanical shock. Sections of all switchgear groups shall meet the Grade A shock requirements of MIL-S-901 when tested as specified in 4.4.3.3.

3.6 Insulation.

3.6.1 Insulating material. In order to restrict the use of material which might catch fire or emit fumes when exposed to flame, the quantity of insulating material shall be kept to a minimum and used only where necessary to provide electrical insulation between live parts and to ground. Insulating material for bus supports and spacers, fuse bases, and other similar parts shall be in accordance with MIL-E-917, a minimum of a Class B insulation system.

3.6.2 Insulation distances. Insulation distances in air and surface creepage distances on insulating materials for equipments shall conform to the applicable specifications. For all other live parts, such as bus work, and bus to component line-side and load-side stud connections on circuit breaker bases which have a frame size greater than 100 amperes, values shall meet the applicable creepage and clearance distances in table I. See 3.10.18 for 100 ampere circuit breaker connection requirements.

3.6.2.1 Insulating material. Insulating material used to obtain electrical clearance shall be a minimum of 1/8 inch thick when there is a possibility of impact or abrasion to the insulating material resulting from high-impact shock or vibration. Otherwise, it may be 1/16 inch thick. Insulating material shall be secured by through-bolting.

TABLE I. Switchboards.

Voltage	**In air (inches)**	**Insulation distances to ground or to opposite polarity surface creepage**	
		Bottom and side surfaces (inches)	**Top and flat surfaces [1/] (inches)**
125 AC or DC	0.50	0.94	1.13
230 AC	0.63	1.20	1.50
500 AC or DC	0.78	1.56	2.00
1000 AC	1.31	2.50	3.340

NOTE:

[1/] Values for top creepage apply to flat surfaces or to curved surfaces presenting sufficient irregularities to permit accumulation of dust and moisture. Values are not intended to apply to simply cylindrical surfaces having a radius of 3 inches or less where side creepage values will apply.

3.6.2.2 Insulation resistance. Insulation resistance from phase to phase and from any phase to the frame/chassis of the switchgear shall not be less than 10 megohms at 77 °F (25 °C).

3.7 Hinged and removable enclosing panels.

3.7.1 Structure. Panels shall be made from sheet 3/32 to 1/8 inch thick of U.S. Gauge number 11 (commercial tolerances acceptable). Panels shall be formed with bent angle or channel edges. Flanges of panels shall be welded at the corners and ground smooth. There shall be no butt joints on the panel surfaces. Where the strength of the paneling is materially weakened by cutouts, it shall be reinforced by stiffening members. Size of the cutout for Type AQB and ACB circuit breaker operating handles and escutcheons shall be in accordance with MIL-DTL-17361 and MIL-DTL-17587, respectively. Removable sheets and panels on the front and rear shall be provided with lifting handles. Mounting and alignment devices shall be provided to facilitate installation and removal of removable enclosing panels. Alignment pins or devices shall be staggered or have a unique arrangement in order to prevent interchangeability of panel fronts or rears between units of the same switchboard section and units of other switchboard sections within the same switchboard group or ship's compartment. When installed, the panels shall be electrically grounded to the unit framework in accordance with MIL-STD-1310. Removable and hinged enclosure access panels with mounted energized components shall be grounded to the enclosure using a flexible ground strap when any voltage on the access panel exceeds 30 volts.

3.7.2 Panel hinging. Panels shall be hinged to provide access to electrical equipment mounted thereon. Means shall be provided so that these hinged sections may be opened without removing the guard rail. Hinged panels shall be provided with door stops or positioning devices to stop the door in its opening swing and to hold it in the open position. The preferred side for hinging panels is the left-hand side when facing the front of the panel. A typical panel hinge assembly is shown on figure 14. Hinged panels shall be electrically grounded to the unit framework by a separate conductor. Hinges are not considered to be an acceptable grounding path.

3.8 Mounting of equipment.

3.8.1 Securing of equipment. Equipment shall be secured to the panels of framework in order to insure against dislodgement caused by shock. Brackets and mounting lugs or feet shall have fully enclosed holes or slots. Open end slots shall not be acceptable. Devices mounted on the unit side sheet or internal partitions shall be easily removable from the inside of the unit. Devices mounted on the unit side sheet shall not interfere in any way with the inner unit bolting to form switchboard sections.

3.8.2 Mounting bolts and screws. Bolts used in the assembly of the framework and for securing the large devices to the framework shall be hexagon or hexagon socket head type. Screws for miscellaneous purposes shall be hexagon socket head, flat, or phillips head type.

3.8.3 Arrangement of equipment. No device shall extend beyond the edges of the panel on which it is mounted. Symmetrical arrangements of equipment on the units are desirable, but should not take precedence over arrangements where space may be saved for future or spare equipment.

3.8.4 Polarity. For DC, when facing the front of the switchboard or panel, left-hand contacts shall be of the same polarity (negative) and the right-hand contacts of the same polarity (positive).

3.8.5 Phase rotation. For AC, when facing the front of the switchboard or panel, the phase rotation shall be A, B, and C, respectively, from right to left, top to bottom, or front to back.

3.8.6 Casualty power equipment.

3.8.6.1 Arrangements. For ship's service and emergency switchgear groups the casualty power circuit breaker and casualty power terminal (required herein on the generator units) shall be available for use in the event of damage to the remainder of the switchboard on which the generator unit is located. The lead from the generator bus on generator units for the main bus on power distribution units to the casualty power connection and equipment shall be as short and direct as practicable and the casualty power terminal shall be readily accessible to permit rapid connection of the casualty power cable. Casualty power terminals and circuit breakers are required on load centers as specified in 3.4.4.1.

3.8.6.2 Mounting of casualty power equipment. Casualty power circuit breakers and back-connected terminals shall be mounted at the rear or on the side of the unit. When mounted within the unit, the casualty power equipment shall be readily accessible from the rear of the unit so that cables may be connected to the terminal without undue exposure of the personnel to live parts. Rear enclosures shall not be used for support of the terminal or circuit breaker, nor shall its removal be necessary for access to the terminal or for operation of the circuit breaker. When mounted on the side of the unit, the riser terminal shall be surface mounted, and the circuit breaker shall be removable without removal of the side sheet. Normally, the circuit breaker and riser terminal shall be located adjacent to one another so that personnel may readily determine that the breaker is open and the terminal not energized before making connections. Allow approximately a 14-inch diameter area about the centerline of the terminal for installation of cables into terminal.

3.8.6.3 Casualty power circuit breaker rating. Circuit breaker Type AQB-A or AQB-LF shall be provided with an element rated at 250 amperes. Unless otherwise specified (see 6.2), instantaneous trip settings shall be as follows: AQB-A circuit breaker - 3400 amperes and AQB-LF circuit breaker - 3000 amperes. For generators rated 1000 kilowatts and below, an AQB-A circuit breaker shall be furnished. For generators rated above 1000 kilowatts, an AQB-LF fused circuit breaker shall be furnished.

3.8.7 Voltage regulator equipment. Where voltage regulator equipment conforming to MIL-R-2729 is required to be installed in the switchboard, the space and arrangement of this equipment shall allow for accessibility for maintenance and provide the electrical insulation distances as specified (see 6.2).

3.8.8 Accessibility. Equipment, bus work, fasteners, and electrical connections that may require servicing, repair, or replacement during the life of the switchboard shall be readily accessible for servicing, inspection, tightening, repair, or replacement. Access shall be maintained after all bus work, switchboard wiring, and ship cabling are installed.

3.9 Shore power. (see figure 2)

3.9.1 Phase sequence indicator. The phase sequence indicator shall conform to MIL-I-16103. It shall be wired through a multiposition selector switch. The switch shall have one position for each shore power feeder and an off position.

3.9.2 Reference selector switch. The reference selector switch shall be used to establish a reference shore power feeder for checking phase orientation. There shall be one switch position for each shore power feeder. The A and B phases of each feeder shall be connected to the switch terminal and the corresponding switch terminal of the phase sequence/orientation test switch. The phase sequence/orientation test switch shall be used to check that the A and B phases of the incoming shore power are connected to the A and B phases of the other shore power feeders. There shall be one switch position for each shore power feeder. The wiper arm of the reference switch shall be connected to one terminal of the indicator. The other terminal of the indicator shall be connected to the phase sequence/orientation test switch wiper arm. Both green indicators shall light if the phases are the same. The indicator shall be located next to the reference selector switch and the phase sequence/orientation test switch.

3.9.3 Circuit breaker control switch. The circuit breaker control switch shall be a momentary contact, new position indicator with a close contact and an open contact for each shore power breaker. The switch shall simultaneously control all shore power circuit breakers. Circuit breakers shall be Type AQB-LF 400, motor operated with a 400 ampere element. Instantaneous shall be at the maximum setting. Breaker shunt trip shall be wired through the shore power receptacle interlock switch so the circuit breaker trips when the shore power receptacle cover is open or the cable is not connected.

3.10 Bus bars and connectors.

3.10.1 Bus connections. Bus connections shall be made with solid copper. See 3.10.18 for 100-ampere circuit breaker connection requirements.

3.10.2 Copper bus bars. Rectangular copper bus bars with rounded corners or round edges, hard temper in accordance with ASTM B187/B187M, shall be used for bus bars. Bars shall be silver surfaced at the contact areas as specified herein.

3.10.3 Cable connector sizes. On switchboards having an AC bus structure designed for short circuit currents of 15,000 amperes or less, single-conductor insulated copper cable, size AWG 4, in accordance with NEMA HP 6, Type SSB, 392 °F (200 °C), shall be used for connections to 100-ampere frame size Type AQB circuit breakers. On switchboard buses having a total connected DC generator capacity of not more than 150 kilowatts at 120 volts, similar cable connections shall be provided for 100-ampere frame circuit breakers.

3.10.4 Cable connector sizes for casualty power. Cable connecting a casualty power circuit breaker to the line-side of an AC generator circuit breaker shall be size AWG 1/0, in accordance with NEMA HP 6, Type SSB, 392 °F (200 °C). Casualty power terminal shall be enclosure type similar to that depicted by method 2D-3-2 in accordance with MIL-STD-2003-2. Cable connecting the casualty power circuit breaker and the casualty power terminal shall be size AWG 2 in accordance with NEMA HP 6, Type SSB, 392 °F (200 °C).

3.10.5 Bus bar sizes. Size of the bus bars shall be selected on a basis of the current carrying ratings shown in table II. In no case shall the bus bar sizes be smaller for a given current than the corresponding sizes listed in table II.

TABLE II. Ampere rating of rectangular bus bars placed on edge.

Number of bars parallel	Size of bars (inches)	Cross-sectional area (square inches)	Copper bus, silver surface, AC ampere rating, 60 Hz	Copper bus, silver surface, DC ampere rating
1	1/2 x 1/8	0.063	140	140
	5/8 x 1/8	0.078	175	175
	3/4 x 1/8	0.094	210	210
	1 x 1/8	0.125	285	285
	1-1/2 x 1/8	0.188	425	425
	2 x 1/8	0.250	555	555
	3/4 x 3/16	0.140	265	265
	1 x 3/16	0.188	355	355
	1-1/2 x 3/16	0.278	550	550
	2 x 3/16	0.375	700	710
	3/4 x 1/4	0.188	295	295
	1 x 1/4	0.250	410	410
	1-1/2 x 1/4	0.375	600	600
	2 x 1/4	0.500	780	800
	2-1/2 x 1/4	0.625	1,000	1,050
	3 x 1/4	0.750	1,140	1,185
	4 x 1/4	1.000	1,425	1,490
	5 x 1/4	1.250	1,760	1,850
	6 x 1/4	1.500	2,100	2,190

TABLE II. Ampere rating of rectangular bus bars placed on edge – Continued.

Number of bars parallel	Size of bars (inches)	Cross-sectional area (square inches)	Copper bus, silver surface, AC ampere rating, 60 Hz	Copper bus, silver surface, DC ampere rating
2 (1/4 inch apart)	1 x 1/4	0.500	650	650
	1-1/2 x 1/4	0.750	950	950
	2 x 1/4	1.000	1,350	1,370
	2-1/2 x 1/4	1.250	1610	1610
	3 x 1/4	1.500	1,825	2,000
	4 x 1/4	2.000	2,280	2,530
	5 x 1/4	2.500	2,740	3,100
	6 x 1/4	3.000	3,140	3,630
3 (1/4 inch apart)	3 x 1/4	2.250	2,200	2,620
	4 x 1/4	3.000	2,660	3,110
	5 x 1/4	3.750	3,200	3,830
	6 x 1/4	4.500	3,600	4,560
4 (1/4 inch apart)	3 x 1/4	3.000	2,650	3,130
	4 x 1/4	4.000	3,020	3,870
	5 x 1/4	5.000	3,450	4,750
4 (2 pairs/phase, 3/4 inch between pairs)	6 x 1/4	6.000	4,000	----
4 (2 pairs/phase 2-1/2 inches between pairs	5 x 1/4	5.000	4,200	----
	6 x 1/4	6.000	5,000	----
	8 x 1/4	8.000	6,400	----

3.10.6 Grouping and arrangement of bus bars. Particular attention shall be given to the grouping and arrangement of buses for AC (60 Hertz and above) currents near magnetic material, since proximity of such material will create additional heating, thereby interfering with the dissipation of heat from conductors and reducing their capacity.

3.10.7 Cabling for circuit breakers. Where single conductor cable is used for connection to circuit breaker, cables shall be securely bound together with nonflammable cord and secured to the supports as necessary to prevent distortion under short circuit conditions. Cable runs shall not come in contact with the bus bars except at the bus bar terminating end of the cable. Binding shall be applied in such a manner that it will not cut into the cable insulation due to the forces exerted under short circuit conditions. Binding shall be especially heavy where cables turn out of the pack. Terminal lugs shall be used for terminating cable at the circuit breaker terminals and at the bus bar. Through-bolts shall be used for securing the cable terminal to the bus bar. No more than two cable terminals shall be clamped by one bolt and when two are used they shall be placed on the opposite sides of the bus. Cables shall be neatly formed and, where their length exceeds approximately 12 inches, they shall be supported by the switchboard structure and not by the bus bars.

3.10.8 Bus bar forming. Flat bends for 1/8-inch bus bar shall have an inside radius 1.5 times the thickness of the bus bar, and the ends of the bus bars shall be neatly finished. Flat bends for bus bar greater than 1/8 inch shall have an inside radius of no less than the thickness of the bus bar, and the ends of the bus bars shall be neatly finished. Edgewise bends of copper bars up to 2 inches in width may be made on an inside radius of 1 inch, and those over 2 inches, but not exceeding 4 inches in width, may be made on an inside radius of 2 inches. Bars shall be free from cracks or flaws at bends.

3.10.9 Silver surfacing of buses. Silver surfacing of buses and connections shall be electrodeposited Type 1, Grade A, B, or C silver coatings as specified in ASTM B700. Silver coatings shall conform to the requirements of ASTM B700 with the exception that the silver plate shall not be less than 0.0002 inch thick. Contact surfaces of bus bars shall be silvered up to 1 inch past the joint area. The entire bus may be silver-surfaced at the discretion of the contractor. Threaded surfaces shall have silver thickness of at least 0.0002 inch.

3.10.9.1 Holes in bus bars. Holes in bus bars for bolting may be either punched or drilled, but the contact area shall be smoothed and burr free before silver surfacing. Where punching is used, the operation shall not appreciably indent the surface of the bus bar in the vicinity of the hole. Slotted holes are not permitted. Contact surfaces of bus bars and contact nuts shall be finished true to give adequate contact. Contact nuts and contact spacer nuts for copper stud contacts shall be of rolled brass and shall be of sufficient size to provide the necessary area for contact surface. Contact nuts and contact spacer nuts for silvered contacts shall be silver-surfaced, as specified in 3.10.9 for threaded surfaces. Holes in bus bars for standard bolts shall have the dimensions specified in table III.

TABLE III. Bus bar hole size.

Bolt size (inch)	Hole size (inch)
3/8	7/16
1/2	9/16
5/8	11/16

When 5-inch or larger bus bars are joined together, the bolt hole size may be enlarged to provide 1/8-inch clearance.

3.10.9.2 Preparation of joints. Joints of all bus bars shall be specially prepared before bolting. Method of preparation shall be as follows:

a. Apply a thin film of corrosion preventive paste, in accordance with MIL-C-11796, to the mating faces of the joint. Paste may be applied to the hardware. If paste is applied to the hardware, the hardware is to be treated as lubricated for tightening purposes.

b. Bolt joints together without removing the paste.

c. After joints are bolted together, remove paste from all exposed surfaces with a clean, dry cloth.

3.10.10 Bolts and nuts used in bus bar joints. Bolts and nuts used in bus bar joints shall be of the coarse thread series made of a 300 series corrosion resistant steel (CRES); silicon bronze conforming to ASTM B98/B98M, ASTM B411/B411M, or ASTM B371/B371M; or zinc plated steel conforming to MIL-DTL-1222 (a minimum of Grade 2 or 5 depending on stress on the bolts and nuts). Silicon bronze hardware shall be used in bus bar joints 4000 amperes and above. Washers of material similar to the nuts and bolts shall be used under all bolt heads and nuts adjacent to the conductors. For typical bus joint hardware connections, see figure 15. For typical bus bar mountings, see figure 16. Locking devices listed in 3.5.12.3 shall be used in bus bar joints for surface ships and for submarines. Bus bars may be joined by welding; however, welding shall be restricted to assemblies where disassembly will not be required for maintenance or repair of underlying assemblies. All welders and weld procedures for copper bus bars shall be qualified in accordance with S9074-AQ-GIB-010/248.

3.10.11 Pressure of bus bars. Bus bar joints shall be made in accordance with table VI and figure 15. Bolts for bus bar joints may be lubricated (see 3.10.9.2) and tightened to the torques specified in table IV.

TABLE IV. Torque requirements for bus bar joints.

Bolt diameter (inches)	Torque (foot-pounds)			
	CRES and zinc plated steel		Silicon bronze/copper	
	Min/max lubricated	Min/max non-lubricated	Min/max lubricated	Min/max non-lubricated
1/4	2/3	3/4	----	----
5/16	6/7	9/10	4/5	6/7
3/8	14/16	21/24	10/11	15/16
1/2	30/33	45/50	21/23	31/34
5/8	50/55	75/80	35/39	52/58

For connections made to circuit breaker studs, the torque requirements of table V shall apply.

TABLE V. Torque requirements for circuit breaker stud connections.

Copper stud size	Steel cap screw size	Torque (foot-pounds)	
		Min/max lubricated	Min/max non-lubricated
3/8 - 16	----	7/8	10/12
1/2 - 13	----	15/17	22/25
3/4 - 16	----	25/28	37/42
1-1/8 - 12	----	40/44	60/66
----	5/8 - 11	50/55	75/80
----	1 - 8	130/145	195/215
5/16 - 24	----	5/6	7/9

TABLE VI. Bolting of connection bars - diameter and number of bolts.

Size bars (inches)	Size bars (inches)											
	1/2 (inch)	5/8 (inch)	3/4 (inch)	1 (inch)	1-1/2 (inch)	2 (inch)	2-1/2 (inch)	3 (inch)	4 (inch)	5 (inch)	6 (inch)	8 (inch)
1/2	One 1/4	-	-	-	-	-	-	-	-	-	-	-
5/8	One 1/4	One 3/8	-	-	-	-	-	-	-	-	-	-
3/4	One 1/4	One 3/8	One 3/8	-	-	-	-	-	-	-	-	-
1	Two 1/4	One 3/8	One 3/8	One 1/2	-	-	-	-	-	-	-	-
1-1/2	Two 1/4	Two 3/8	One 3/8	One 1/2	One 5/8	-	-	-	-	-	-	-
2	Two 1/4	Two 3/8	Two 3/8	Two 3/8	One 5/8	One 5/8	-	-	-	-	-	-
2-1/2	Two 1/4	Two 3/8	Two 3/8	Two 3/8	Two 1/2	Two 1/2	Two 1/2	-	-	-	-	
3	Two 1/4	Two 3/8	Two 3/8	Two 1/2	Two 1/2	Two 1/2	Two 5/8	Two 5/8	-	-	-	-
4	Two 1/4	Two 3/8	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Two 5/8	Four 5/8	-	-	-
5	Two 1/4	Two 3/8	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	-	-
6	Two 1/4	Two 3/8	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	Five 5/8	-
8	Two 1/4	Two 3/8	Two 3/8	Two 1/2	Two 5/8	Two 5/8	Two 5/8	Three 5/8	Five 5/8	Five 5/8	Five 5/8	Six 5/8

3.10.11.1 Tightening nuts for bus bar joints. A tightening sequence (torque and location) as described in S9086-CJ-STM-010, NSTM Chapter 075 shall be used when multiple bolts are present. Prevailing torque self-locking fasteners shall be torqued to 100 percent of table IV values, plus the prevailing torque that is measured when the nut is turned on the bolt in its unloaded state. All full height nuts that are not prevailing torque self-locking fasteners shall be torqued to 100 percent of table IV values.

3.10.12 Bus supports. A short circuit test shall be performed at maximum RMS asymmetrical short circuit currents (see 6.2). The construction, number, spacing, and mounting of the bus bar supports shall be in accordance with calculations based on the magnitudes of forces and stresses encountered on the buses being supported when subjected to maximum RMS asymmetrical short circuit currents as specified (see 6.2). Values of maximum stress in the outside fibers shall be based on the yield strength of the bus bar and not upon the tensile strength of the bus bar. Support shall prevent contact of live parts with each other or ground during short circuit, high-impact shock, or vibration. Any permanent deformation or displacement of the bus bars following a short circuit shall not reduce the specified clearance distances by more than 30 percent of their original values.

3.10.13 Bus bar capacity. Main bus bar rating shall be not less than the largest feeder circuit element rating of the power source supplying the main bus. If the bus is fed via a transformer, bus bar rating shall not be less than the transformer secondary current. Units shall accept the maximum bus size required for standardized units as shown on figure 9. Either main bus taps or branch bus taps feeding three or more AQB circuit breakers shall be sized based on 75 percent of the sum of the active and spare circuit breaker frame sizes (maximum current rating) supplied, but not exceeding the main bus rating. Main bus taps and branch bus taps feeding one or two circuit breakers shall be sized based on 100 percent of the active and spare circuit breaker frame sizes supplied, but not exceeding the main bus rating.

3.10.14 Bus bar insulation. When specified (see 6.2), bus bars within the switchboard shall be insulated with MIL-E-22118 materials or other approved electrical insulating materials or compounds to improve creepage distances. When insulating varnish is utilized the coating shall be flexible, tough, moisture and acid resisting, and shall have an insulation resistance value of at least 500 volts per mil of thickness. One coat, 0.004 to 0.006 inch thick, shall be applied. Before painting, burrs and sharp edges shall be removed and bus bars cleaned to remove dust, grease, oil, or other foreign material. Paint may be applied by spraying or flowed on with a soft bristle brush when spraying is impractical. Coatings shall be free from pinholes. Bus bars shall be painted before assembly up to 1/4 to 1/2 inch from joint area. All current-carrying parts, including bus joints and connections, shall be insulated upon completion of final shipboard assembly. A hard copy of installation instructions shall be provided by the switchboard manufacturer and installation instructions shall include a list of joints that are required to be insulated during installation as well as procedures for insulating the listed joints.

3.10.15 Cable lug terminals. Cable lug terminals installed on all cables entering or within the switchboard shall be crimp Type CLC or CLCG in accordance with MIL-T-16366 or ring tongue SAE-AS7928, Type I, Class 1 or cable lug terminals approved by the installing activity as specified (see 6.2). Prior to assembly and crimping, a light coating of corrosion preventive paste in accordance with MIL-C-11796 shall be applied to the conductor and the interior of the terminal lug barrel. CLC or CLCG lug terminals shall be used with ACB circuit breakers or bus bar applications. Cable lug terminals shall not be installed on spare circuit breakers to which a cable is not attached. For all cables, cable lug terminals shall be secured by means of locking devices in accordance with 3.5.12.3. A tightening sequence (torque and location) as described in Section 4 of S9086-CJ-STM-010, NSTM Chapter 075 shall be used when multiple bolts are present. Cable lug terminals for cables entering a switchboard may be furnished by the installing activity when specified (see 6.2).

3.10.16 Connections between buses. Connections between the buses of adjacent sections of a switchgear group may be made by cables instead of solid bus bars to permit relative movement of the sections under shock without rupturing the switchboard main bus circuit. A means for readily disconnecting the cables from the bus shall be provided in all sections having a source of power other than from the connecting cables. The disconnecting device shall have a rating equal to the main bus. Cable connections shall be made by the installing activity. Switchboard arrangement shall include means to provide for the entrance of the connecting cable into the switchboard structure and for connecting the cables to the switchboard bus. Connecting cables shall have a current rating equal to that of the smaller of the two connected buses. Consideration shall be given to facilitate connection (by the installing activity) for the ship's cable to the switchboard so that these cables will not result in restriction of access features. Armor shall be removed from the portion of ship's cables inside the switchboard. Instructions for interconnecting wiring shall be shown on the switchboard drawings.

3.10.17 Cables entering switchboards. Cables shall enter the switchboard from either the top or bottom. Cables entering through the top dripshield shall not compromise the watertight integrity of the dripshield. Switchboard arrangement as specified (see 6.2) shall provide for proper cable connections without restrictions of access features.

3.10.18 Special requirements for 100-ampere frame circuit breaker base connections.

3.10.18.1 Insulation distances. Bus to component stud line-side and load-side connections on 100-ampere frame circuit breaker bases shall meet the following requirements:

a. Bus connections within 4 inches of the bus/component stud connection shall meet the clearance distances of MIL-E-917.

b. Bus connections greater than 4 inches from the bus/component stud connection shall meet the clearance values of table I.

c. Creepage distance shall be in accordance with values provided in table I.

3.10.18.2 Bus connections. The ends of bus bar connections to the studs of 100-ampere circuit breakers shall be trimmed to a radius equal to one half the width of the bus bar.

3.10.18.3 Holes in bus bars. All 1/8- by 3/4-inch bus work that connects to 100-ampere circuit breaker bases shall be manufactured with 13/32-inch holes.

3.11 Wiring of control and instrument circuits.

3.11.1 Control and instrument cable types. Cables used for control and instrument circuits, ground detector, indicator lights, communications devices, and other parts shall conform to NEMA HP 6, Type SSB, 392 °F (200 °C). Control and instrument wiring shall not be smaller than size AWG 16 of NEMA HP 6, Type SSB, 392 °F (200 °C), but may be larger, if necessary, for current carrying capacity requirements. Communication device wiring shall not be smaller than size AWG 20 of NEMA HP 6, Type SSB, 392 °F (200 °C). Control cable for low-level signals for electronic devices and load sharing shall be shielded type. The flexible strand wire shall be used for wiring between hinged panels and the stationary structure, when applicable. Cables within each unit shall be of the same solid color.

3.11.2 Cable end connectors. Ends of each wire shall be connected to the apparatus studs by means of an accepted solderless terminal or by forming a wire loop around the apparatus stud or terminal screw and retaining the loop in a cup or crimped washer. The wire loop shall be soldered to secure the strands together. Locking devices in accordance with 3.5.12 shall be used to secure the nuts or screws connecting wire loops to the apparatus connection point. See figure 17 for illustration of wire connections.

3.11.3 Forming and securing switchgear power cables and control wiring groups.

3.11.3.1 Power cables. Power cable groups shall adhere to the following requirements:

a. Cables shall be neatly formed into groups which shall be bundled or banded and supported or clamped in a manner that will prevent chafing of the insulation caused by vibration. Cables shall not be supported by bus bars. There shall be a minimum clearance of 1/4 inch between cables and bus bars to prevent abrasion under conditions of vibration, except at the bus bar terminating end of the cable.

b. Cable straps or metal clamps may be used to support or secure cables, but where metal is used it shall be covered with a flame-retardant, heat-resistant material which will prevent chafing of the cable insulation. Commercial nylon cable straps are not permitted for use to support or secure power cables to the framework or structure of the switchboard unit.

c. There shall be no splices in the cable and connections shall be made at the terminal studs of the devices or terminal boards.

3.11.3.2 Control wiring. Control wiring shall adhere to the following requirements:

a. Wires shall be neatly formed into groups which shall be bundled or banded and supported or clamped in a manner that will prevent chafing of the insulation caused by vibration.

b. Bundling material shall be either nylon straps, nonflammable cord, glass fiber tape conforming to Type SR-1 of MIL-I-3158, or pressure sensitive adhesive plastic tape conforming to MIL-I-24391. The last two materials are specifically adapted for serving switchgear control wiring in locations subject to abrasion. Glass fiber tape may be coated with adhesive on one side, but when used with this adhesive coating, it shall be covered with pressure sensitive adhesive plastic tape for permanent adhesion.

c. Wire groups running from hinged panels shall be formed and clamped so that sharp bends do not occur with the panel in either the open or closed position and shall be connected to terminal blocks on the fixed portion of the switchgear structure.

d. There shall be no splices in the wire and connections shall be made at the terminal studs of the devices or terminal boards.

e. Where wires run from one section of a switchboard to an adjacent one, and these sections are separated for shipping or installation purposes, a terminal board shall be provided on one of the units and located in order to facilitate completion of the interconnections during installation of the switchboard on the ship.

3.11.4 External control cable connections. External control cable connections to the switchboards shall terminate at terminal boards accessibly located near the top or bottom of the switchboard, corresponding to the ship's cable entrance. Where calibrated shunt leads are required, they shall terminate on the instrument studs. An excess length of shunt leads shall be neatly coiled and secured to prevent interference with access to other equipment. Small wiring to circuit breaker trip coils shall run directly to the coils and associated contact circuits and shall not be routed through terminals of other apparatus. Taps from bus bars shall be made by through-bolting terminals to the bus bars.

3.11.5 Synchronizing control circuits. The synchroscope shall be supplied by the phase A-B transformers, and the synchronizing lights shall be supplied by the phase B-C transformers provided for metering, synchronizing, and relaying potential as shown on figure 18. The loss of one transformer shall not disrupt both synchronizing facilities. Closing control circuit of electrically-operated circuit breakers (AC generators, bus ties, and shore power) shall be connected through contacts of the corresponding synchronizing switch. Synchronizing control equipment shall be provided as specified in MIL-S-24188 to electrically prevent closing of the generator circuit breakers, bus tie circuit breakers, or shore power circuit breakers, as applicable, unless the energized systems to be connected are properly synchronized. Control circuitry external to the synchronizing protective equipment shall be arranged so synchronizing and paralleling can be accomplished after failure of the synchronizing protective equipment. Automatic paralleling devices shall be as specified (see 6.2).

3.11.6 Space heater circuits. When space heaters are provided with the associated generator, the heater circuit shall be supplied through a heater control switch from a local lighting circuit for 120-volt space heaters or from a power source having emergency supply for 450-volt space heaters. An indicator light (white) shall indicate when generator heaters are energized. This heater circuit shall be wired through a normally closed contact (closed when breaker is open) of the associated generator circuit breaker auxiliary switch.

3.11.7 Indicator light power. On surface ships, the indicator lights of the mimic bus shall be supplied from a local lighting system that has available both normal and emergency power. On submarines, power for the indicator lights shall be taken from the AC or DC control power buses.

3.11.8 Control transformers. Control transformers shall be provided as required.

3.11.9 Ground detector lights. Ground detector lights shall be connected as shown on figure 19.

3.11.10 Voltage regulator connections. Voltage regulator equipment shall be connected in accordance with the drawings provided with the regulator equipment.

3.11.11 Wire and terminal marking. Internal wiring of equipment shall be marked on both ends by fiber tags or by synthetic resin tubing Type F, Grade A of MIL-I-631 (see figure 17). Markings shall agree with the designation shown on the switchboard drawings to facilitate checking of connections. It shall not be necessary to mark the terminal studs on instruments and control switches, but wiring diagrams shall clearly indicate the studs or contacts to which marked wires are connected. Terminal blocks shall be equipped with marking strips. These marking strips shall be permanently marked at each terminal with a number (for example, 1 to 12) and also to agree with the corresponding number on the wiring diagram. Terminal blocks in each unit shall be numbered TB1, TB2, and so forth.

3.11.12 Shunt trip coil circuits. Shunt trip coil circuits (both AC and DC) for tripping Type ACB and AQB circuit breakers shall be routed through a normally open contact (open when the breaker is open) of the circuit breaker auxiliary switch, so that the trip coil cannot remain energized after the circuit breaker is open.

3.11.13 Control voltage. Control voltage within the switchboard shall normally be 120 volts AC or DC. Where 450-volt control circuits are used for circuit breaker control, they shall be clearly identified.

3.12 Circuit breakers. Circuit breakers shall conform to MIL-DTL-17587 (for Type ACB), MIL-DTL-17361 (for Types AQB and NQB), and MIL-C-17588 (for Type ALB). Unless otherwise specified (see 6.2), Type ACB circuit breakers 1600-ampere frame size and larger shall be electrically-operated and circuit breakers 1600-ampere frame size and smaller may be manually operated. Circuit breakers controlled from an EPCP, EPCC, or by the synchronizing protective equipment specified in 3.11.5 shall be electrically-operated.

3.12.1 Mounting (AQB and NQB). Types AQB and NQB circuit breakers for switchboard use shall be equipped with removable contacts on both line- and load-side, connections being made by use of terminal mounting blocks in accordance with MIL-DTL-17361 for AQB and NQB. When circuit breakers are mounted vertically, the line-side terminals shall be at the top and the operating handle shall be in the downward position when the breaker is intentionally open. When interlocks are required for Types AQB and NQB circuit breakers, they shall be mounted in front of the panel and shall be suitable for use with circuit breakers of any make by no further modification than possible reassembly of the interlock. Circuit breaker escutcheon shall be centered in its panel cutout on the switchboard.

3.12.2 Mounting (ACB). Type ACB circuit breakers shall be of a removable assembly construction. Each circuit breaker shall be supplied as a complete removable switchboard assembly consisting of circuit breaker, separable disconnects and associated control wiring, circuit breaker drawout mechanism, assembly structural supports, back plate including stationary main bus connections, and stationary terminal for connection of the necessary external control wiring. Circuit breaker stationary assembly shall be secured to the vertical member or the horizontal structural member or both.

3.13 Switches, disconnecting devices, and transfer switches. Control and instrument switches shall be in accordance with MIL-S-18396. For applications below 125 volts, style JR switches as specified in MIL-DTL-21604 and MIL-DTL-21604/5 may be used. Control and instrument switches shall have gray or natural light tan escutcheon plates with black lettering. Switches shall be provided with four styles of handles to identify the function for which the switch is provided. The handle styles and corresponding function shall be as follows:

a.	Round	-	governor control (spring return).
b.	Oval	-	synchronizing and voltage regulator, synchronizing monitor, and field flashing.
c.	Round (knurled)	-	instruments (voltmeter, ammeter, frequency meter, temperature indicator).
		-	test (emergency switchboard, spring return).
d.	Pistol-grip	-	circuit breaker and ground lamps (spring control).
		-	control bus selector.

Control switches installed within the enclosure (such as relay defeater switches) shall be sufficiently close to the access opening to minimize personnel exposure to energized components.

3.13.1 Disconnecting devices. Disconnecting devices and associated tools for performing power disconnecting functions shall conform to MS17831. With full rated current through the disconnect devices, the maximum temperature rise of the devices shall not exceed 122 °F (50 °C). Disconnect devices shall be mounted inside the switchboard and shall be readily accessible after removal of the rear enclosure. Tools conforming to MS17832 (if required) for operation of the devices shall be mounted outside of the switchboard enclosure adjacent to the panel that must be removed for operation of the device. A warning plate shall be provided near the disconnect device to read: “DO NOT OPERATE WHEN ENERGIZED”. The plate shall be constructed in accordance with the requirements of 3.20 with letters no less than 3/16 inch.

3.14 Fuses and terminal boards. Fuses shall be in accordance with MIL-PRF-15160. Fuses for 450-volt applications shall be Characteristic C of MIL-PRF-15160. Fuses and fuseholders shall be silver plated in accordance with MIL-PRF-15160. Fuseholders shall be dead-front type with blown fuse indicator in accordance with MIL-PRF-19207.

3.14.1 Fusing of transformers. Each metering potential transformer shall be fused on the primary side with a separate fuse in each leg of each transformer. Fuse size shall be 250 to 400 percent of transformer rated primary current. Control transformers shall be fused on the primary side. Transformer secondary circuits shall not be fused, except where a circuit leaves the switchboard. In such a case, the ungrounded portion of the circuit which leaves the switchboard shall be fused, and the fuses shall be located so as not to open any other circuits on the local switchboard. One 6-ampere fuse shall be provided in each primary leg of each indicator light transformer. The control circuits for electric operation of circuit breakers shall be fused for short circuit protection only. Potential circuits for generator voltage regulators on excitation systems shall not be fused.

3.14.2 Fuse mounting. Fuses mounted on switchboards shall be accessibly located for replacement. Fuses shall be grouped on subpanels and the length of leads between fuses and the power circuit taps shall be kept to a minimum.

3.14.2.1 Dead-front fuseholders. Dead-front fuseholders shall be of the types in table VII in accordance with MIL-PRF-19207 and shall not be installed for any distribution circuit fuse on power or lighting distribution switchboards or panels.

TABLE VII. Dead-front fuseholder types.

Type	Specification
FHL10U	MIL-PRF-19207/1
FHL11U	MIL-PRF-19207/2
FHL12U	MIL-PRF-19207/3
FHL14G	MIL-PRF-19207/5
FHL32W	MIL-PRF-19207/21
FHL33W	MIL-PRF-19207/22
FHL34W	MIL-PRF-19207/23
FHL35W	MIL-PRF-19207/24

3.14.3 Terminal boards. To minimize the possibility of breakage of the terminal boards caused by distortion of the mounting support under shock, the length of the terminal board shall not exceed 12 terminal points. Terminal boards shall be in accordance with A-A-59125 and A-A-59125/2 or A-A-59125/9, or the equivalent.

3.15 Instruments, relays, and instrument transformers.

3.15.1 Electrical measuring instruments. Electrical measuring instruments shall conform to MIL-I-1361, MIL-T-15377, MIL-DTL-16034, MIL-S-16104, MIL-M-16125, MIL-W-19088, MIL-V-23151, and MIL-M-23167 having a 4-1/2-inch, rectangular case with 250-degree scale. Instrument scales shall be white with black markings and lettering and shall be marked to indicate the full load and normal voltage calibration points.

3.15.2 Digital indicators. Digital readout indicators shall be segment readouts in accordance with MIL-DTL-28803. The height of the indicator characters shall be a minimum of 0.45 inch. Display colors shall be selected in accordance with 3.16, except that red shall be used for alpha-numeric displays.

3.15.2.1 Digital readout circuitry. The need for digital indicators may require that some circuitry be mounted with the digital indicators to reduce the number of connections necessary between the equipment and the digital indicators.

3.15.2.1.1 Digital requirements for digital readout circuitry. Any circuitry that is to be mounted with the digital indicators shall be constructed according to the following guides with the order of importance being the same as the order of the guides:

a. Minimize the complexity of the indicator component.

b. Minimize susceptibility.

c. Minimize the number of connections between the equipment and the digital indicators.

3.15.2.2 Digital indicator flicker. The digital indicators that display the parameter measurements in engineering units shall reduce flickering of the readout equipment. The least significant digit will inherently change from one digit to another at the transfer point. Every effort shall be made to reduce objectionable flicker in the least significant digit.

3.15.2.3 Isolation. Isolation shall be used among the various instrument outputs so that shorting or opening any digital output circuit will not produce a change in any other output in excess of the specified accuracy requirements.

3.15.3 Instrument transformers.

3.15.3.1 Transformers for metering and relaying. Instrument transformers for metering and relaying shall conform to MIL-I-1361 having an accuracy for Navy secondary standard rating. Transformer type of devices used to provide phase angle for single-phase wattmeters on three-phase circuits or similar functions shall conform to MIL-I-1361. Instrument transformers provided for voltage regulators shall not be used to supply any other burden. For each group of instruments, relays and synchroscope, one set of instrument transformers shall be used unless the burden on one set would be too great for the accuracy required. Potential transformers for each group of instruments, relays, and synchroscope shall not be used for other potential devices. Where two potential transformers are used for three-phase operation, they shall be connected open delta on the primary and secondary. One transformer shall be connected across phase A-B and the other across B-C. Where current transformers are required to supply three-phase current, two transformers shall be used, one connected in phase A, one in phase C. Their secondaries shall be connected open delta. Current transformer secondary circuits that extend beyond the section containing the current transformers shall be provided with protective devices conforming to MIL-I-1361 to prevent high voltage in the event of an open circuit. Protective devices shall be connected so that their operation will not shunt out protective relays that may be connected in the circuit. A short circuiting switch shall be connected in parallel with the protective device for manually short circuiting the remote part of the current transformer circuit. Connections shall be as shown on figure 20. Current transformer secondary circuits, which supply both metering and electric governor input, shall be wired so that when the metering test receptacle cover is removed, the current transformer secondary is short circuited through the electric governor so that performance of the electric governor will be unaffected. Current transformers shall not be used as bus bar supports.

3.15.3.2 Grounding of secondary terminal. One secondary terminal of each metering and relaying (potential and current) transformer shall be grounded, except for the following:

a. For three-phase connections where one ground connection shall be made to the common or B phase of the two transformers.

b. For current and potential transformers used in voltage regulator circuits.

3.15.4 Inductive relays. Inductive relays, both protective and auxiliary types, shall conform to MIL-R-2033 and shall be of types that have been tested for Class A high-impact shock. Auxiliary relays shall be in accordance with MIL-DTL-2212 and MIL-R-19523. Solid-state relays shall be in accordance with MIL-PRF-28750. Relays used in the circuit breaker control circuits shall be selected so that under switchboard shock they will not cause the circuit breakers to change state.

3.15.5 Transformers. Transformers shall conform to MIL-T-15108 and MIL-T-16315, as applicable.

3.15.6 Resistors and rheostats. Resistors and rheostats shall conform to MIL-DTL-15109. Power dissipation shall not exceed 50 percent of the rated value after ambient temperature and other applicable derating factors are applied in accordance with the part specification.

3.15.7 Reverse power monitor. Reverse power monitors shall be in accordance with MIL-M-24350.

3.16 Indicator lights. Whenever possible, indicator lights shall be Light Emitting Diode (LED) type. If an LED type indicator light is not available for a particular application, an incandescent type indicator light may be used. LED indicator lights shall be in accordance with A-A-59781. Incandescent indicator lights shall conform to MIL-DTL-3661, MIL-L-3661/38, MIL-L-3661/62, MIL-L-3661/63, MIL-L-3661/64, and MIL-L-3661/65, as applicable. Indicator lights shall be furnished with lamps. For position indication of circuit breakers, blue indicator lights shall be used to show that the circuit breaker is closed. Other indicator lamps have color caps as specified for the particular application. The color code shall be as follows:

a.	Red	-	danger or emergency condition requiring immediate attention or corrective action.
b.	Green	-	normal condition.
c.	White	-	power available or power on.
d.	Blue	-	closed, advisory.
e.	Clear (not etched)	-	synchronizing or ground detector lights.
f.	Yellow	-	abnormal, but not requiring immediate attention.

3.17 Switchboard enclosures.

3.17.1 Rear enclosures. The rear of each unit shall be provided with a removable enclosure. These rear enclosures shall be made of expanded metal (rolled flat), perforated sheet, or solid sheets. Rear enclosures shall be sectionalized into not less than two horizontal parts to facilitate handling. When solid sheets are used, ventilation openings shall be provided at the top and bottom with louvers or openings similar to those in expanded metal or perforated sheet. Enclosures shall be adequately secured but shall not be used for structural strength. Openings in expanded metal or perforated sheet shall not pass a rod having a diameter greater than 3/8 inch. Provision shall be made for removal of fuses without removing the rear enclosure of a unit. On bench type of control units having equipment mounted on the rear enclosures, the rear enclosures shall be a hinged, solid sheet. Clearances between live bus work and disconnect devices, or both, and rear enclosures shall be adequate, in order to prevent these nonstructural strength panels from coming into contact with live bus work, if the panels are buckled inward.

3.17.2 Top enclosure. The top of each section shall be enclosed by a sheet cover. The top shall prevent dripping water or falling objects from entering the switchboard enclosure or damaging instruments on the front panels. It shall extend approximately 4 inches out over the face of the front panels and 4 inches beyond the rear of the switchboard structure or rear panel, if applicable. Clearance between the upper edge of the front panels and the underside of the top sheet, where it extends over the front, shall be at least 1/4 inch. Front and rear edges of the top sheet shall be turned up to form a l-inch flange along the entire length of the section or switchboard to prevent water from spilling over the front or rear. To ensure watertight integrity at the corners, the turned-up front and rear flanges shall be extended around the corners and along the end of the top sheet approximately 8 inches. The edge of the top sheet shall be turned down to form a flange and shall overlap the side sheets of the switchboard to allow drainage over the end in a manner that prevents water from seeping down the inside of the side sheet.

3.17.3 Panel fastening. Hinged and removable panels on the front and rear of the unit shall be secured by thumb screws (see figure 21 and figure 22). See 3.5.12.2 for thumbscrew anchoring devices.

3.17.4 Protection of enclosure from waterspray for submarine applications. When specified (see 6.2), switchgear shall be protected on all sides from waterspray from any angle (see 4.4.3.6.1). Protection shall be obtained by means of transparent, gasketed, quick opening covers mounted over circuit breaker handles, fuses, meters, or other devices subject to water damage and by installing baffles (see figure 12) over louvers to exclude waterspray. An operator's view of instruments and his ability to operate equipment shall not be impaired.

3.18 Guard rails. Each switchboard unit, except for distribution units, shall be provided with a vertical grab rod located on the right-hand side, facing the unit (see figure 23). Rod shall be of smooth electrically insulated material or hardwood supported with a sufficient number of brackets to provide adequate support for personnel under all operating conditions of the ship. The rod shall be attached in such a manner that all panels can be removed and hinged panels opened without removal of the rod from the member to which it is attached. These rods shall be located so that they will not interfere with operation of the equipment and shall not extend more than 4 inches from the front of the panel.

3.18.1 Removable guard rails. Removable guard rail sections shall be provided on the rear framework of the switchboard when the rear enclosure is removed (see figure 24). In general, two horizontal rails shall be required at proper levels to prevent personnel from being thrown against live buses caused by the motion of the ship. Rails shall be made of smooth, electrically insulated material or hardwood. Rails shall be mounted on the inside of the rear vertical members so as not to protrude beyond the rear or ends of the structure. Guard rail sections shall be easily removable for maintenance access but shall be provided with securing bolts or other locking means to prevent dislodgement caused by shock.

3.19 Painting and powder coating.

3.19.1 General. Exterior and interior surfaces of enclosures shall be painted or powder coated. The order of operations shall be as follows:

a. Complete fabricating operations such as welding, machining, drilling, and tapping.

b. Remove rust and other visible corrosion products.

c. Remove grease, oil, and dirt by solvent wiping, vapor degreasing, or caustic washing and rinsing.

d. For Method I (see 3.19.2.1) and Method II (see 3.19.2.2) only, apply primer pretreatment coating or chemical treatment and primer.

e. For Method I (see 3.19.2.1) and Method II (see 3.19.2.2) only, apply enamel.

f. For Method III (see 3.19.2.3) only, apply powder coat.

3.19.2 Painting or powder coating method. Painting shall be in accordance with Method I (see 3.19.2.1) or Method II (see 3.19.2.2). Powder coating shall be in accordance with Method III (see 3.19.2.3).

3.19.2.1 Method I.

3.19.2.1.1 Primer. Primer (TT-P-645) shall be applied at a thickness of 0.0015 - 0.0025 inch to hand tooled (SSPC SP 2) or power tooled (SSPC SP 3) surfaces.

3.19.2.1.2 Enamel. One coat of gray enamel conforming to Class 2, Type II or III of MIL-DTL-15090 shall be applied as a continuous film, each approximately 0.001 inch thick. A second coat of enamel shall be applied to the outside of the switchgear.

3.19.2.2 Method II.

3.19.2.2.1 Primer. A phosphate treatment shall be applied conforming to Type I of TT-C-490, 0.0001 - 0.0002 inch thick.

3.19.2.2.2 Enamel. Enamel shall be applied in accordance with the following:

a. First color coat - Parts shall be coated with one coat of a light gray, modified epoxy enamel applied by electrodeposition, at 150 to 300 volts for 1 to 3 minutes at a paint temperature of 65 to 120 °F (18.3 to 48.9 °C) and a solid content of the electrocoating level of 5 to 15 percent. Dry film thickness shall be at least 0.001 inch. This shall be followed by a tap water and deionized water rinse and then baking for 20 to 25 minutes at 350 °F (176.7 °C).

b. Second color coat (exterior) - Exterior surfaces shall receive one coat of a thermosetting acrylic enamel, light gray, semigloss meeting the appearance requirements of MIL-DTL-15090, applied to a 0.001-inch minimum dry film thickness. This shall be applied by spraying over the first color coat. This coating shall then be baked and completely cured in 15 minutes at 400 °F (204.4 °C), in 20 minutes at 375 °F (190.6 °C), or in 25 minutes at 350 °F (176.7 °C).

3.19.2.3 Method III.

3.19.2.3.1 Powder coating. Powder coating may be used as an alternative to painting. The powder coating shall be in accordance with MIL-PRF-24712. The type of powder, process of application, curing, and repair procedures and testing shall be approved by NAVSEA 05P23.

3.19.3 Grounding fasteners with paint or powder coat. Grounding connections must be free of paint or powder coat. “Star” washers or similar shall not be used to grind paint/powder coat away under screws for grounding.

3.20 Identification plates, information plates, and marking.

3.20.1 Identification and information plates. Identification and information plates on the outside of the switchboard shall conform to Types A, B, C, F, or H of MIL-DTL-15024 and MIL-P-15024/5. Plastic identification and information plates shall be light gray. Inscriptions or markings for all type plates shall be black, except for danger, warning, and caution plates, which shall have words in red for emphasis or be red with white markings. Identification and information plates inside the switchboard shall conform to Type F of MIL-DTL-15024 and MIL-P-15024/5.

3.20.2 Location. Identification and information plates shall be placed in close proximity to the equipment to which it refers and, generally, either directly above or directly below it.

3.20.3 Size. In general, identification and information plates shall be of the size as listed in MIL-DTL-15024 and MIL-P-15024/5.

3.20.3.1 Thickness. Thickness of identification and information plates shall be in accordance with MIL-DTL-15024 and MIL-P-15024/5.

3.20.3.2 Shape. Information plates for rheostat handwheels and other rotary devices where required shall be circular or some other shape to suit the equipment.

3.20.4 Information. Identification plates with information consistent with the following shall be provided at or near the top of the front enclosure of each switchgear section or for each unit, if required individually:

a. Name or functional designation of item.

b. Manufacturer's name.

c. Manufacturer's drawing number (front view).

d. Year manufactured.

e. NAVSEA drawing number (front view), if assigned.

f. Stock number, if assigned.

g. NAVSEA manual number, if assigned.

h. Serial number.

3.20.5 Abbreviations. Unless lack of space prevents spelling out the words, abbreviations of words on identification and information plates shall be avoided except in the case of words which have abbreviations in common use in accordance with ASME Y14.38.

3.20.6 Installation. Identification and information plates shall be fastened securely to such parts of the equipment as ordinarily will not be renewed during its service life. Identification and information plates shall be attached in accordance with MIL-DTL-15024 and MIL-P-15024/5. Metal and laminated identification and information plates and mimic bus may be attached with an adhesive.

3.20.7 Detail application requirements. Information plates shall be installed immediately above each circuit breaker and shall contain the following information:

a. Circuit name.

b. Circuit designation and number.

c. Circuit breaker element rating.

3.20.8 Blank plates. Information plates without markings shall be provided for mounted spare circuit breakers.

3.20.9 Instrument identification. Instruments shall be marked with the name of circuits; marking may appear on instrument or on a separately mounted information plate. Switchboard devices and component assemblies shall be provided with identification sufficient to identify each component from the information contained on the applicable switchboard drawings.

3.20.10 Fuse marking. Fuses for each switchboard control circuit, instrument, and instrument transformer shall have an information plate showing name or designation of circuit, phase (if applicable), fuse ampere rating, and type designations.

3.20.11 Marking switchboard buses. Buses shall be clearly marked in a visible location with their polarity or phase identification. If marking is accomplished by painting (stencil) application, the ink shall conform to A-A-208, Type III. Information plates for buses may be similar to the warning plates specified in 3.20.14.

3.20.12 Polarity. Positive and negative polarities of DC buses shall be indicated with + and - signs, respectively.

3.20.13 Phase identification. Phase identification of AC buses shall be indicated by the capital letters A, B, or C, as applicable. A neutral bus of a four-wire, three-phase circuit, where used, shall be indicated by the capital letter N. The letters A, B, and C, in that order, shall indicate the phase sequence.

3.20.14 Bus bars. Bus bars facing and closest to the rear of the unit shall be stenciled "DANGER _____ VOLTS". Applicable voltage shall be entered. Letters shall be white and not less than 3/4 inch high. As an alternative to stenciling, bus bars may be provided with a warning plate bearing the same legend. Letters shall be not less than 3/4 inch high. Plate shall be pressure sensitive adhesive backed elastomeric film with a carrier or separator sheet applied over the adhesive. Film shall consist of a white printed opaque polyvinyl fluoride film 0.002 inch thick laminated to a 0.001-inch clear polyethylene terephthalate film. Plate adhesive shall consist of an acrylic base vinyl polymer of a pressure sensitive type. A minimum of two warning stencils or plates per unit shall be provided, one in the upper and one in the lower section.

3.21 Tools. Where the construction of the switchboards or any of the devices installed thereon requires the use of certain special tools for their proper service maintenance, the quantity required shall be as specified (see 6.2). Special tools are defined as those tools not listed in the Federal Supply Catalog [copies of this catalog may be consulted in the office of the Defense Contract Administration Service Management Area (DCASMA)]. Storage for any tool furnished shall be provided and labeled on the switchboard enclosure.

3.22 Government furnished material. The Government will furnish material as specified (see 6.2).

3.23 Maintainability. The switchgear shall facilitate trouble-shooting, fault isolation, and repair down to the lowest nonrepairable part or nonrepairable assembly (see 4.4.3.2).

3.24 Electromagnetic interference (EMI). The complete switchboard with electronic devices (if applicable) shall meet and demonstrate compliance with the applicable emissions and susceptibility requirements and limits of MIL-STD-461 for surface ship, below deck, metallic hull installations.

3.24.1 EMI test procedures. EMI test procedures and results shall be in accordance with MIL-STD-461. Test procedures shall be approved by the NAVSEA EMI TWH or TWH representative prior to the start of testing. Final approval/disapproval of test results shall be approved by the NAVSEA EMI TWH or TWH representative.

3.25 Dielectric strength. Switchgear shall be constructed to withstand for a period of 1 minute a dielectric test voltage of twice the rated voltage of the equipment plus 1,000 volts RMS between separate circuits and to ground.

3.26 Ambient temperature. The switchgear shall meet all the specification requirements when operating in an ambient temperature of 122 °F (50 °C) and have no more than a 45 °F (25 °C) temperature rise for surface ships and for submarines (see 4.4.3.6.3).

3.27 Drawings. When specified (see 6.2), drawings shall be prepared.

3.28 Workmanship.

3.28.1 General. Workmanship shall be in accordance with the requirements herein applicable to soldering, marking of parts and assemblies, wiring, welding and brazing, plating, riveting, finishes, machine operations, screw assemblies, and freedom of parts from burrs, sharp edges, or any other damage or defect that could make the part (or equipment) unsatisfactory for the purpose intended.

3.28.2 Threaded parts or devices. Screws, nuts, and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs.

3.28.2.1 Tightness. Screw-type fasteners shall be tight. The word tight means the screw shall be firmly secured and that there shall be no relative movement possible between the attached parts.

3.28.3 Wiring. Insulated wire shall be formed into cables or ducted wherever practicable. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges.

3.29 Arc fault detectors. When required (see 6.2), arc fault detectors (AFD) that have been previously approved for Navy use shall be installed in accordance with the arc fault detector vendor's instructions. The AFD System components installed in the switchboards can include sensor interface modules, photo sensors, ionization detectors, and pressure sensors.

3.30 Voltage spike. The complete switchboard with electronic devices (if applicable) shall withstand voltage spikes on control circuits in accordance with MIL-STD-1399-300. Voltage spikes shall not cause failure or mal-operation of electronic devices.

3.31 Noise. When fans are installed, switchboards shall meet airborne and structureborne noise requirements of MIL-STD-1474, Equipment Grade E, and MIL-STD-740-2, Type IV.

3.32 Water mist. When specified (see 6.2), switchgear shall be designed to meet the blowing rain test requirements of MIL-STD-810, Method 506.5, Procedure II (see 4.4.3.6.2). The pressure, flow rate, droplet size range, and duration of the test shall be as specified (see 6.2).

4. VERIFICATION

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

a. First article inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 First article inspection. First article inspection shall be performed on electrical power dead-front, switchboard sections when a first article sample is required (see 3.1). This inspection shall include the examination and tests of 4.4 and table VIII.

TABLE VIII. First article and conformance inspection.

Inspection	First article	Conformance	Requirement paragraph	Inspection paragraph
General examination	X	X	3.4	4.4.3.1
Maintainability	X	----	3.23	4.4.3.2
Shock	X	----	3.5.14	4.4.3.3
Vibration	X	----	3.5.10	4.4.3.4
Dielectric strength	X	X	3.25	4.4.3.5
Waterspray	X	----	3.17.4	4.4.3.6.1
Watermist (if required)	X	----	3.32	4.4.3.6.2
Ambient temperature and temperature rise	X	----	3.26	4.4.3.6.3
Electromagnetic comparability	X	----	3.24	4.4.3.7
Voltage spike	X	----	3.30	4.4.3.8
Short circuit	X	----	3.10.12	4.4.3.9
Insulation resistance	X	X	3.6.2.2	4.4.3.10
Noise	X	----	3.31	4.4.3.11

4.3 Conformance inspection. Conformance inspection shall include the examination and tests of 4.4 and table VIII.

4.3.1 Sampling for conformance inspection.

4.3.1.1 Inspection lot. Equipment of the same type and size identified for inspection at one time shall be considered a lot for conformance inspection.

4.3.2 Classification of defects. Classification of defects shall be as listed in table IX. In addition, failure to satisfy any test of 4.4 shall be counted as a defect. Defects resulting from failure to satisfy tests of 4.4.3 shall be classified as major.

TABLE IX. Classification of defects.

Classification	Defects
Critical:	
1	Enclosures, panels, compartmentation not provided to prevent injury from electric shock; rear enclosure perforations, ventilating louvers exceed size limit.
2	Grab rails and guard rails not located or mounted as specified to ensure safe operations.
Major:	
101	Type, number, or section arrangement nonconforming.
102	Section unit not complete, devices or component parts missing.
103	Evidence of use of unauthorized material.
104	Parts broken, cracked, distorted, or chipped.
105	Control benchboard (if required) dimensions, arrangement of devices nonconforming.
106	Structure not in accordance with drawing; not framed, bolted, welded, or dimensioned as required; gusset plates nonconforming.
107	Framework bracing not as specified; bolt size less than minimum; unauthorized use of rivets.
108	Standard units or special sections not bolted to foundation channel in accordance with drawing; number and size of bolts nonconforming.
109	Side sheets less than specified thickness; welding to frame nonconforming, bus bar cutouts not located in accordance with applicable drawing.
110	Compartmentation not as specified; circuit breakers not isolated; insulation distance not as specified.
111	Ventilation not adequate; openings not sized for circuit breaker load; openings not screened.
112	For submarine applications, enclosure does not meet spraytight requirements; construction of equipment impairs operator’s view of instruments or restricts its operation.
113	Locking devices not of acceptable type; not provided where required.
114	Panel thickness, size, forming, stiffening, or location nonconforming.
115	Panel not hinged as specified, when required.
116	Equipment brackets, bolting, or arrangement nonconforming; switches not mounted in specified plane; phases not disposed as required.
117	Casualty power connection, if required, not accessible; mounting nonconforming; casualty power circuit breaker not as specified.
118	Voltage regulator mounting nonconforming.
119	Bus bar not sized properly for amp rating; not silver surfaced formed as specified; ends not neatly finished; bolt hole contact areas not flat; bolt size and number not as specified.
120	Cable connectors not specified type and size for required load and use.
121	Bus bar assemblies not marked with specified warning.

TABLE XI. Classification of defects – Continued.

Classification	Defects
Major:	
122	Evidence that bus bar supports not spaced in accordance with short circuit current available, high-impact shock and vibration requirements.
123	Evidence that bus bar capacity nonconforming.
124	Cable connectors not of specified type; solder, if authorized, not as specified.
125	Means not provided for connecting cables from other units or sections; cable connection arrangement restricts access.
126	Instrument and control wiring nonconforming; not connected as specified; not grouped and strapped as specified.
127	Terminal boards not provided where required.
128	Synchronizing circuits, where required, not connected in specified manner; synchronizing control equipment not as specified.
129	Indicator lights, space heater circuits, transformers, voltage regulators, and trip circuits for ACB circuit breakers not connected or arranged in accordance with applicable specifications or drawings.
130	Wiring not marked or tagged.
131	Circuit breakers not of type specified; location and mounting nonconforming; drawout mechanism (for Type ACB only) not operable as specified.
132	Switches not in accordance with specification; instrument control switches not type or not marked as specified; handle not required shape.
133	Disconnect devices not of specified type; not mounted as required; tools, if required, not located properly.
134	Fuses not in accordance with specification; location identifications and mounting nonconforming.
135	Fuseholders, where required, not enclosed or not in accordance with drawing.
136	Terminal boards exceed allowable length.
137	Instruments not in accordance with specification; case, scale, and mounting nonconforming.
138	Transformers not in accordance with applicable specifications; not provided; not connected as specified; not protected where required.
139	Relays not as specified; not accepted type.
140	Indicator lights nonconforming; not color required by code; resistors not as specified; lamps not provided.
141	Rear and top enclosures not secured firmly to frame; will not clear live bus work if buckled; top flanges do not prevent water from seeping into the enclosure; panel fastening not as specified method employed for making thumbscrews captive inadequate.
142	Top enclosure shape, form, and flanges nonconforming; corners not welded watertight.
143	Buses not marked to indicate polarity or phase.
144	Devices, where so required by applicable specification, not qualified for listing on Qualified Products Lists (QPLs).
Minor:	
201	Painting procedure specified not followed; primer not applied as specified; enamel not of specified type.

TABLE XI. Classification of defects – Continued.

Classification	Defects
Minor:	
202	Identification and information plates not of specified shape, size, thickness, location, letter, and fastening.
203	Special tools, if required, not furnished.
204	Switchboard not cleaned following construction; loose parts, dirt, or metal shavings not removed from unit.

4.4 Examination and test methods.

4.4.1 Test equipment. Test equipment shall be as specified in MIL-E-917, except that the shock machine shall be in accordance with MIL-S-901.

4.4.2 Test conditions. Unless otherwise required in the detailed test herein, the inspection and tests of 4.4 shall be performed under the following conditions. Ambient conditions within the specified ranges need not be controlled:

a. Temperature from 50 to 122 °F (10 to 50 °C).

b. Attitude: Normal operation position.

4.4.3 Detailed inspection.

4.4.3.1 General examination. The completed unit shall be given a thorough examination to determine that it conforms to the applicable specifications and drawings with respect to safety, material, finish, workmanship, construction, assembly, electrical parameters and function of electrical components, dimensions, weight, and marking of identification and description plates. This examination shall be limited to those that can be performed without disassembling the unit in such a manner that its performance, durability, or appearance would be affected. This examination shall include a check of operating controls, circuit functions, and adjustments as applicable. Defects shall be as specified in table XI.

4.4.3.1.1 The 100-hour burn-in test. The 100-hour burn-in test shall be conducted by energizing control voltage to the equipment for 100 hours at nominal voltage and frequency, ambient temperature and with all control voltage inputs and outputs connected to effect maximum rated loading. If a failure occurs during this test, the failure shall be corrected and test shall be repeated from the start. The 100-hour burn-in test may be accomplished at the end of first article testing.

4.4.3.2 Maintainability demonstration. When specified (see 6.2), compliance with 3.23 shall be verified through a maintenance demonstration procedure, maintenance task selection, and maintenance task performance in accordance with Test Method 1 of Appendix B of MIL-HDBK-470.

4.4.3.3 High-impact shock test. Switchboard sections (see 6.3.9) shall be subjected to Type A, Class I, high-impact shock test in accordance with MIL-S-901. Passing subsidiary component testing, such as QPL testing, does not preclude the requirement of system level shock qualification. The complete switchboard section, including all subsidiary components and subassemblies installed within the switchboard during the test, shall meet the shock test acceptance criteria. The following requirements shall be met:

a. All equipment, including spare circuit breakers, shall be installed in the switchboard section in accordance with the shipboard configuration during testing.

b. All lengths of ship's cabling (except for spare and blank circuit breakers) and bus work shall be installed in the switchboard section in accordance with the shipboard configuration during testing.

c. All lengths of ship's cabling (except for spare and blank circuit breakers) that extend outside the foundation of the switchboard section shall be stubbed to 12- to 18-inch length with the bitter ends insulated.

d. The test shall be conducted with all equipment and cables in the section energized with no load.

e. Switchboard section mounting location, mounting plane and mounting orientation for the shock test shall simulate the worst case shipboard installation as specified (see 6.2).

f. For each compartment of the switchboard section with ACB breakers installed, a minimum of one ACB circuit breaker of each type shall be monitored for contact bounce during testing. Monitoring shall include all main contacts and at least one normally open and one normally closed auxiliary contact.

g. For each compartment of the switchboard section with AQB breakers installed, a minimum of one AQB circuit breaker of each type shall be monitored for contact bounce during testing. If one compartment contains the same AQB circuit breaker type or types installed above and below the switchboard section center of gravity, a minimum of two AQB circuit breakers of the same type (one located above and one located below the center of gravity) shall be monitored for contact bounce during testing. Monitoring shall include all main contacts and, if applicable, at least one normally open and one normally closed auxiliary contact.

h. To determine compliance with 3.5.14, switchgear components shall be subjected to electrical tests and visual examinations to determine their ability to perform their principal function after the shock test using the acceptance criteria specified in 4.4.3.3.1.

i. Fans, when required, shall be energized during this test.

j. When lengths of ship's cabling are not practical to the test set-up, suitable dummy weights shall be included in shock testing.

4.4.3.3.1 Principal function acceptance criteria. The following criteria shall be used to determine switchgear component pass or failure acceptance criteria:

a. Hair line cracks are permitted in the framework, but no separation of parts shall result.

b. Any resulting distortion shall not be of sufficient magnitude to impair the operation of the equipment contained within or prevent the circuit breakers from being withdrawn.

c. The enclosure shall not distort to an extent which might result in contact with any electrically conducting part within the section.

d. The bus work shall not be mechanically damaged nor the bus clearance distances reduced below the minimum requirements.

e. Insulation resistance shall not be reduced below that specified in 4.4.3.10.

f. The section shall pass the dielectric strength test of 4.4.3.5 at 65 percent of the specified voltage.

g. Circuit breakers shall not change position/state from "on" to "off", from "off" to "on", or from "on" to "trip" during the test. An "off" to "trip" position/state change is permitted.

h. Any closing of circuit breaker main and auxiliary contacts from the open position shall not be acceptable.

i. Momentary opening of ACB Type circuit breaker main and auxiliary contacts shall not be in excess of 0.020 seconds during a single shock event.

j. Momentary opening of AQB Type circuit breaker main and auxiliary contacts shall not be in excess of 0.010 second during a single shock event. Multiple contact bounces are acceptable providing that the total elapsed time from the beginning of the first bounce to the end of the last bounce does not exceed 0.015 seconds for auxiliary contacts and 0.060 second for main contacts for a single shock event.

k. Circuit breaker control relays shall not cause the circuit breakers to change position/state.

l. For electronic circuit breakers, trip unit adjustable settings shall not change position.

m. All circuit breakers shall complete an open/close operation after each shock blow.

n. All circuit breakers with racking capability shall complete a racking cycle after each shock blow. Racking shall be accomplished using the racking mechanism and standard racking tool without removal of circuit breaker front cover.

o. Bus and cable fasteners shall be verified to not have loosened.

4.4.3.3.2 Disposal of shock tested equipment. Equipment which has been subjected to high-impact shock may be accepted as a production unit of the contract or order only if each of the following conditions are met:

a. The vibration test is conducted after the completion of all shock tests.

b. Damaged parts are replaced.

c. Damaged structural members are repaired or replaced.

d. Post shock and vibration electrical tests and inspections show conformance to specified performance.

e. The unit is covered by the same guarantee by the manufacturer as other production units.

f. The shock tested unit is free from any distortion of the frame members or enclosure that would prevent its being bolted to the deck or to other switchgear units to form a switchboard section. Measurements shall be made to detect any misalignment of bolt holes or bent framework.

4.4.3.3.3 Extension of shock tests. Extension of satisfactory shock test results to other sections shall be in accordance with the requirements of MIL-S-901. Requests for test extension shall include, but shall not be limited to, the following:

a. Change in weight and mass.

b. Change in center-of-gravity.

c. Change in moments-of-inertia.

d. Changes in dimensions (i.e., height and footprint).

e. Changes in circuit breaker frame sizes, locations, and quantities.

f. Change in materials or size and location of structural members.

g. Changes in method of circuit breaker mounting.

h. Changes in bus bar arrangement or method of support.

i. Changes in ship mounting classification (i.e., deck or hull mounting).

j. Changes in mounting orientation (i.e., athwartship or fore/aft).

4.4.3.4 Vibration test. A vibration test shall be conducted on switchboard sections in accordance with the Type I requirements of MIL-STD-167-1 (see 4.4.3.3.1). Any major redesign of the tested section which might alter the ability of the sections to withstand this test shall require a retest to determine conformance to these requirements (see 4.4.3.3.3). Separate tests shall be conducted on steel and aluminum switchgear sections (see 3.5.10).

4.4.3.4.1 Vibration test energization, contact monitoring, and pass/fail criteria. Vibration test energization, contact monitoring, and pass/fail criteria shall be the same as for shock testing except that no contact bounce is acceptable. Also, all circuit breakers shall complete an open/close operation after endurance axis change. Also, all circuit breakers with racking capability shall complete a racking cycle after endurance axis change. Fans shall be energized during vibration testing.

4.4.3.4.2 Extension of vibration tests. Extension of vibration test results to other sections shall meet the requirements as specified (see 6.2). Requests for test extension shall include similar information as stated in 4.4.3.3.3.

4.4.3.5 Dielectric strength. Equipment shall withstand, for a period of 1 minute, a dielectric test voltage of twice the rated voltage of the equipment plus 1,000 volts RMS value. The frequency of the test voltage shall be not less than 60 Hertz. It shall approximate a true sine wave. The source of the test potential shall have a rating of at least 1 kilowatt (see 3.25).

4.4.3.6 Waterspray, watermist, and heat tests for switchgear. (see 6.2)

4.4.3.6.1 Waterspray test. When the contractor has developed a design for making switchgear enclosures spraytight, the waterspray test shall be conducted on one representative unit of this construction. If the methods employed by the contractor to achieve spraytight construction in a design are modified, a retest shall be conducted to reestablish that the spraytight requirements are met. Switchgear shall be subjected to the waterspray test requirements of MIL-STD-108 for spraytight enclosure with the following exceptions (see 3.17):

a. Direct a stream of fresh water against the enclosure at representative covers, handles, seams, plates, and so forth. The stream of water shall be directed at the front, back, sides, and top of the enclosure for not less than 15 minutes on each of the above surfaces. At a 90-degree position to each of the above enclosure surfaces, the water nozzle shall be slowly rotated in an arc from 45 degrees right to 45 degrees left, and 45 degrees up to 45 degrees down from the perpendicular axis. If, under the above spray test procedure on the front and rear surfaces of the enclosure, the stream of water cannot strike the intakes to the lowest ventilation louvers or openings when the nozzle is positioned at 45 degrees below the perpendicular axis, then the entire enclosure shall be first tilted 30 degrees from the top toward the rear, and then 30 degrees from the rear toward the front and the above spray test procedure performed on these two surfaces.

b. Insulation resistance test shall be conducted on the complete switchboard within 30 minutes after the completion of the test at the voltage specified in 3.25.

4.4.3.6.1.1 Pass/fail criteria. Insulation resistance readings of less than 10 megohms shall constitute a failure.

4.4.3.6.2 Watermist (when specified). When the contractor has developed a design for making switchgear enclosures water mist resistant, the water mist test shall be conducted on one representative unit of this construction. If the methods employed by the contractor to achieve water mist construction in a design are modified, a retest shall be conducted to reestablish that the water mist requirements are met. Switchgear shall be subjected to the blowing rain test requirements of MIL-STD-810, Method 506.5, Procedure II. The pressure, flow rate, droplet size range, and duration of the test shall be as specified (see 6.2). Fans shall not be running when the water mist event occurs. Insulation resistance test shall be conducted on the complete switchboard within 30 minutes after the completion of the test at the voltage specified in 3.25.

4.4.3.6.2.1 Pass/fail criteria. Insulation resistance readings of less than 10 megohms shall constitute a failure.

4.4.3.6.3 Temperature rise tests for switchboards.

4.4.3.6.3.1 Switchboard sample(s). The test shall be conducted on a complete switchboard section for each sample or samples chosen. All equipment (including spare circuit breakers), cabling, and bus work shall be installed in accordance with the shipboard installation. All circuit breakers (except spares) and all disconnects shall be fully cabled including those that are not used as a load during testing.

4.4.3.6.3.2 Test chamber. Testing shall be conducted without recirculation of air into the test chamber. Fans may be used to maintain ambient temperature and to prevent air stratification within the test chamber. These fans shall be directed away from the switchboard towards the sides of the test chamber enclosure. Air from these fans shall not blow directly onto or be deflected onto any part of the switchboard section during testing.

4.4.3.6.3.3 Sensors and sensor locations. Temperature sensors (thermocouples or other approved methods) shall be installed to determine ambient temperature within the test chamber (but outside the switchboard section) and temperature rise in each compartment of the switchboard section.

4.4.3.6.3.3.1 Ambient temperature sensors. Six sensors shall be installed in one of the following configurations:

a. Three sensors shall be installed 3 feet away from both the left and right sides of the switchboard section at half the depth and at the following locations:

(1) One sensor shall be 6 inches from the bottom of the switchboard section.

(2) One sensor shall be 6 inches from the top of the switchboard section.

(3) One sensor shall be at half the height of the switchboard section.

b. Three sensors shall be installed 3 feet away from both the front and back surfaces of the switchboard section at half the section width and at the following locations:

(1) One sensor shall be 6 inches from the bottom of the switchboard section.

(2) One sensor shall be 6 inches from the top of the switchboard section.

(3) One sensor shall be at half the height of the switchboard section.

4.4.3.6.3.3.2 Compartment temperature sensors.

4.4.3.6.3.3.2.1 Compartments other than bus compartments. Each switchboard section compartment other than a bus compartment shall have two temperature sensors at the following locations:

a. One sensor shall be 2 inches from the top at the compartment midway point from front-to-back and as close to the center of the compartment as possible.

b. One sensor shall be 2 inches from the bottom at the compartment midway point from front-to-back and as close to the center of the compartment as possible.

4.4.3.6.3.3.2.2 Bus compartments. There shall be three temperature sensors per switchboard unit in the bus compartment (i.e., a three-unit section shall require nine separate sensors) at the following locations:

a. One sensor shall be 2 inches from the top at the compartment midway point from front-to-back and as close to the midway point of the unit width as possible.

b. One sensor shall be 2 inches from the bottom at the compartment midway point from front-to-back and as close to the midway point of the unit width as possible.

c. One sensor shall be at the half way point from the top to bottom of the compartment at the compartment midway point from front-to-back and as close to the center of the unit width as possible.

d. Sensors shall be mounted to each phase of the circuit breaker stationary element line and load terminals.

4.4.3.6.3.4 Temperature stabilization and temperature rise determination. All temperature readings for each test shall be recorded during the same time frame and shall be of sufficient duration to allow stabilization of the measured temperatures to a rate of rise within 3.6 °F (2 °C) per hour. Ambient temperature at each ambient sensor location shall be maintained at 122±3.6 °F (50±2 °C). An average ambient temperature shall be determined by averaging together the ambient sensor readings. The average ambient temperature shall be used to determine the temperature rise of the switchboard compartments.

4.4.3.6.3.5 Circuit breaker loading and equipment energization. Circuit breakers shall be loaded to their designed full load (element rating, continuous current setting, or rating plug value as applicable) at any convenient voltage to simulate the heat dissipation characteristics the switchboard will have under actual operating conditions. All transformers and equipment that utilizes internal transformers shall be energized. Turbine generator control units shall be tested at 75 percent load. When a low voltage primary power source is used for testing, an alternate control voltage source may be used for devices that tap off of primary power.

4.4.3.6.3.5.1 One-unit switchboard section. All ACB circuit breakers shall be fully loaded. If applicable, any remaining load shall be divided among as many different AQB circuit breaker frame sizes as possible. If a section only has AQB circuit breakers, the load shall be divided among as many different AQB frame sizes as possible. If applicable, disconnects may be used for any remaining load after circuit breakers are loaded as discussed above. Total loading of the unit shall not exceed the rating of the unit.

4.4.3.6.3.5.2 Multiple-unit switchboard section. Separate temperature rise tests equaling the number of units in the section shall be conducted (i.e., a three-unit section shall require three separate tests). Each unit shall be loaded in accordance with 4.4.3.6.3.5.1. If applicable, any remaining load shall be divided among the other units as necessary. Total loading of a particular unit shall not exceed the rating of that unit. If the unit being fully loaded receives power from a circuit breaker in another unit of the same switchboard section, that circuit breaker shall be used to provide power to the fully loaded unit.

4.4.3.6.3.6 Voltage regulator loads. Dummy type resistive loads shall be used to simulate voltage regulator components in the spaces allocated to these. These dummy loads shall be equal to the maximum heat dissipation ratings of the regulator components.

4.4.3.6.3.7 Pass/fail criteria. Temperature rise tests shall be conducted to verify that the maximum air temperature within any compartment in the switchboard section does not exceed 167 °F (75 °C) when operating within an ambient temperature of 122 °F (50 °C). A functional check of applicable controls and communications shall be performed at temperature stabilization. In addition, temperature rise shall not exceed 158 °F (70 °C) for circuit breaker stationary element terminals.

4.4.3.7 Electromagnetic interference. The EMI tests of MIL-STD-461 for surface ship, below deck, metallic hull installations shall be conducted on switchboards with electronic devices. Testing shall not cause false tripping of circuit breakers or failure of electronic devices. Fans shall be energized during EMI testing.

4.4.3.8 Voltage spike testing. The control circuits shall be tested in accordance with the voltage spike testing requirements of MIL-STD-1399-300. Testing shall not cause false tripping of circuit breakers, abnormal operation, or failure of components.

4.4.3.9 Short circuit tests. Switchboards shall be subjected to short circuit tests in accordance with IEEE C37.20.1. The maximum RMS asymmetrical short circuit current shall be as specified (see 6.2).

4.4.3.10 Insulation resistance. Insulation resistance tests shall be performed on the switchboard section(s) before and after shock testing. Insulation resistance shall be measured with a 500 volt test potential in accordance with MIL-E-917. With all circuit breakers closed, the insulation resistance shall be measured from phase to phase and between each phase and the switchboard frame/chassis. Insulation resistance shall not be less than 10 megohms at 77 °F (25 °C) for any readings before and after shock testing.

4.4.3.10.1 Insulation resistance correction factor. Correction shall be made on the basis of insulation resistance doubling for each 27 °F (15 °C) decrease in temperature from 77 °F (25 °C).

4.4.3.11 Noise testing. When fans are installed, airborne and structureborne noise testing in accordance with MIL-STD-1474, Equipment Grade E, and MIL-STD-740-2, Type IV shall be conducted.

4.4.4 Test reports. When specified (see 6.2), vibration and shock test reports, a first article inspection report, and a first article inspection procedure shall be prepared.

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. Switchgears covered by this specification are intended to provide protection, control, and distribution of electrical power on Naval ships.

6.2 Acquisition requirements. Acquisition documents should specify the following:

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

b. Specific issue of individual documents referenced (see 2.2.1 through 2.3).

c. When first article is required (see 3.1).

d. If equipment or components used are made of or contain PVC material (see 3.3.1.4).

e. When the equipment does not conform to the general requirements of MIL-E-917 and is not designed for operation, maintenance, and repair by the 5th through the 95th percentile user as described in MIL-STD-46855 (see 3.4).

f. Type, number, and arrangement of units comprising the switchgear sections (see 3.4.1 to 3.4.3, inclusive).

g. Sections comprising a switchgear group (see 3.4.1 to 3.4.3, inclusive).

h. Power, current, and voltage rating of generators controlled and quantity of casualty power equipment (see 3.4.1.1, 3.4.1.2, 3.4.2.1, 3.4.2.2, and 3.4.4.1).

i. Space, mounting, and wiring requirements for the voltage regulator equipment including associated current and potential transformers (see 3.4.1.1(g), 3.4.1.1.1(g), 3.4.1.2.1(i), 3.4.1.5.3(a), 3.4.1.5.4(c)(1), 3.4.2.1.1(h), and 3.8.7).

j. Space, mounting, and wiring and associated control equipment for electric governor equipment (see 3.4.1.1(m), 3.4.1.1.1(o), 3.4.1.1.1.1(j), 3.4.1.2.1(f), and 3.4.1.5.4(c)(5)).

k. If load sensing relays are provided (see 3.4.1.1.1(i)).

l. When automatic paralleling devices are required (see 3.4.1.1.1(q), 3.4.1.2.1(m), and 3.11.5).

m. Control switches, rheostats, and similar devices required in conjunction with speed regulating equipment (see 3.4.1.1.1.1(f) and 3.4.1.5.4(b)(1)).

n. If generator space heaters and temperature detectors are provided with the generators (see 3.4.1.1.1.1(i), 3.4.1.1.1.1(n), 3.4.1.2.1(h)(o), 3.4.1.5.3(g)(p), and 3.4.2.1.1(j).

o. Disconnect devices (see 3.4.1.1.2(c) and 3.4.1.3 (c)).

p. Rating for shore power connection circuit breaker (see 3.4.1.3(h), 3.4.1.4.2(a), and 3.4.5.2.2).

q. When a chair for EPCP is required (see 3.4.1.5.1).

r. Whether desk type or vertical type EPCP is required (see 3.4.1.5.1 and 3.4.1.5.2).

s. Space for internal communications (IC) equipment (see 3.4.1.5.1.1).

t. Whether or not the ship has a centralized machinery control system including EPCP (see 3.4.1.5.3(cc)).

u. When mimic bus material is required (see 3.4.1.5.3).

v. Material to be used in construction of switchgear structure and switchgear buses (see 3.4.1.5.5(a)(3), 3.5.11, and 3.10.1).

w. Solid-state frequency changer failure mode indicators (see 3.4.1.5.5(h)).

x. Feeders, breakers, and switches (see 3.4.1.6, 3.4.1.7, 3.4.1.8, and 3.4.5.3).

y. Requirement for Type AQB circuit breaker on emergency switchgear for diesel cooling water pump (see 3.4.2.1(d)).

a. Requirement for electrically-operated emergency bus unloader switch (see 3.4.2.2(g)).

aa. MIL-STD-108 degree of enclosure (see 3.5.9.1, 3.17.4, and 4.4.3.6).

bb. Maximum frequency of vibration (see 3.5.10).

cc. If instantaneous trip settings are other than as specified (see 3.8.6.3).

dd. Electrical insulation distances where voltage regulator equipment conforming to MIL-R-2729 is required to be installed in the switchboard (see 3.8.7).

ee. Buses to be provided in each switchgear section (see 3.10.1).

ff. Maximum available RMS short circuit current (see 3.10.12 and 4.4.3.10).

gg. Bus bar insulation (see 3.10.14).

hh. Cable lugs (see 3.10.15).

ii. Location of cable entrance (see 3.10.17).

jj. Use of automatic paralleling devices (see 3.11.5).

kk. Circuit breaker frame size (see 3.12).

ll. Circuit breaker trip element ratings and tripping characteristics (see 3.12).

mm. Quantity of special tools (see 3.21).

nn. List of Government furnished material (see 3.22).

oo. When drawings are required (see 3.27 and Appendix A).

pp. Arc fault detectors required (see 3.29).

qq. Watermist required and testing details (see 3.32 and 4.4.3.6.2).

rr. Fans allowable (see 3.5.9.2).

ss. Whether a maintainability demonstration is required (see 4.4.3.2).

tt. The following items are not a part of any individual standard unit. They will be supplied by the contractor only when complete switchgear sections are ordered. Otherwise they will be supplied by the Command or agency assembling the standard units into switchgear sections:

(1) Foundation channels.

(2) Top sheet and drip shield.

(3) Main bus bars.

(4) Main bus supports, main bus spreaders and bus opening cover on end units.

(5) Cable and wiring between units.

(6) End trims.

uu. Switchboard section shipboard mounting location, mounting plane, and mounting orientation (see 4.4.3.3).

vv. Vibration extension requirements (see 4.4.3.4.2).

ww. Test reports (see 4.4.4).

xx. Packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Branch bus taps. Branch bus taps are bus bars connected to the main bus taps.

6.3.2 Compartment. An internal switchboard section or unit subdivision formed by barriers of sheet metal, nonconductive material, or a combination of both.

6.3.3 Desk type EPCP. A desk type EPCP is a switchgear section consisting of switchgear type units and a control desk combined in a single structure with the top of the control desk, either horizontal or inclined, attached to the front switchgear section panels. It is provided with the necessary instruments and controls for centralized operation, monitoring, and control of the electric plant including control of generator, bus tie, and feeder circuits (including battery on submarines) of one or more switchgear groups.

6.3.4 EPCC. A desk type EPCC is a console consisting of control desks provided with the necessary instruments and controls for centralized operation, monitoring, and control of the electric plant including control of generator prime movers, generators, bus ties, and feeder circuits of one or more switchboard groups.

6.3.5 Load center. A load center distribution section is a section consisting of one or more distribution units. It serves as a power distribution center in locations requiring power supplies exceeding the capacity of distribution panels.

6.3.6 Low voltage. Low voltage refers to voltages up to and including 1 kilovolt.

6.3.7 Main bus taps. Main bus taps are bus bars connected to the main bus.

6.3.8 Nonstandard switchgear. Nonstandard switchgear is switchgear consisting of units, sections, and groups, not conforming to the standardization requirements of figure 7, figure 8, and figure 9.

6.3.9 Section. A switchgear section is a self-contained assembly of switchgear units consisting of a complete framework with all required enclosures and with a common base mounting.

6.3.10 Standardized unit. A standardized switchgear unit is a vertical subdivision of a section complete with separate front panels and all required devices designed to be mechanically and electrically interchangeable between switchboard manufacturers. It should be constructed in accordance with the basic dimensions shown on figure 7, figure 8, and figure 9.

6.3.11 Switchboard. A switchboard is a large single panel, frame, or assembly of panels on which are mounted on the face, the back, or both, switches, overcurrent and other protective devices, buses, and instruments.

6.3.12 Switchgear group. A switchgear group is synonymous with the term switchboard; however, switchboard groups may consist of two or more individual sections rather than all units being assembled together into a single structure.

6.3.13 Vertical EPCP. A vertical EPCP is functionally similar to the desk type EPCP except that all necessary instruments, controls, and indicating apparatus are mounted on vertical panels.

6.4 Qualification under referenced specifications. When any specification which forms a part of this specification requires that the product be subjected to and pass qualification tests, only products which are qualified for listing on the applicable Qualified Products List on the date of invitation for bids or date of initiation of purchase action should be utilized. In the event that no Qualified Products List has been issued, the contractor should request instruction as to what testing will be required to determine whether the product meets the requirements of this specification.

6.5 Subject term (key word) listing.

Branch bus tap
Bus bar
Bus connection
Bus tie unit
Cable end terminal
Cable lug terminal
Circuit breaker
Compartmentation
Digital indicator
Distribution unit
Electric plant control console
Electric plant control panel
Electromagnetic interference
Emergency generator control
Fuse mounting
Generator control unit
Insulation distances
Load center
Main bus tap
Switch
Transformer
Ventilation
Voltage regulator
Wire and terminal marking
Wiring

6.6 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.

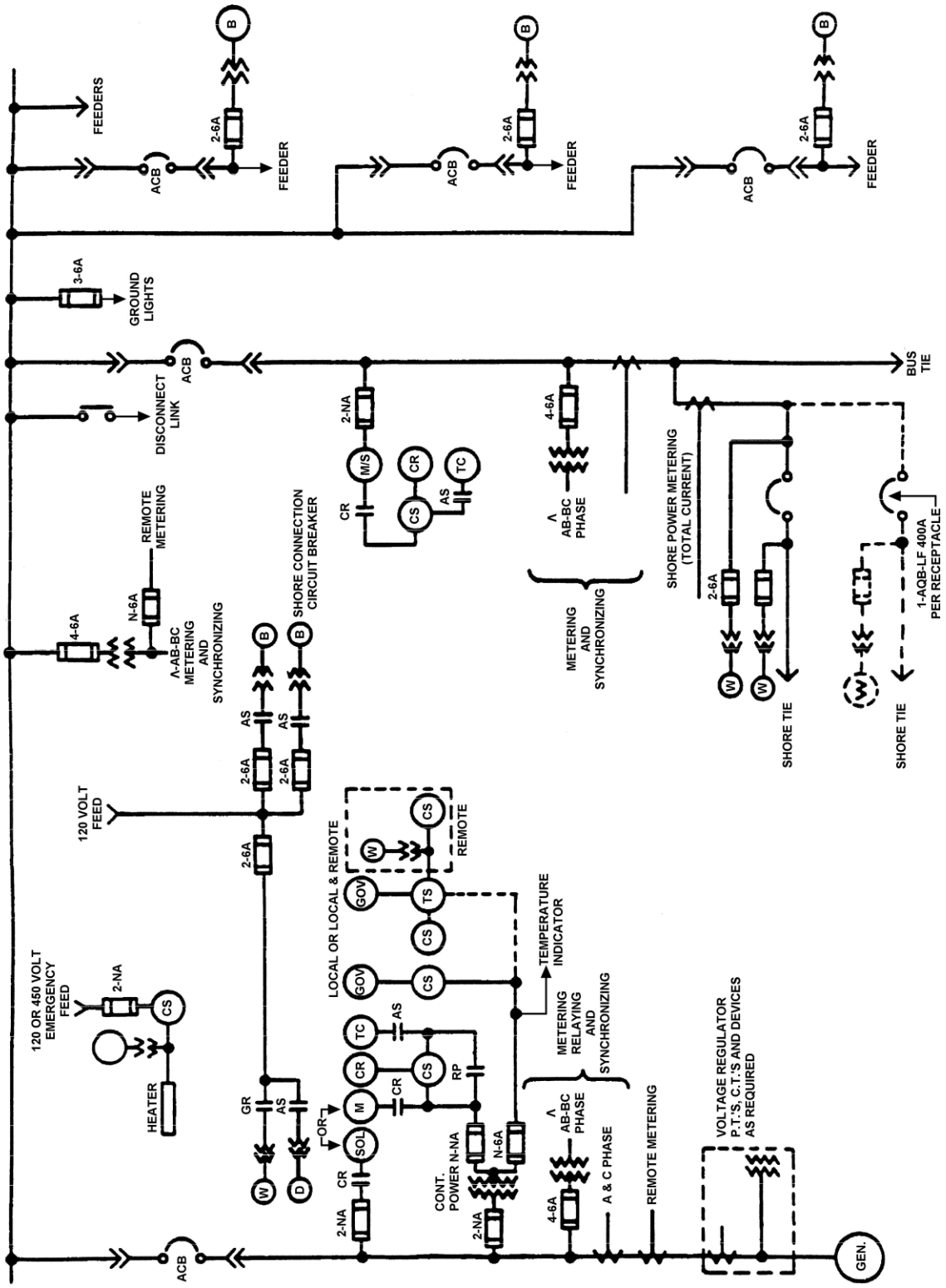


FIGURE 1. Typical one-line control diagram for ship's service AC power switchgear group having an EPCP.
(see figure 3 for legend)

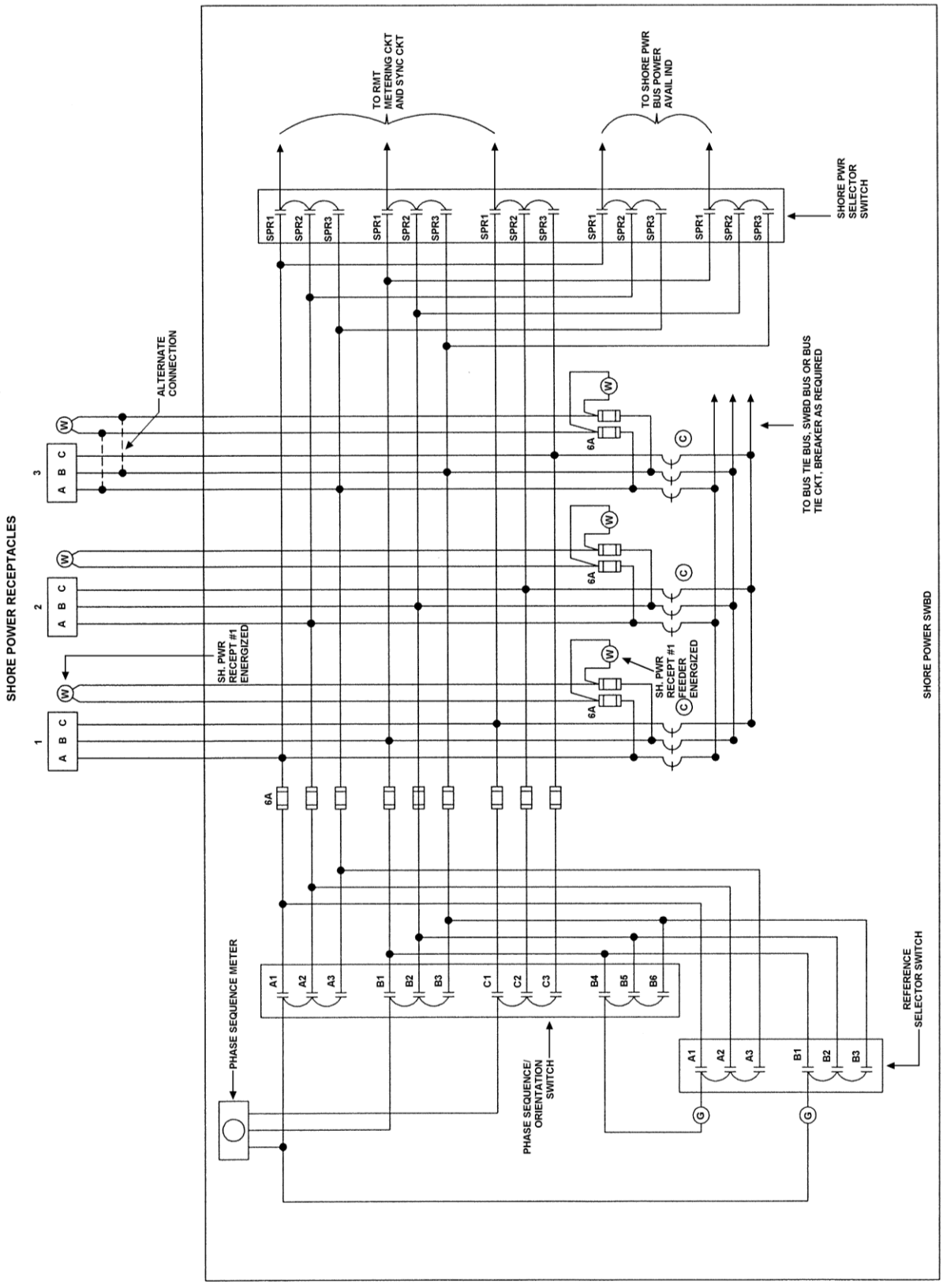


FIGURE 2. Typical shore power connection diagram (sheet 1 of 3).

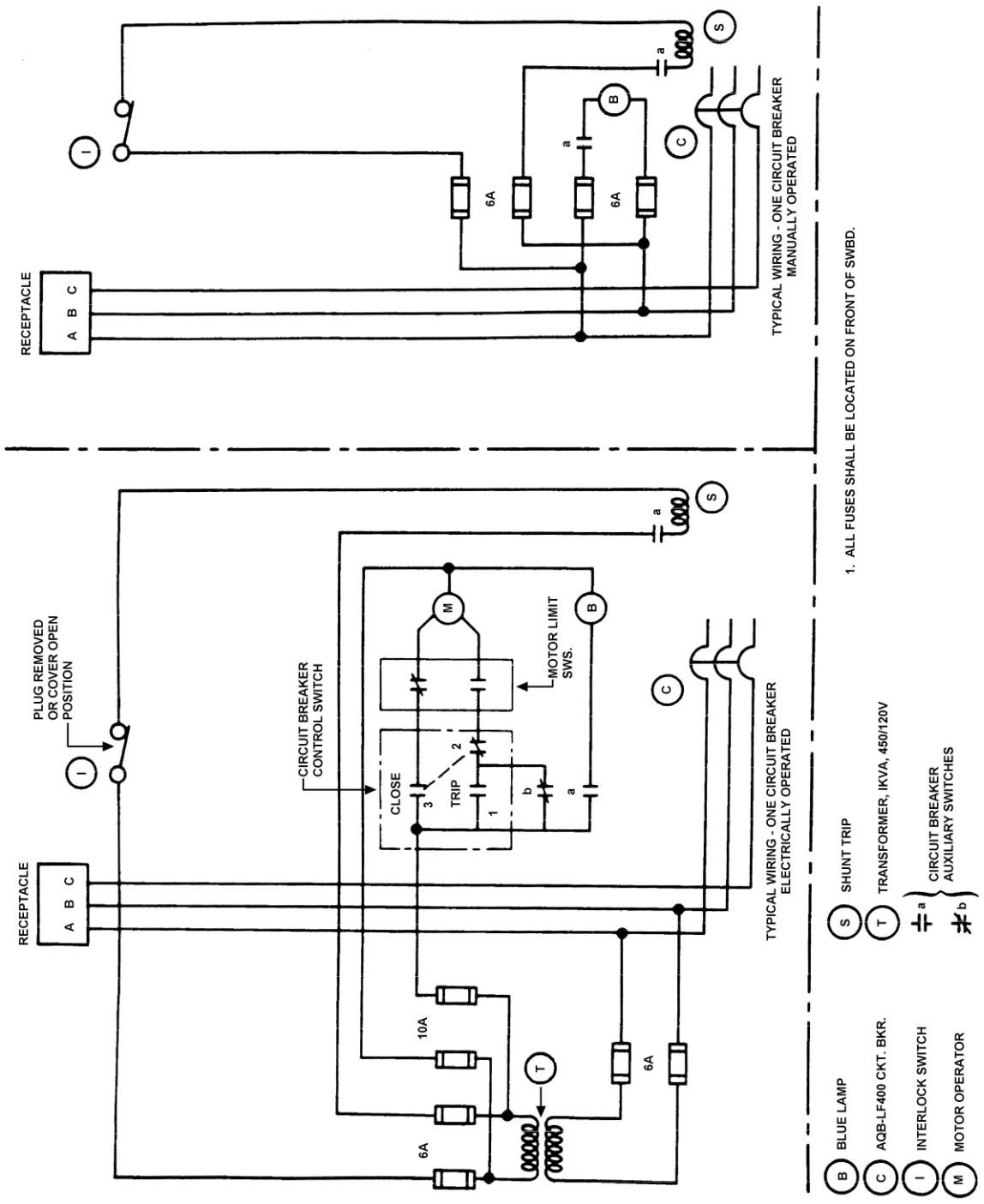


FIGURE 2. Typical shore power connection diagram (sheet 2 of 3) – Continued.

TYPICAL SWITCH CONTACT ARRANGEMENTS

PHASE SEQUENCE/ORIENTATION TEST SWITCH

CONTACT	POSITION			
	OFF	1	2	3
A1		X		
B1		X		
C1		X		
A2			X	
B2			X	
C2			X	
A3				X
B3				X
C3				X
B4		X		
B5			X	
B6				X

1. CONTACT ARRGTS. APPLY TO THE 3 RECEPTACLE CIRCUITS SHOWN ON SHT. NO. 1 OF 3

2. ADDITIONAL CONTACTS SHALL BE PROVIDED ON THE REFERENCE SELECTOR SWITCH TO SWITCH METERING AND SYNCH. EQUIPT. TO THE RECEPTACLE SELECTED AS THE REFERENCE, AS REQUIRED

REFERENCE SELECTOR SWITCH

CONTACT	POSITION			
	OFF	1	2	3
A1		X		
A2			X	
A3				X
B1		X		
B2			X	
B3				X

CIRCUIT BREAKER CONTROL SWITCH

CONTACT	POSITION		
	TRIP	NORMAL	CLOSE
1	X		
2	X	X	
3			X
4	X		
5	X	X	
6			X
7	X		
8	X	X	
9			X

FIGURE 2. Typical shore power connection diagram (sheet 3 of 3) – Continued.

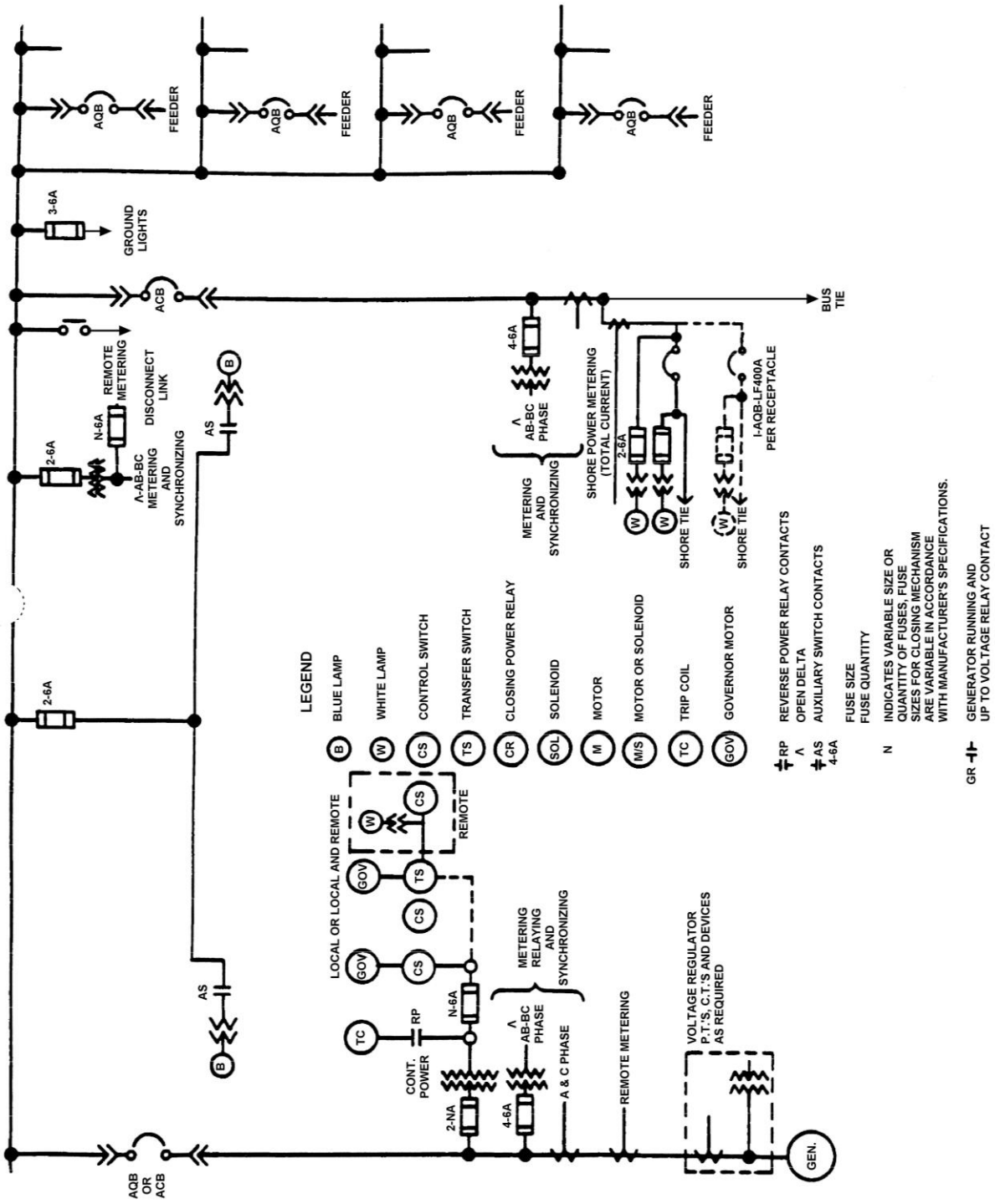


FIGURE 3. Typical one-line control diagram for ship's service AC power switchgear group not having EPCP or EPCC.

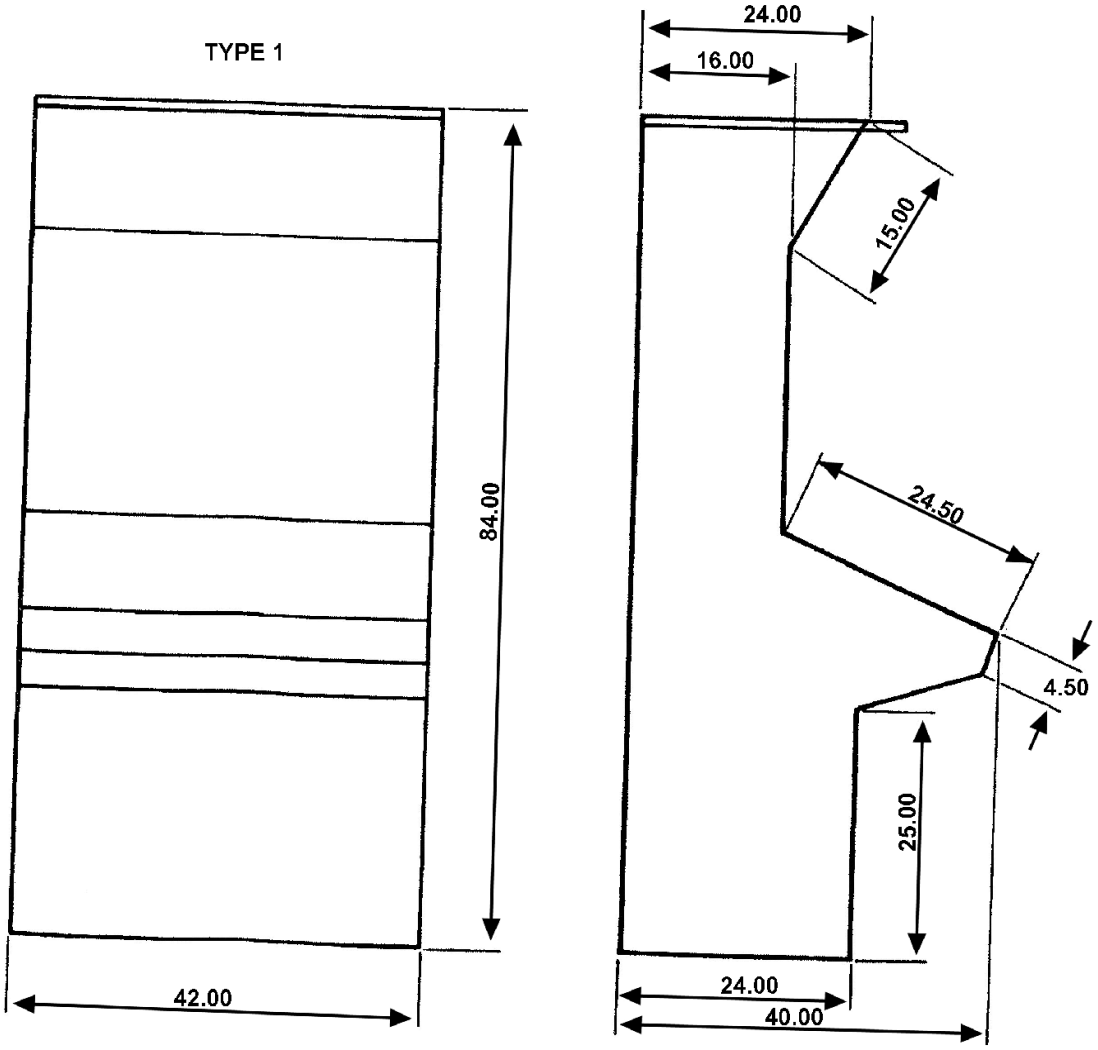


FIGURE 4. Desk types EPCP (sheet 1 of 2).

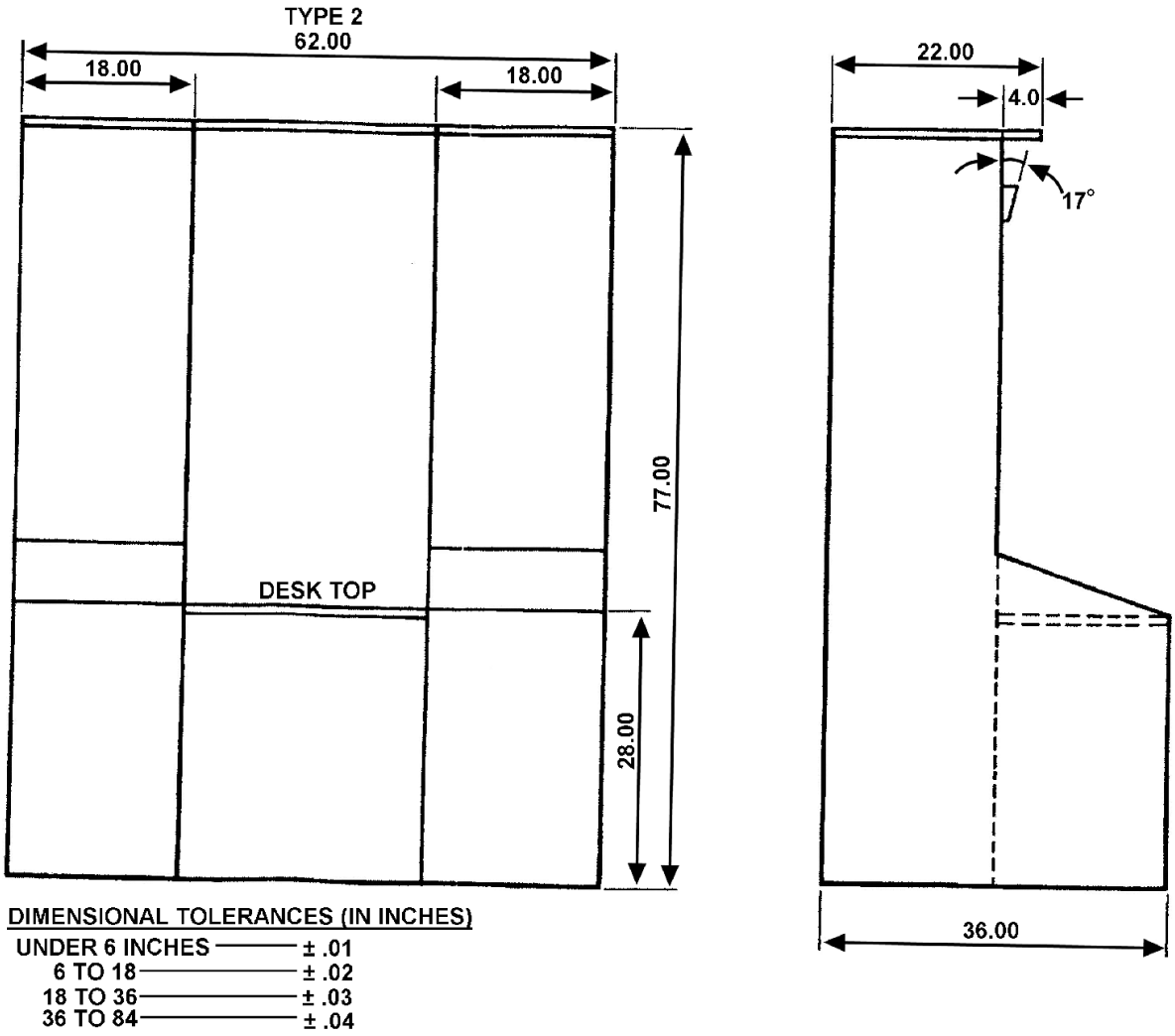


FIGURE 4. Desk types EPCP (sheet 2 of 2) – Continued.

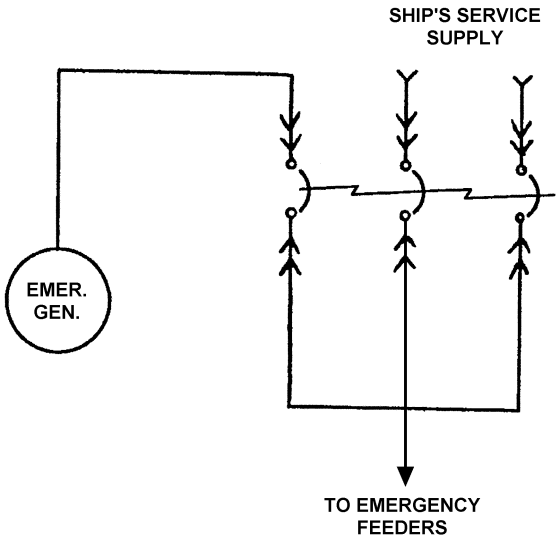


FIGURE 5. Three-way bus transfer type ABT-A3 (ES), circuit breaker type.

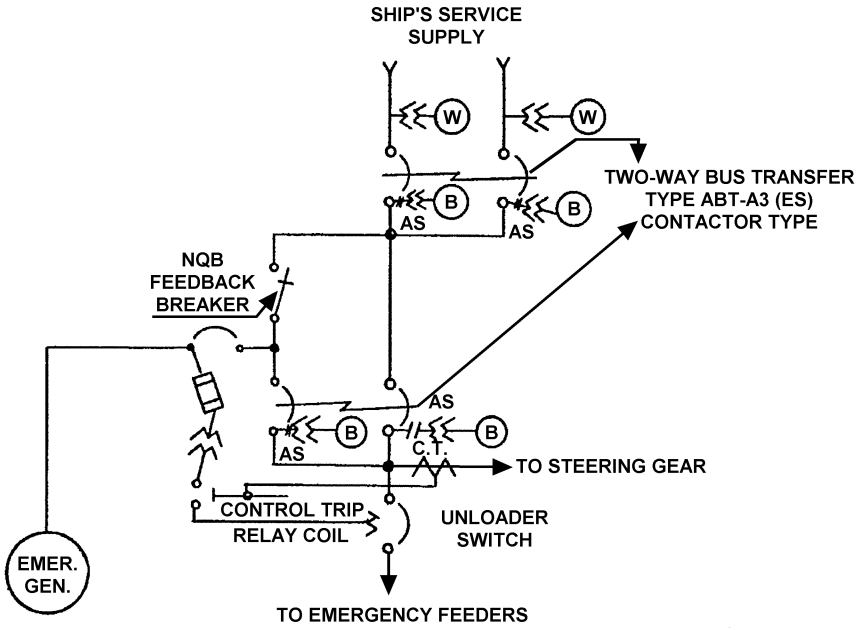


FIGURE 6. One-line diagram of emergency power system.

TABLE A. Standardized switchgear units.

Generator size in kw	Type unit	AQB 250 or 400	AQB 800 or ACB 900, 902	ACB 1600	ACB 3200	ACB 4000	Dimensions of units (all dimensions in inches)										Diagrams (figure 8 and figure 9)
							A	B	C	D	E	F	G	H	K	M	
30-60-100-200	G1	1					74	20	33-1/2				26-3/4				2,5,7,8
200-300-500	2		1				81	20	40-1/2	9	14	13		13-1/8	20-5/8	5-3/16	1,6,7,9
750-1000	3			1			81	27	40-1/2	9	14	13		13-1/8	20-5/8	8-11/16	1,6,7,9
1500-2000	5				1		81	33	44-1/2	13	11	16		12-1/4	23-1/2	11-11/16	1,6,7,10
2500	7						81	39	49-1/2	18	11	16		17-1/4	25-1/2	14-11/16	1,6,7,11 or 12
30-60 (DC)	10	1				1	74	20	33-1/2				26-3/4				2,5,7,8
150-200 (DC)	11		1				81	20	40-1/2	9	14	13		13-1/8	20-5/8	5-3/16	1,6,7,9
	B20		2				81	18	40-1/2	9	14	13		13-1/8	21-7/8	3-7/8	1,4,7,9
	21			2			81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	22			2			81	27	44-1/2	13	11	16		12-1/4	26-3/4	8-3/8	1,4,7,10
	25				2		81	33	49-1/2	18	11	16		17-1/4	26-3/4	3-7/8	1,4,7,11 or 12
	26				2		81	33	44-1/2	13	11	16		12-1/4	26-3/4	11-11/16	1,4,7,10
	D50		3				81	18	40-1/2	9	14	13		13-1/8	21-7/8	11-11/16	1,4,7,9
	51			2			81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	52			2			81	27	44-1/2	13	11	16		12-1/4	26-3/4	8-3/8	1,4,7,10
	55			2			81	27	49-1/2	18	11	16		17-1/4	26-3/4	8-3/8	1,4,7,11 or 12
	56				2		81	33	49-1/2	18	11	16		17-1/4	26-3/4	11-11/16	1,4,7,11 or 12
	D60		5			2	81	18	40-1/2	9	14	13		13-1/8	21-7/8	3-7/8	1,4,7,9

FIGURE 7. Standardized switchgear units.

TABLE A. Standardized switchgear units – Continued.

Generator size in kw	Type unit	AQB 250 or 400	AQB 800 or ACB 900, 902	ACB 1600	ACB 3200	ACB 4000	Dimensions of units (all dimensions in inches)										Diagrams (figure 8 and figure 9)
							A	B	C	D	E	F	G	H	K	M	
	61			1	or 1	2	81	18	40-1/2	9	14	13		13-1/8	21-7/8	3-7/8	1,4,7,9
	62		12			1	81	20	40-1/2	9	11	16		13-1/8	20-5/8	3-7/8	1,6,7,9
	63		12	2		1	81	22-1/2	40-1/2	9	11	16		13-1/8	20-5/8	3-7/8	1,6,7,9
	64		8	4		1	81	22-1/2	40-1/2	9	11	16		13-1/8	20-5/8	3-7/8	1,6,7,9
	70			6		2	81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	71			2	or 2	2	81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	72		16			1	81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	73		12			1	81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	74		6			1	81	27	40-1/2	9	11	16		13-1/8	21-7/8	8-3/8	1,4,7,9
	80	14	or 10				74	14-1/2	33-1/2				26-3/4				2,5,7,8
	D81		12				81	14-1/2	31-1/2				24-3/4				3,5,7
	82	22	or 15				74	20	33-1/2				26-3/4				2,5,7,8
	83		18				81	20	31-1/2				24-3/4				3,5,7
	85			10			81	22-1/2	31-1/2				24-3/4				3,5,7
	86			15			74	32	33-1/2				26-3/4				2,5,7,8
	87			15			81	32	31-1/2				24-3/4				3,5,7

FIGURE 7. Standardized switchgear units – Continued.

TABLE A. Standardized switchgear units – Continued.

Generator size in kw	Type unit	AQB A101 or A102	AQB A101 A102 fused	AQB 250	ACB 900, 902	ACB 1600	Dimensions of units (all dimensions in inches)										Diagrams (figure 8 and figure 9)
							A	B	C	D	E	F	G	H	K	M	
	88			5			74	14-1/2	33-1/2				26-3/4				2,5,7,8
	89			5			81	14-1/2	31-1/2				24-3/4				3,5,7
	90	24	or 16				74	22-1/2	33-1/2				26-3/4				2,5,7,8
	91		20	2			81	22-1/2	31-1/2				24-3/4				3,5,7
	92	16	or 12	4			74	22-1/2	33-1/2				26-3/4				2,5,7,8
	93		12	6			81	22-1/2	31-1/2				24-3/4				3,5,7
	95		18	9			81	32	31-1/2				24-3/4				3,5,7
	96	8	or 6	2			74	14-1/2	33-1/2				26-3/4				2,5,7,8
	97		6	3			81	14-1/2	31-1/2				24-3/4				3,5,7
	E40	ABT-A3 (ES)					74	20	33-1/2				26-3/4				2,5,7,8
	40A	ABT-A3 (ES) SAME AS E40 EXCEPT HAS UNLOADER					74	22-1/2	33-1/2				26-3/4				2,5,7,8
	41	ABT-A3 (ES) (ACB-900 or 902)					81	36	40-1/2	9	11	16		13-1/8	21-7/8	3-7/8	1,4,7,9
	42	ABT-A3 (ES) (ACB 1600)					81	54	40-1/2	9	14	13		13-1/8	21-7/8	8-3/8	1,4,7,9

FIGURE 7. Standardized switchgear units – Continued.

TABLE B. Side sheet cutout groups.

Group	Drawing	Units			
1	8	G1	D80	D88	E40
		10	82	90	40A
			86	96	
				92	
2	9	G3	B20	D50	D64
			20S	51	70
			21	60	71
			21S	61	72
				62	73
				63	74
2A	9	G2	E41		
		11	42		
3	10	G5	B22	D52	
			22S		
			26		
			26S		
4	11	G7	B25	D55	
	12		25S	56	

NOTES:

1. The switchboard unit type numbers shown shall be supplemented with prefix letters as shown below to designate the materials used for the switch gear framework and bus bars.

Frame	Bus bar	Prefix	Typical type no.
Steel	Copper	None	G1
Aluminum	Copper	CA	CAC1

2. Bus tie units B20-26 used as bus tie and shore power units shall have the letter “S” added to the end of the type designation (e.g., B21S).

FIGURE 7. Standardized switchgear units – Continued.

3. Standardized switchboard units – type number series.

Type number	Description of units
G1-7	AC generator
G10-11	DC generator
B20-26	AC bus tie
E40-42	Emergency switchboard
D50-56	ACB distribution
D60-64	AQB and ACB 640, 900, 902 distribution
D70-74	AQB and ACB 1600 distribution
D80-97	AQB distribution 100A or 250A

4. Circuit breaker quantities listed are typical.
5. If necessary, the depth (dimension "C") may be altered on AQB feeder units so the feeder units can have the same main bus as required for the generator and bus tie units.
6. Diagram figure numbers refer to the side bolting pattern, floor plan, front plan, and side sheet cutout plan.
7. "B" dimension includes side sheets.
8. "A" dimension is without foundation channels.

Dimension tolerances (in inches)			
Dim	Decimals		Fraction
	2 PL	3 PL	
Under 6	±0.01	±0.005	±1/64
6 to 18	±0.02	±0.010	±1/32
18 to 36	±0.03	±0.015	±1/16
36 to 84	±0.04	±0.020	±1/8

NOTES:

All dimensional tolerances are in accordance with table unless otherwise noted. Tolerances shall be noncumulative.

Two place tolerances for dimensions A, B, and C.

Three place tolerances for dimensions D, E, F, G, H, K, I, and M.

FIGURE 7. Standardized switchgear units – Continued.

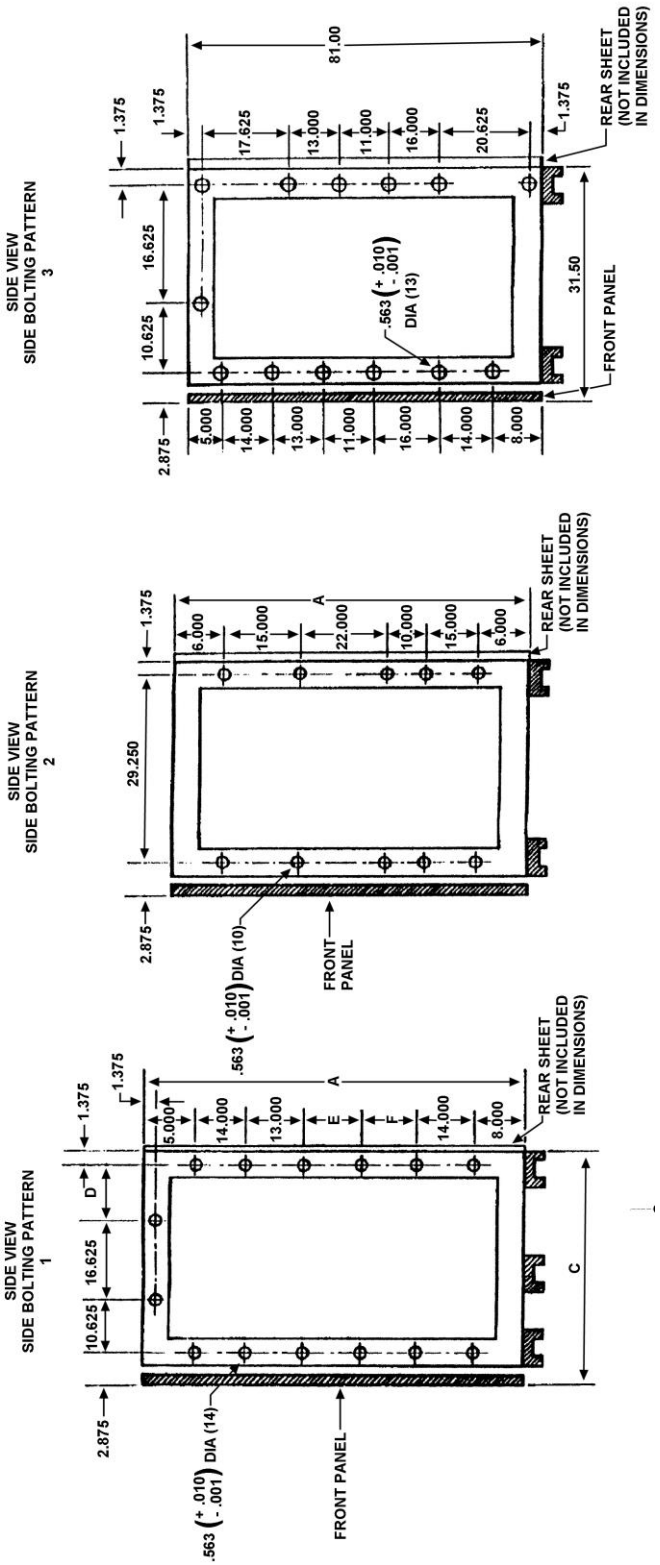


FIGURE 8. Standardized switchboard plans (sheet 1 of 2).

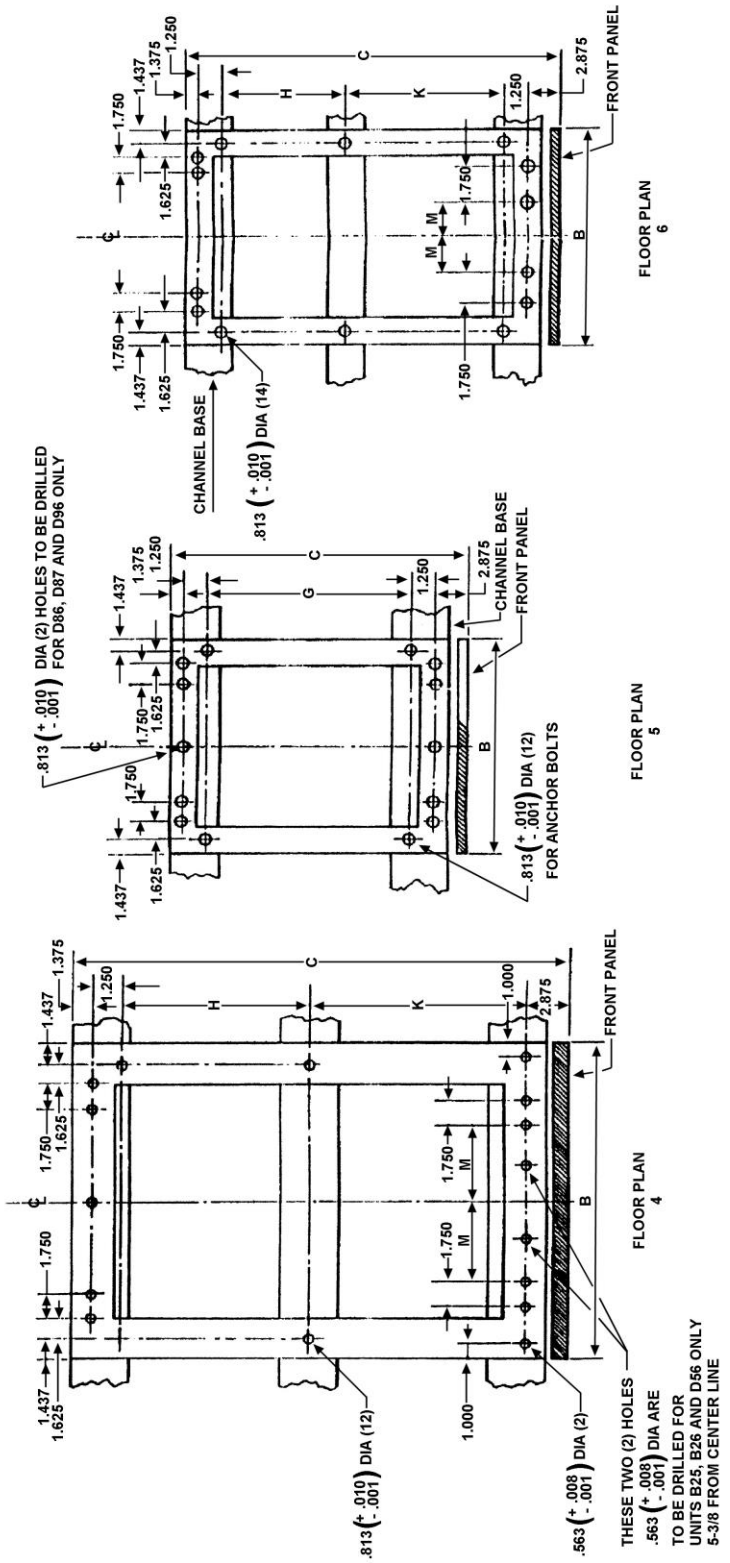


FIGURE 8. Standardized switchboard plans (sheet 2 of 2) – Continued.

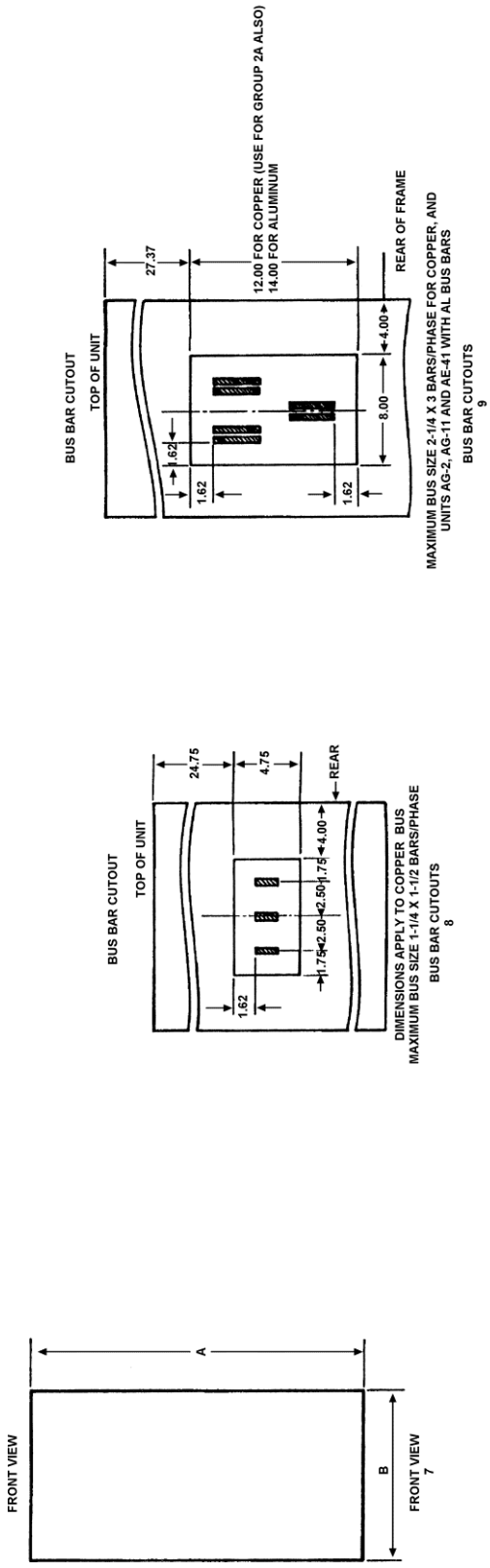


FIGURE 9. Standardized switchboard plans (sheet 1 of 2).

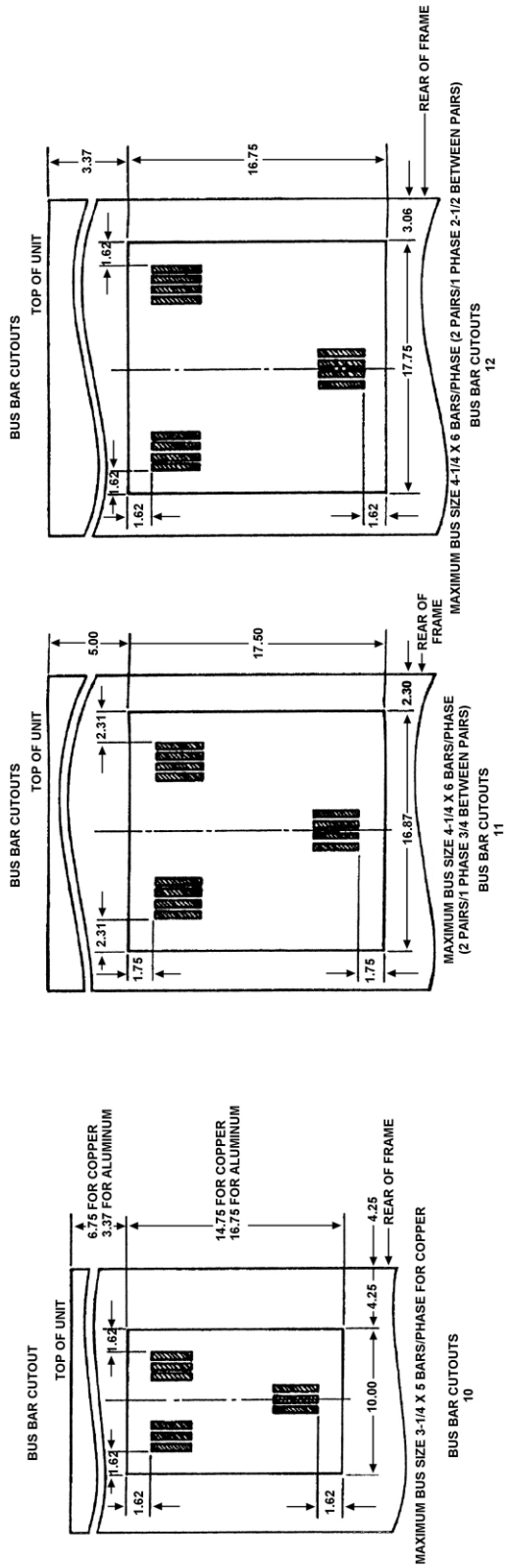


FIGURE 9. Standardized switchboard plans (sheet 2 of 2) - Continued.

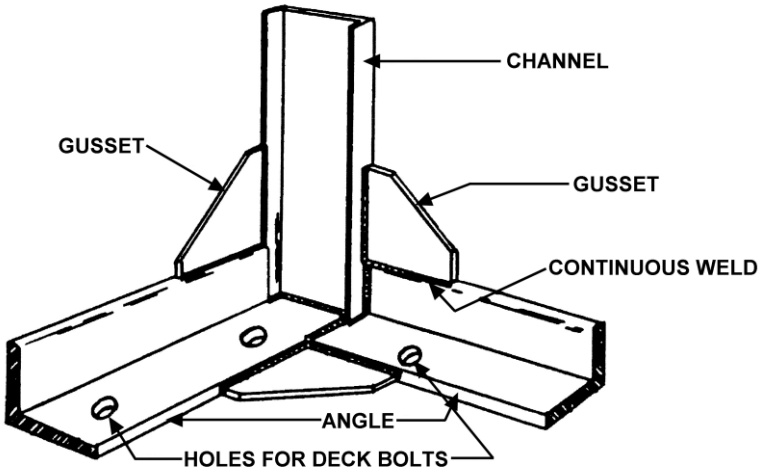
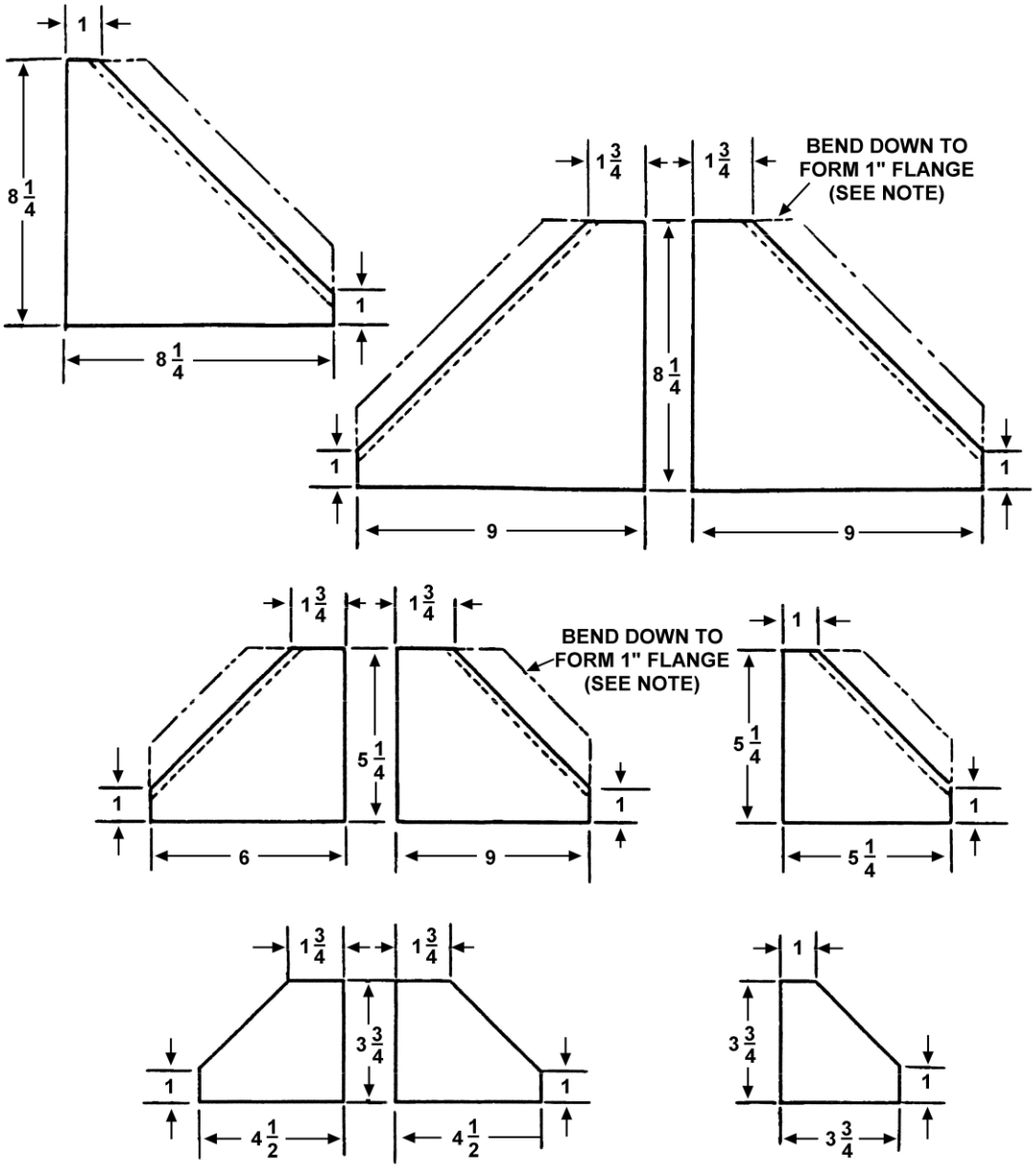
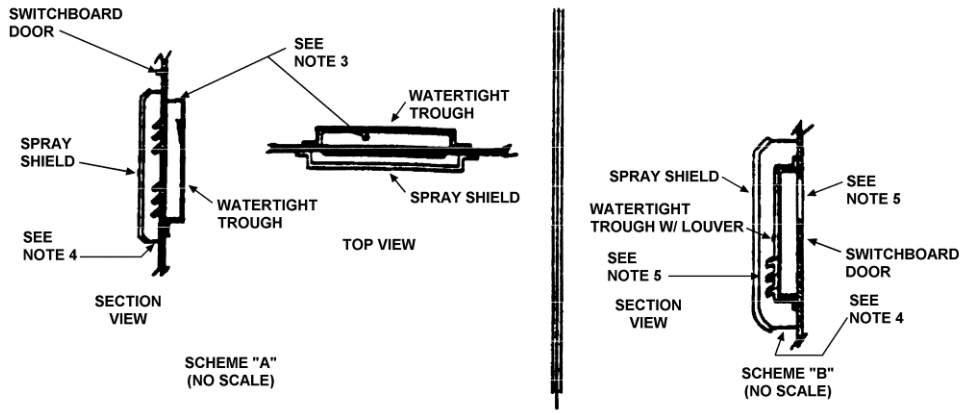


FIGURE 10. Typical bottom, corner construction.

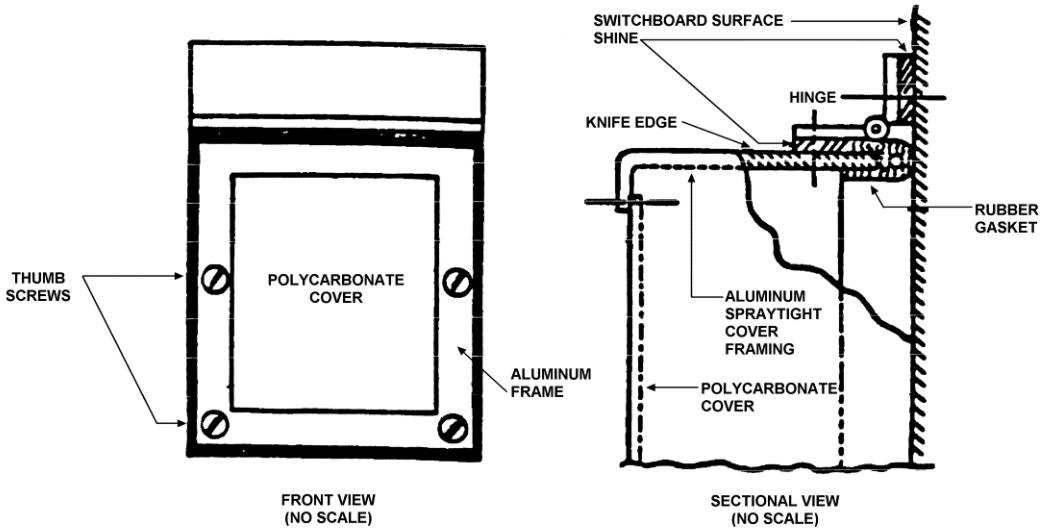


NOTE: Flanges shall be used when thickness of gusset plates is less than 3/16 inch. Gusset plates shall be not less than 1/8 inch thick.

FIGURE 11. Typical gusset plates.



TYPICAL WATERTIGHT TROUGH MOUNTING



TYPICAL HINGED COVER ASSEMBLY

NOTES:

1. Scheme “A” where watertight trough can be mounted behind switchboard door.
2. Scheme “B” where watertight trough cannot be mounted behind switchboard door.
3. Open area at top of watertight trough shall be equal to the area of ventilation provided by the louvers, if spraytight baffle was not provided.
4. The combined open area at the top and bottom of the spray shield shall be equal to the area of ventilation provided by the louvers.
5. Area of ventilation to be provided by louvers on watertight trough and open area on switchboard door shall be equal to the area of ventilation provided by the louvers, if spraytight baffle was not provided.
6. The number of thumbscrews used for the hinged cover assembly shall be the minimum necessary for firm compression.
7. The gasket used for covers and panel assembly shall be Class 2, Grade 60, and shall conform to MIL-PRF-6855.

FIGURE 12. Typical spraytight construction.

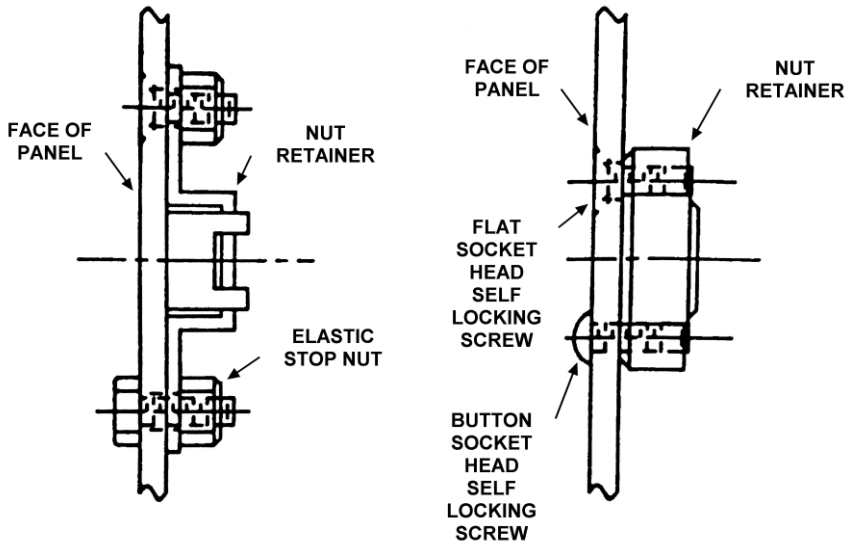


FIGURE 13. Anchor devices for thumbscrews.

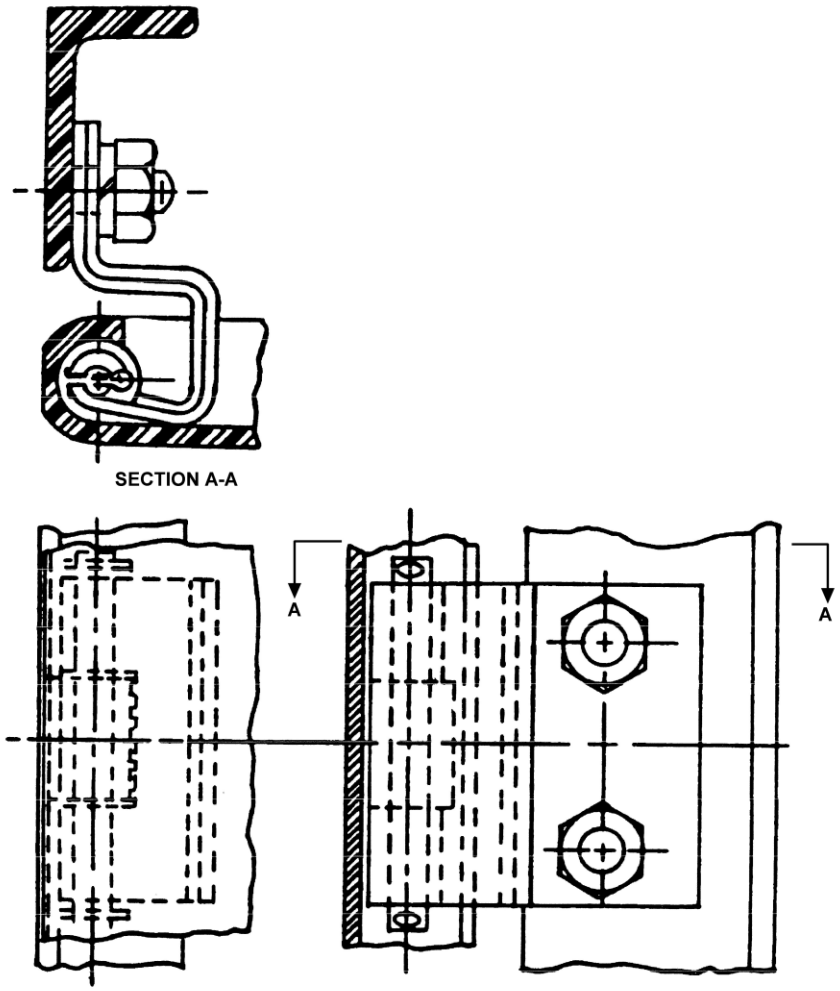


FIGURE 14. Typical panel hinge assembly.

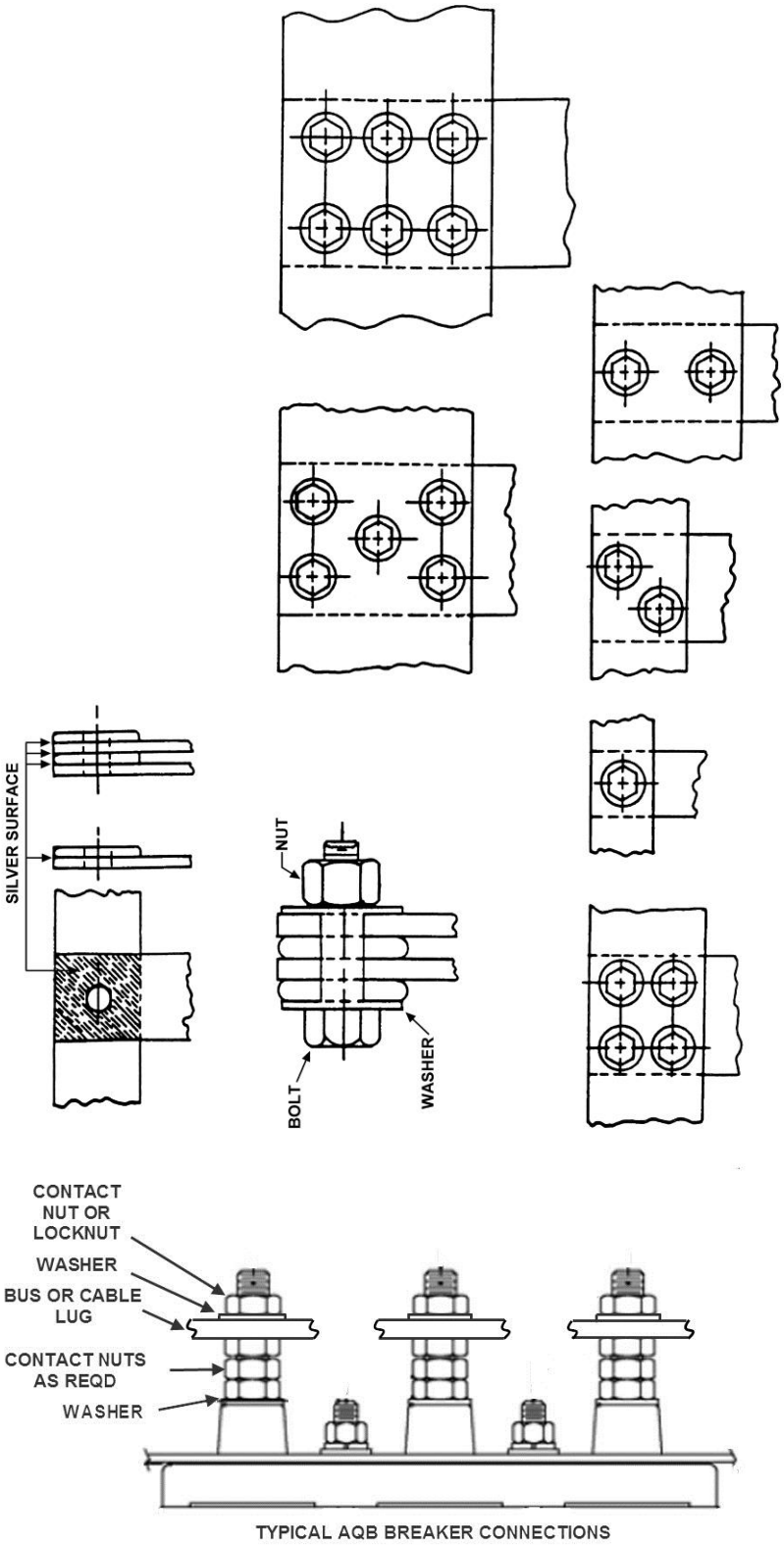


FIGURE 15. Typical arrangement for bolting of bus connections.
(for combination of bolt and bus sizes, see table VI.)

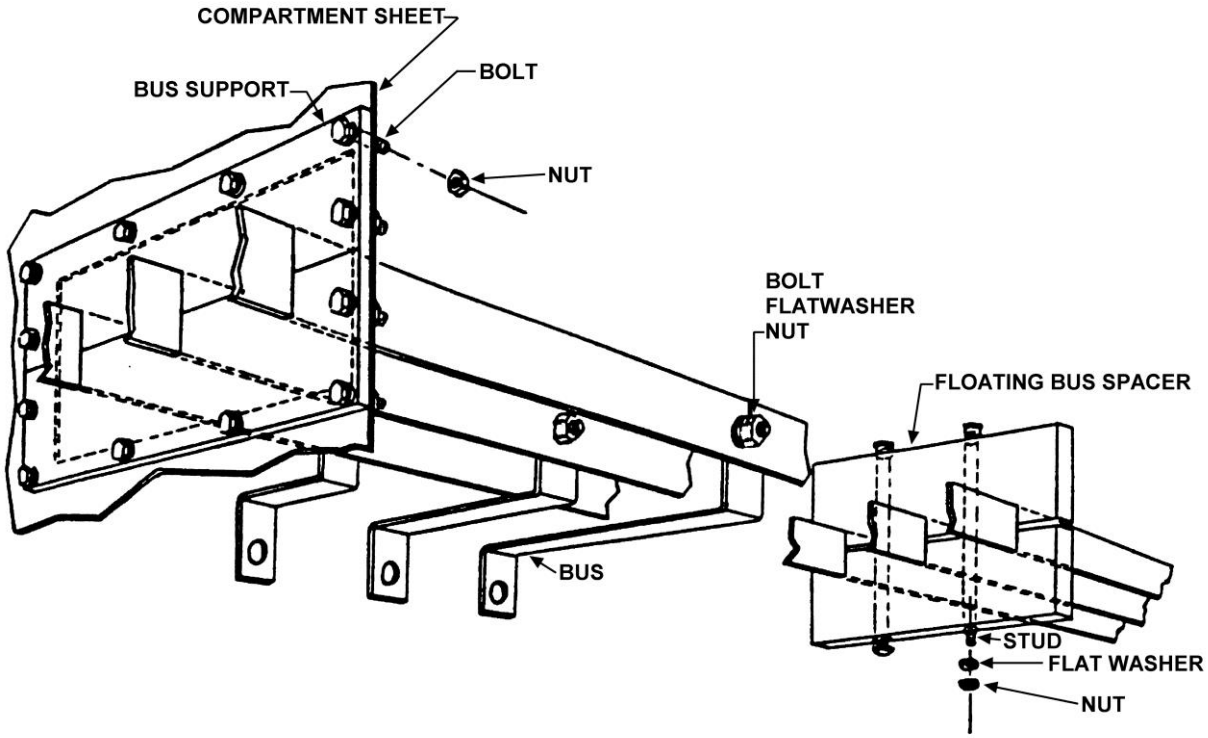
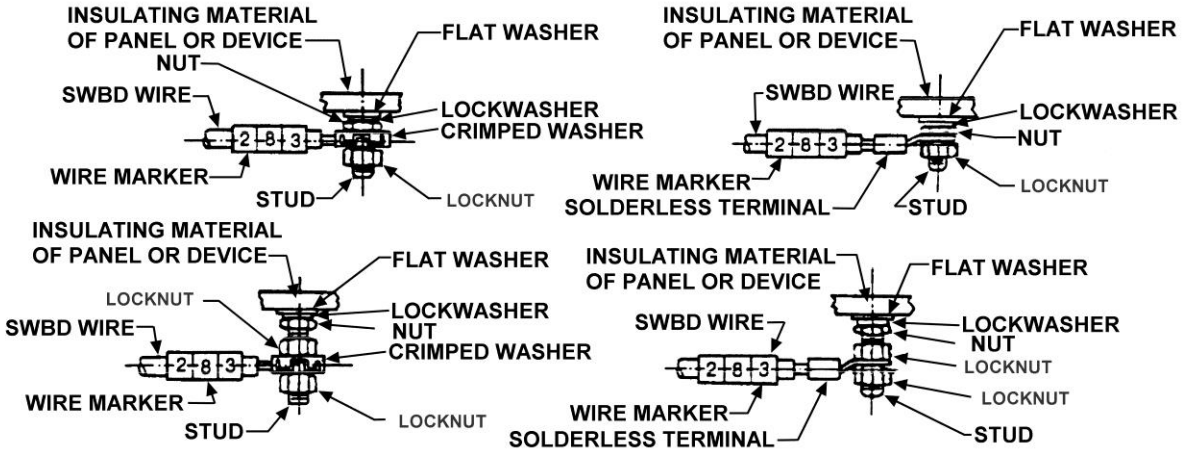
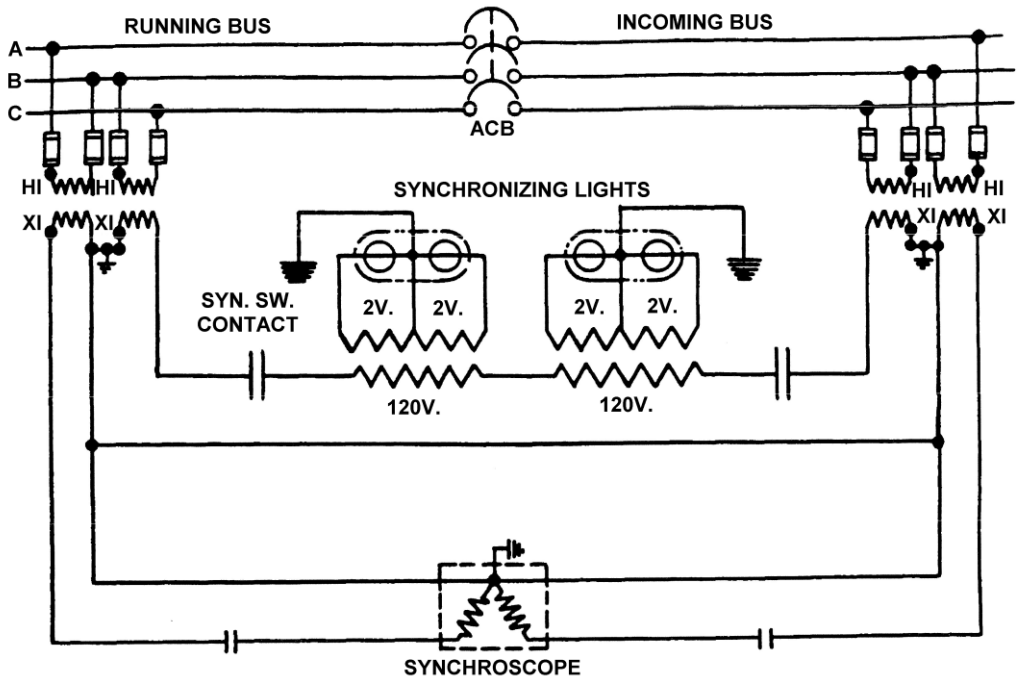


FIGURE 16. Typical bus bar mounting.



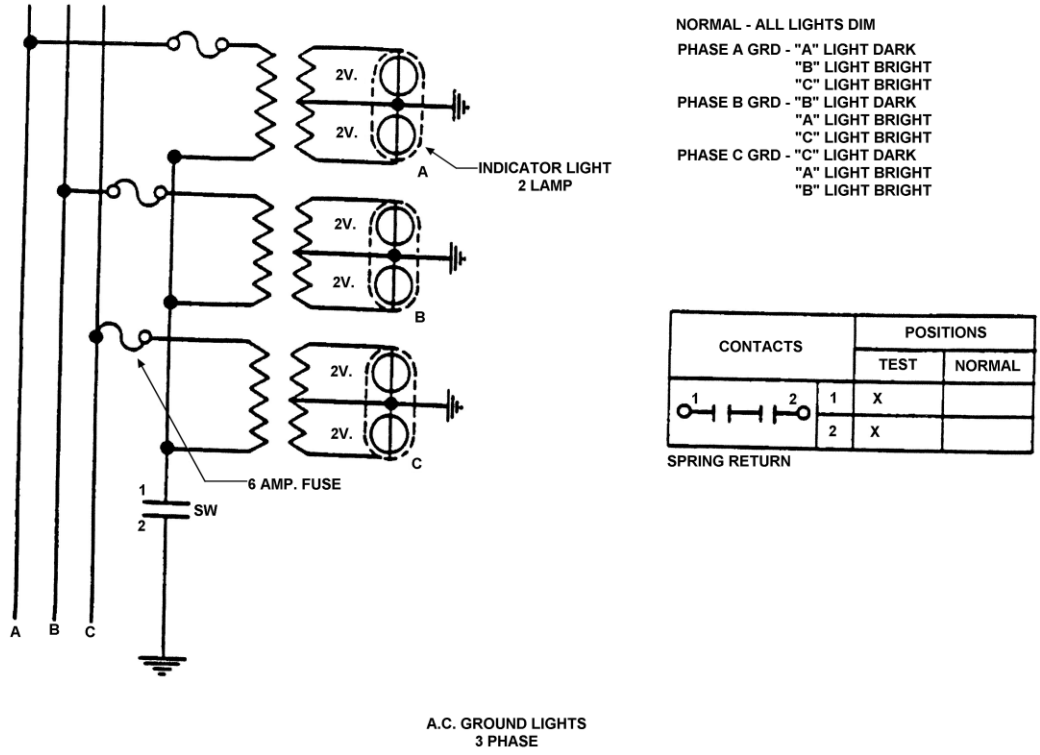
NOTE: Markings may be stamped on wire terminals or, if terminals are too small to permit stamping, synthetic resin tubing of MIL-I-631, Type F, Grade A, or fiber tags shall be used.

FIGURE 17. Typical cable marking and connections.



NOTE: This diagram is typical only, representing a reference bus and a second bus to be synchronized with it. Where provision should be made for a third bus to be synchronized with either of these buses, additional contacts in the synchronizing transfer switch shall be provided as required.

FIGURE 18. Synchronizing connections.



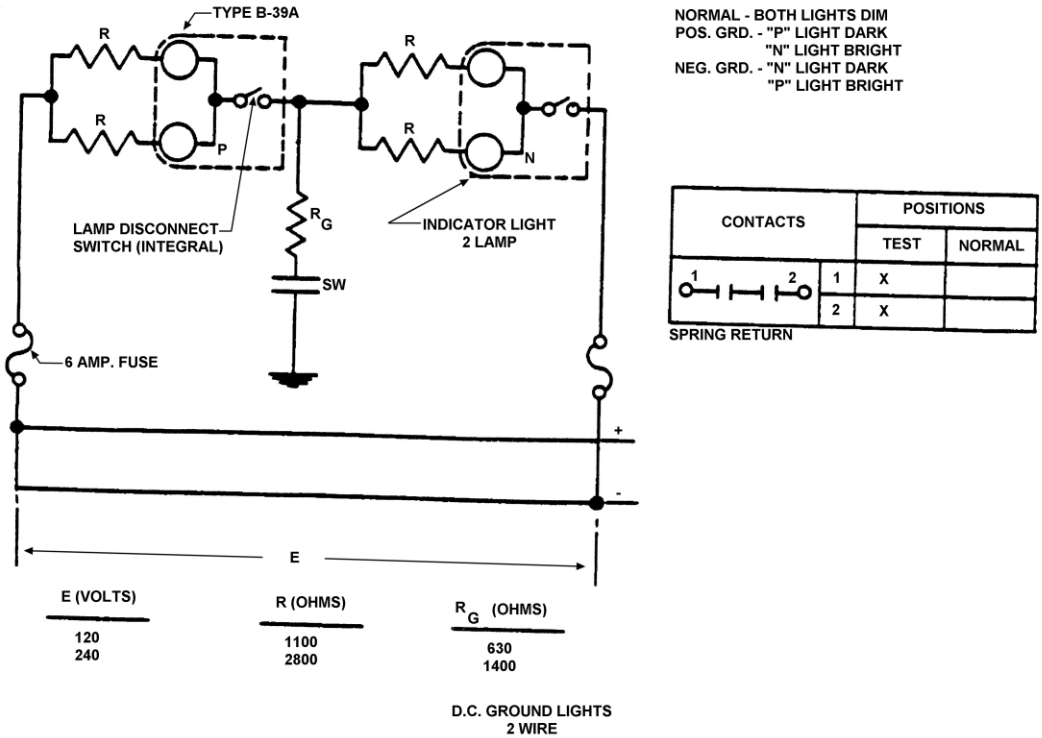


FIGURE 19. Ground light schemes.

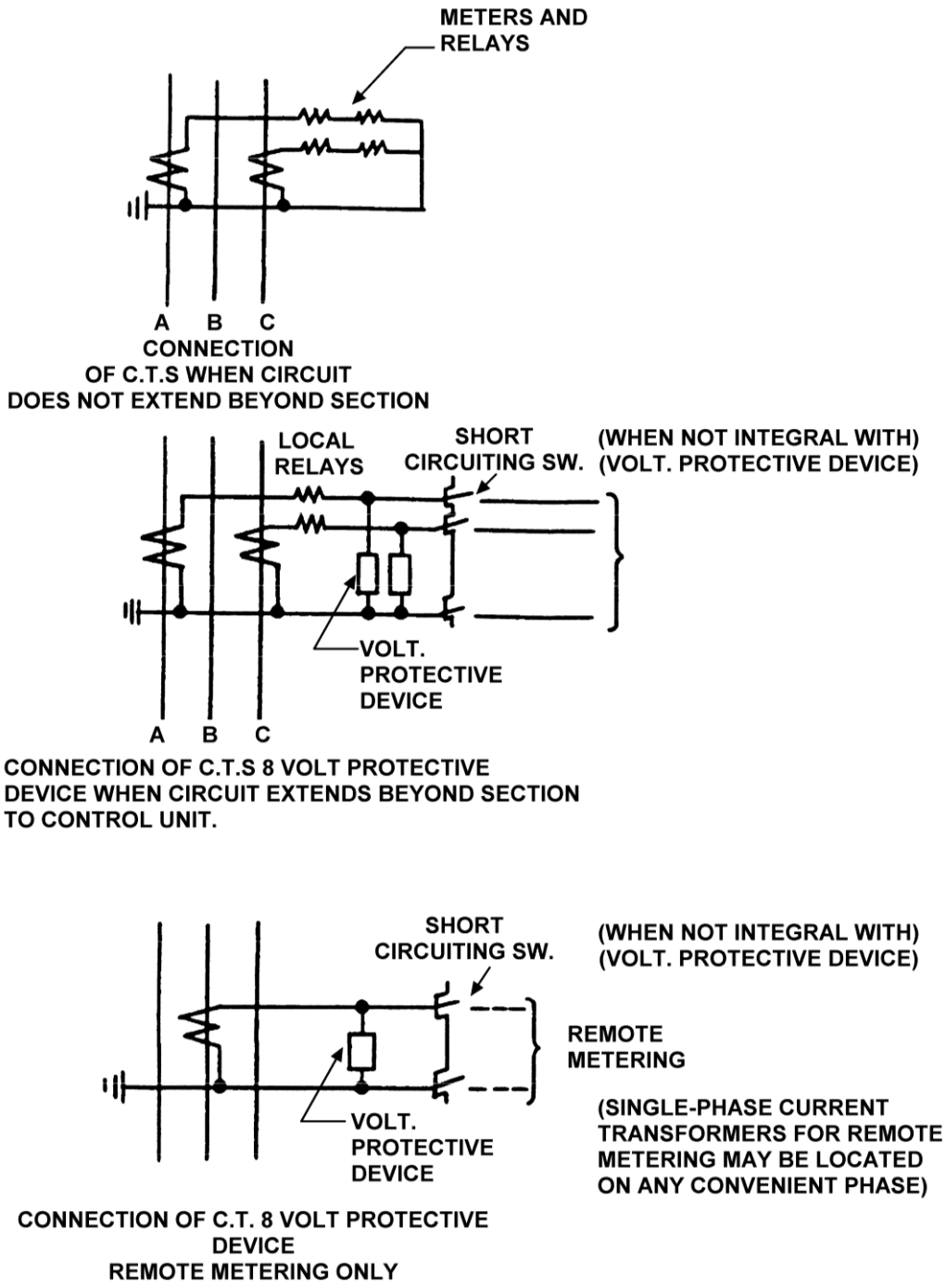


FIGURE 20. Connections of current transformers and voltage protective devices.

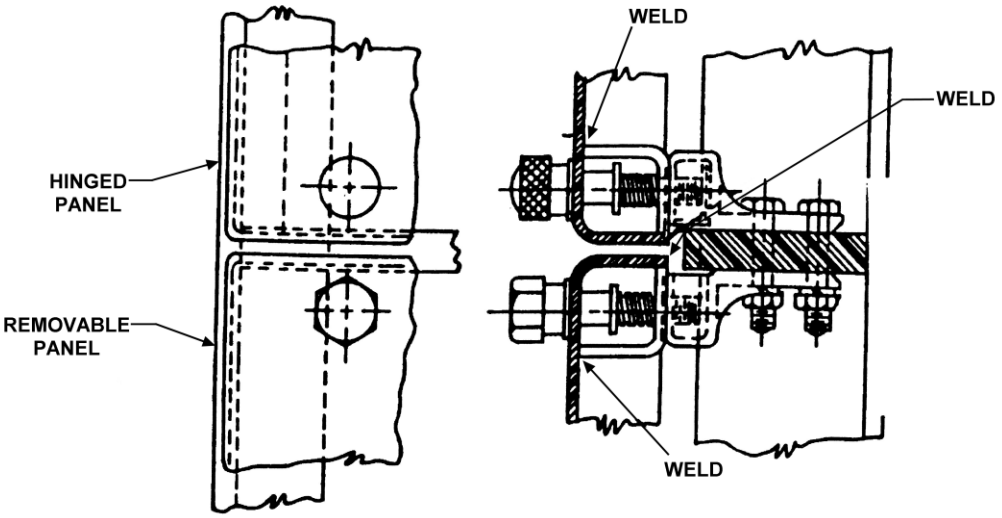


FIGURE 21. Typical panel latch bolt for hinged and removable panel.

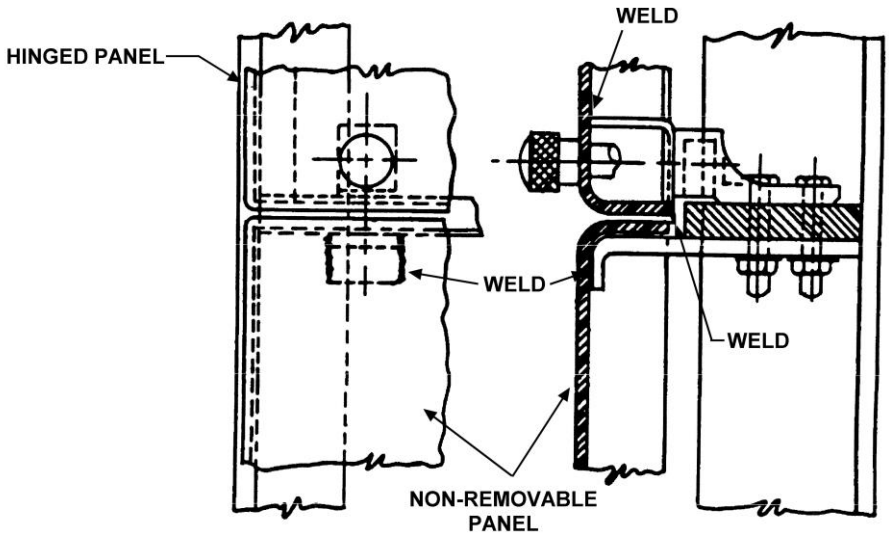


FIGURE 22. Typical panel latch bolt for hinged panel and method of securing stationary panel.

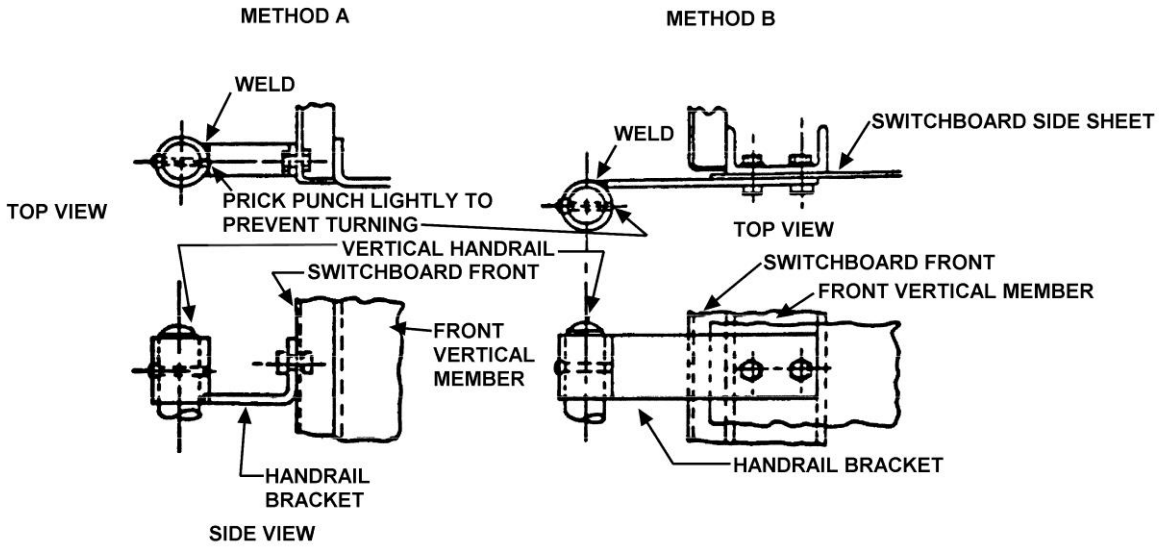


FIGURE 23. Typical vertical guard rail mounting.

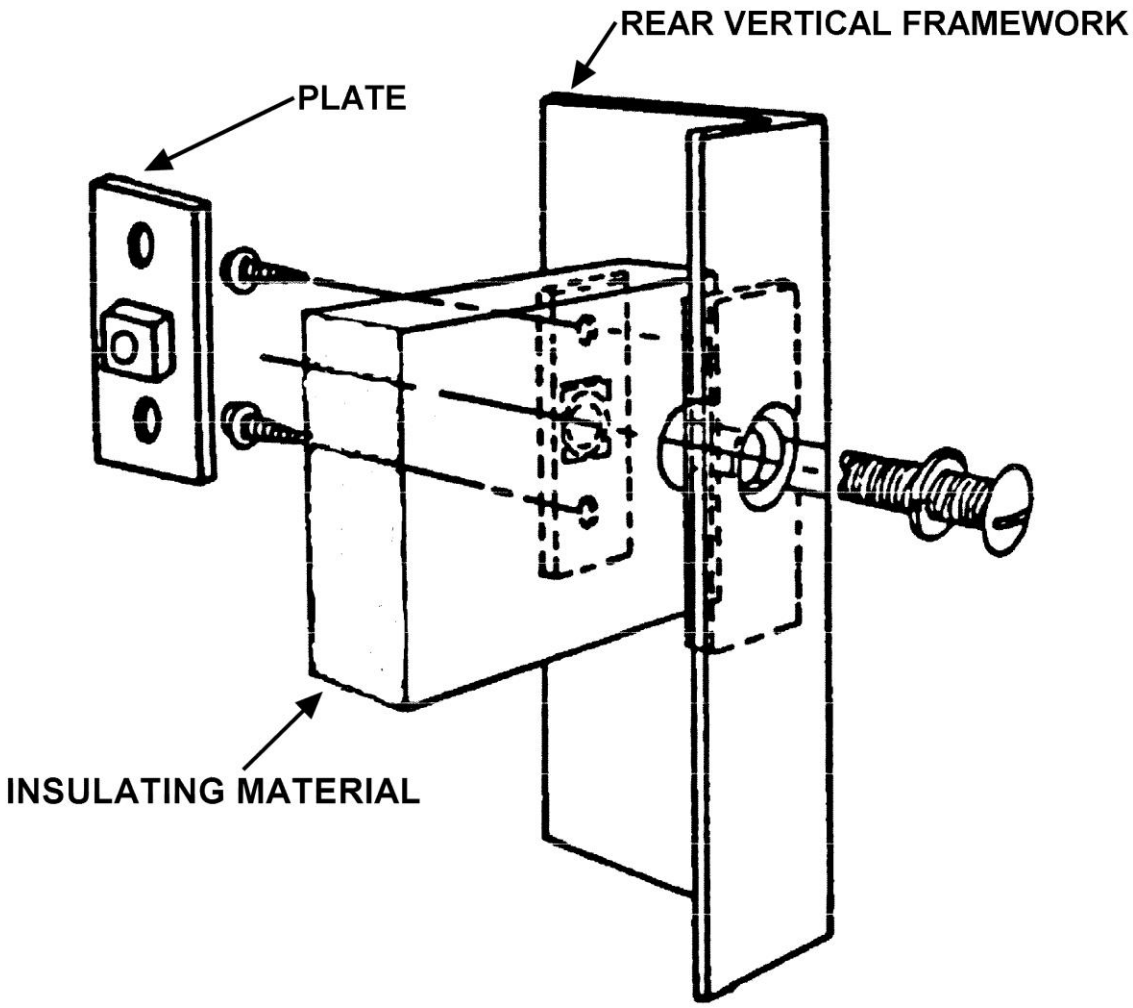


FIGURE 24. Typical guard rail mounting.

APPENDIX FOR DRAWING TECHNICAL REQUIREMENTS

A.1 SCOPE

A.1.1 Scope. This appendix covers the technical requirements for drawings covered by this specification. This Appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

A.2 DATA CONTENT

A.2.1 Unit drawings. Unit drawings should contain the following:

a. Dimensional front, side, and rear views of the switchboard unit showing standardized overall dimensions of the unit; number, size, and location of holes for interframe bolting; location of required equipment; and center of gravity location and function of all devices; location and size of main buses passing through the unit and connections thereto.

b. Dimensional rear elevation view showing casualty power equipment and rear enclosure, where specified.

c. Dimensional floor or mounting view to show arrangement of anchor bolt drilling.

d. Supplementary views showing the necessary dimensions and equipment not shown in items (a), (b), and (c) above.

e. Typical construction methods of the switchboard unit, including details of framework, details of attaching front panels, details of joining structural members, and location and types of welding should be shown or referenced. Total weight of unit with and without circuit breakers should be shown on drawing.

f. Drawings should show the contractor's recommended method for support of incoming cables.

g. Drawings should show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

h. Detail drawings of devices should be shown or referenced. Where devices are required to be of types for which test record drawings or certification data sheets are furnished by the Command or agency concerned, no working or corrected drawings of such devices will be requested. However, each test record drawing or certification data sheet covering the devices should be referenced, and the items in question should conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outline, or detail drawings of such items are necessary in the judgment of the Command or agency concerned, they should be furnished by the contractor.

i. A one-line wiring diagram of main power circuits. Circuit breakers, disconnect links, main switches, other power circuit switching equipment, and main and interconnecting buses should be shown.

j. Information plate list of parts having general application; complete list of material with name of parts, part numbers; Command or agency certificate of acceptance, drawing numbers or specification numbers, together with material for parts included in standardized units. Switches, circuit breakers, contactors, fuses, and resistors should be marked to show their current carrying capacity and voltage rating where applicable.

A.2.2 Switchboard drawings. Switchboard drawings should contain the following:

a. A dimensional front view of the switchboard showing assembly of units comprising the switchboard, overall diameter of each section, type numbers of units as shown on figure 7, and a single line diagram showing bus sizes. This drawing should show the weight and location of the center of gravity for each switchboard.

b. Views showing necessary details not shown on drawings of the unit (see spacing of footing or mounting members).

c. Identification plate list of parts having specific applications; list of material for specific and interconnecting parts not covered by the drawing in A.2.1 showing required additional information such as fuse or trip element data.

d. Complete wiring diagram showing feeder numbers, terminal blocks, circuit breakers, switch and fuse sizes, and identification plate numbers. No diagram is required for distribution type switchboards which have no control circuitry or wiring. Electrical devices should be marked or indicated by piece numbers to identify them readily with the corresponding part on the list of materials. Where five or more single lines used to represent several leads parallel to each other on the drawing are together, they should be separated into groups (two or three to a group as convenient), to facilitate following with the eyes instead of having them all uniformly spaced.

e. An elementary diagram of metering, relaying, and control circuits. This diagram should show the major bus circuits, the number and location of instruments and control transformers, the instruments, relays, and other equipment connected to each transformer, and the location of the instruments in relation to the various switchboards.

f. Detailed drawings of devices not covered by drawings. Where devices are required to be of types for which test record drawings or certification data sheets are furnished by the Command or agency concerned, no working or corrected drawings of such devices will be required; however, the contractor should reference each test record drawing or certification data sheet covering the device and the items in question should conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outlines, or detail drawing of each item are necessary in the judgment of the Supervisor of Shipbuilding for the purpose of proper inspection or the identification of repair parts, they should be furnished by the contractor.

g. A typical construction drawing showing necessary details not covered by A.2.2.e or by other drawings.

h. Drawings should show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

A.2.3 Electric plant control panel drawings. Electric plant control panel (EPCP) drawings should contain the following:

a. Dimensional front, side, and rear views of the EPCP showing overall dimensions of the EPCP; number, size, and location of holes for bolting; location of required equipment; weight and location of the center of gravity; location and function of all devices.

b. Dimensional rear elevation view showing casualty power equipment and rear enclosure, where specified.

c. Dimensional floor or mounting view to show arrangement of anchor bolt drilling.

d. Supplementary views showing the necessary dimensions and equipment not shown in items (a), (b), and (c) above.

e. Typical construction methods of the EPCP, including details of framework, details of attaching panels, details of joining structural members, and location and types of welding should be shown or referenced.

f. Drawings should show the contractor’s recommended method for support of incoming cables.

g. Drawings show piece numbers, identification and information plate numbers, and device numbers. These should agree with the corresponding numbers on the identification and information plate list and list of materials.

h. Detail drawings of devices should be shown or referenced. Where devices are required to be of types for which test record drawings or certification data sheets are furnished by the Command or agency concerned, no working or corrected drawings of such devices will be required. However, each test record drawing or certification data sheet covering the devices should be referenced and the items in question should conform completely to such drawings or certification data sheets, unless otherwise noted. If supplementary assembly, outline, or detail drawings of such items are necessary in the judgment of the Command or agency concerned, they should be furnished by the EPCP.

i. Information plate list of parts having general application; complete list of material with name of parts, part numbers, Command or agency certificate of acceptance, drawing numbers or specification numbers, together with material for parts included in EPCP. Switches, circuit breakers, contractors, fuses, and resistors should be marked to show their current carrying capacity and voltage rating where applicable.

j. A diagram of metering, relaying, and control circuits. This diagram should show the main power circuits, the number and location of instruments and control transformers, the instruments, relays, and other equipment connected to each transformer, and the location of the instruments in relation to the various switchboards.

Custodian:
Navy – SH

Review activity:
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