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DETAIL SPECIFICATION

CIRCUIT BREAKERS, VACUUM TYPE (VCB), ELECTRIC POWER, MEDIUM VOLTAGE, ALTERNATING CURRENT, DRAW-OUT REMOVABLE CONSTRUCTION, WITHOUT INTERNAL OVERCURRENT PROTECTION

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 all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers medium voltage, alternating current, electric power vacuum type circuit breakers (VCB) without internal overcurrent protection, with attachments and draw-out removable construction for shipboard use.

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.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-S-901	-	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-DTL-915	-	Cable, Electrical, for Shipboard Use, General Specification for
MIL-E-917	-	Electric Power Equipment Basic Requirements
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-P-15024/5	-	Plates, Identification
MIL-DTL-16036	-	Switchgear, Power, Low Voltage, Naval Shipboard
MIL-PRF-24712	-	Coatings, Powder (Metric)
MIL-DTL-32483	-	Switchgear, Power, Hard-Mounted, Medium Voltage, Naval Shipboard

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	-	Identification Marking of U.S. Military Property
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-1285	-	Marking of Electrical and Electronic Parts
MIL-STD-1399-300	-	Electric Power, Alternating Current
MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-454	-	General Guidelines for Electronic Equipment

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

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/NEMA C37.54	-	Indoor AC High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear - Conformance Test Procedures
ANSI C37.85	-	AC High-Voltage Power Vacuum Interrupters - Safety Requirements for X-Radiation Limits

(Copies of these documents are available from the American National Standards Institute, 25 W. 43rd St, 4th Floor, New York, NY 10036 or online at http://webstore.ansi.org/.)

ASTM INTERNATIONAL

ASTM B700	-	Standard Specification for Electrodeposited Coatings of Silver for Engineering Use

(Copies of this document 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 C37.04	-	IEEE Standard for Rating Structure for AC High-Voltage Circuit Breakers Corrigendum 1
IEEE C37.06	-	IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V
IEEE C37.09	-	IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

(Copies of these documents 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.)

IPC

IPC-CC-830	-	Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies
IPC-2222	-	Sectional Design Standard for Rigid Organic Printed Boards

(Copies of these documents are available from IPC, 3000 Lakeside Drive, 309 S, Bannockburn, IL 60015 or online at www.ipc.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 Qualification. Circuit breakers furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.3).

3.2 Safety. Unless otherwise specified herein, the safety requirements of MIL-E-917 shall be adhered to during design and manufacture of circuit breakers and attachments to ensure maximum personnel safety and to minimize equipment casualties.

3.3 Construction and performance requirements.

3.3.1 Materials and coatings. Materials and coatings contained in or on the circuit breaker shall meet the requirements of MIL-E-917 except as modified or added to by the requirements of this specification.

3.3.1.1 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.

3.3.1.2 Prohibited materials. Unless otherwise specified herein, the prohibited material requirements of MIL-E-917 shall be adhered to during design and manufacture of circuit breakers and attachments.

3.3.1.2.1 Polyvinyl chloride (PVC). PVC material shall not be used unless it is a part of or integral to the leads of a component or as a constituent or integrated element of a component.

3.3.1.3 Non-preferred materials. The following materials are non-preferred and shall be identified to the Naval Sea Systems Command (NAVSEA) materials Technical Warrant Holder (TWH) or TWH representative prior to the start of qualification or comparison testing (see 6.2):

a. Insulating materials which contain halogens, e.g., chlorine, fluorine, and bromine, which evolve gases during combustion including estimated maximum weight.

b. Organic materials not inherently fungus resistant or validated to be fungus resistant. Refer to MIL-HDBK-454, Guideline 4.

c. Corrosion-susceptible materials not in accordance with MIL-E-917 requirements.

d. Lead free solder used for printed circuit boards.

3.3.1.4 Painting. Circuit breaker metal parts not having a corrosion-resistant treatment, or not fabricated of corrosion resisting material of the types specified in MIL-E-917, shall be prepared and painted in accordance with MIL-E-917, with the exception that only one coat of gray enamel shall be applied. Touching up is permitted for marks or scratches due to assembly, testing, or other factory handling.

3.3.1.4.1 Restrictions on painting corrosion-resistant material. Corrosion-resistant material shall not be painted.

3.3.1.4.2 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.

3.3.2 Drawout-mounted construction. Circuit breakers shall be of drawout-mounted construction.

3.3.3 Mounting and dimensions. Maximum outline and mounting dimensions for the circuit breaker types shall be as specified by the original equipment manufacturer (OEM).

3.3.4 Creepage and clearance distances.

3.3.4.1 Creepage and clearance distances for non-primary conductors. Unless otherwise specified (see 6.2), creepage and clearance distances for non-primary conductors shall be in accordance with MIL-E-917, Set C spacing, except wiring boards which shall conform to IPC-2222.

3.3.4.2 Creepage and clearance distances for primary conductors. Acceptable performance of lightning impulse withstand voltage (BIL) testing shall validate the adequacy of spacings for primary conductors.

3.3.5 Insulation. Electrical insulation shall be a minimum of Class B in accordance with MIL-E-917 and shall meet the material, lightning impulse withstand voltage (BIL), power frequency withstand voltage, and insulation resistance specified herein.

3.3.6 Current-carrying connections.

3.3.6.1 Silver plating. Current-carrying connections external to the vacuum interrupter shall be silver-plated in areas of current carrying contact with lugs, terminals, bus ties, and screw bolts. Silver plating shall be in accordance with ASTM B700, with the exception that the silver plate shall be not less than 0.0002 inch thick.

3.3.6.2 Conductivity of current path. Tests shall be made to establish the direct current (DC) resistances or millivolt drops of the primary current paths of the circuit breaker. Individual phase resistances or millivolt drops characteristics shall not exceed the maximum values established by the manufacturer. Recommended values shall be established that include both the switchboard interface and the circuit breaker as a standalone unit.

3.3.7 Wiring. Remote control devices mounted on the circuit breaker shall be completely wired and connected to the secondary disconnecting devices. Wires shall be bundled and secured to the maximum extent possible, to prevent damage from vibration. Each wire more than 8 inches long and all wires combined in a bundle shall be marked on each end.

3.3.8 Electronic devices (see 6.4.1).

3.3.8.1 Electrostatic discharge susceptible items. Electrostatic discharge control for the protection of electrical and electronic parts, components, assemblies, and equipment shall be in accordance with MIL-STD-1686. Items which are subject to damage by electrostatic discharge, such as metal oxide semi-conductors (MOS), whether installed in equipment or held as parts for original installation or as spares, shall be protected against such damage. The package shall be provided with a warning label for handling with care on electrostatic discharge.

3.3.8.2 Conformal coating. Conformal coating shall be provided for printed wiring boards in accordance with IPC-CC-830.

3.3.8.3 Aluminum electrolytic capacitors. Aluminum electrolytic capacitors with a value of 100 volts or greater shall not be used.

3.3.9 Environmental performance requirements.

3.3.9.1 Temperature.

3.3.9.1.1 Ambient temperature. Circuit breakers and attachments shall operate in a switchboard enclosure ambient air temperature outside the switchboard of 0 to 50 °C.

3.3.9.1.2 Temperature rise. Circuit breakers and insulation shall meet the temperature rise requirements specified in table I. Attachment temperature rise requirements shall be as specified in 3.3.11.1.

3.3.9.2 Shock. Circuit breakers and attachments shall withstand, electrically and mechanically, the high-impact shock tests of MIL-S-901 for Grade A, Class I, Type C equipment.

3.3.9.3 Vibration. Circuit breakers and attachments shall withstand, electrically and mechanically, the Type I vibration tests specified in MIL-STD-167-1.

3.3.9.4 Electromagnetic interference (EMI). Circuit breakers 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.

3.3.9.4.1 EMI test procedures and results. EMI test procedures and results shall be in accordance with the Electromagnetic Interference Test Procedures (EMITP) and Electromagnetic Interference Test Report (EMITR) requirements of MIL-STD-461. Test procedures shall be approved by the NAVSEA EMI TWH or TWH representative prior to the start of testing. Test results shall be approved by the NAVSEA EMI TWH or TWH representative.

3.3.9.5 X-radiation. Vacuum interrupters shall meet the ANSI C37.85 X-radiation requirements for new interrupters except as modified, added to, or clarified by this specification (see 4.5.7).

TABLE I. Temperature rises.

Temperature rise test	Parts	Maximum temperature rise above enclosure external ambient (°C)	Maximum temperature with 50 °C enclosure external ambient (°C)
Pre-interruption at rated current	Insulation Class B or greater	80	130
	Terminals	70	120
	Contact stems	80	130
	Conducting mechanical joints	80	130
Pre-interruption at 150% rated current and 5-minute duration	Terminals	85	135
	Conducting mechanical joints	95	145
Post-interruption at rated current	Insulation Class B or greater	100	150
	Terminals	87.5	137.5
	Contact stems	100	150
	Conducting mechanical joints	100	150

3.3.10 Electrical performance requirements.

3.3.10.1 Bi-directional operation (reversing line and load). Circuit breakers shall be capable of bi-directional operation; they shall operate normally when supplying power from the upper terminals to the lower terminals as well as when supplying power from the lower terminals to the upper terminals. The circuit breaker bi-directional capability shall be verified during electrical endurance testing.

3.3.10.2 Nominal frequency and frequency range. Nominal frequency shall be 60 Hertz and frequency range shall be 57 Hertz to 63 Hertz.

3.3.10.3 Rated maximum voltage. Rated maximum voltage shall be one of the values specified in table II.

3.3.10.4 Nominal operating voltage. Nominal operating voltage shall be the value specified in table II that corresponds to the applicable rated maximum voltage.

3.3.10.5 Power frequency withstand voltage. Power frequency withstand voltage shall be the value specified in table II that corresponds to the applicable rated maximum voltage. As circuit breakers and attachments are cycled and tested for qualification, reduced values of power frequency withstand voltage may be invoked.

3.3.10.5.1 Power frequency withstand voltage application points.

3.3.10.5.1.1 Application points between circuit breaker poles, primary current carrying circuits and ground. Insulation in as-new condition shall be able to withstand, without breakdown, at 60 Hertz at the voltages specified in table II for a period of 1 minute. As circuit breakers are cycled and tested for qualification, power frequency withstand voltage requirements at 65 percent of table II values may apply.

3.3.10.5.1.2 Application points on control wiring (excluding charging motor) and ground. Insulation in as-new condition shall be able to withstand, without breakdown, a 60-Hertz voltage of twice the rated voltage plus 1,000 volts for a period of 1 minute.

3.3.10.5.1.3 Application points on charging motor control wiring, and ground. Insulation in as-new condition shall be able to withstand, without breakdown, a 60-Hertz voltage of 900 volts for a period of 1 minute.

3.3.10.6 Lightning impulse withstand voltage (BIL). Circuit breakers shall withstand a BIL without failure or disruptive discharge. The BIL shall be the value specified in table II that corresponds to the applicable rated maximum voltage.

3.3.10.7 Voltage spike. Circuit breakers 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 the circuit breaker or attachments.

3.3.10.8 Nominal control voltage. Nominal control voltage shall not exceed 120 volts alternating current (AC) or 125 volts DC. DC is preferred.

3.3.10.9 Rated continuous current. Rated continuous current shall be as specified by the OEM.

3.3.10.10 Rated load current switching capability. Load current switching capability shall be greater than or equal to rated continuous current root mean square (rms).

3.3.10.11 Rated maximum short-circuit (interruption) current rating and conditions. Circuit breakers shall be subjected to their rated maximum short circuit interruption current at rated maximum voltage in accordance with IEEE C37.04, IEEE C37.06, IEEE C37.09, and the following conditions:

a. Interruption rating shall be specified by the OEM.

b. At interruption rating, circuit breakers shall be able to interrupt an O-0.3 seconds-CO-3 minutes-CO test sequence at a power factor less than or equal to 5.9 percent lagging and a voltage range factor K equal to 1.

c. Maximum opening time shall be less than or equal to 3.0 cycles.

d. Rated close latch current shall be 2.6 times the rated interruption current in rms.

e. Rated transient recovery voltage shall be as specified in IEEE C37.04, IEEE C37.06, and IEEE C37.09.

3.3.10.12 Short-time current duty cycle (withstand) rating and conditions. Circuit breakers shall be subjected to their rated short-time current in accordance with IEEE C37.04, IEEE C37.09, and the following conditions:

a. Short-time current duty cycle (withstand) rating shall be specified by the OEM.

b. Circuit breakers shall be able to withstand the OEM-specified short-time current duty cycle (withstand) rating for a duration greater than or equal to 2 seconds at a power factor less than or equal to 5.9 percent lagging and voltage range factor K equal to 1.

3.3.10.13 Endurance/manual cycling. Circuit breakers shall have the ability to be cycled continuously for 2,000 electrical endurance operations at a power factor less than or equal to 80 percent lagging and 3,000 mechanical endurance operations without failure, evidence of undue wear, or development of operating irregularities in any part. Attachment endurance requirements shall be as specified in 3.3.11.2. Circuit breakers shall have the ability to be manually cycled at various times during qualification testing as required by this specification (see table VI).

3.3.10.14 Functionality at less than rated values. Unless otherwise specified herein, circuit breakers shall function properly for currents, voltages, and time constants less than or equal to the maximum rated value.

TABLE II. Voltage requirements based on rated maximum voltage.

Rating type	Rating		
Rated maximum voltage (rms)	4.76 kV	8.25 kV	15 kV
Nominal operating voltage (rms)	4.16 kV	7.2 kV	11 / 13.8 kV
Power frequency withstand voltage (minimum for one minute) (rms)	19 kV	36 kV	36 kV
BIL minimum (peak)	60 kV	95 kV	95 kV

3.3.11 Attachments. Attachments shall include the electric closing device, open (trip) device, auxiliary switch, secondary disconnect device, operations counter, and mechanical open/close position indicator.

3.3.11.1 Temperature rise. Temperature rise of electric closing devices, shunt trips, auxiliary switches, and secondary disconnect devices shall not exceed the requirements of molding and insulating materials specified in MIL-E-917 in as-new condition.

3.3.11.2 Endurance. Electric operating mechanisms and trip devices shall have the ability to be cycled continuously for the number of mechanical and electrical endurance operations as specified in 3.3.10.13.

3.3.11.3 Electric closing devices. Electric closing devices shall have the following characteristics:

a. Closing springs (if applicable) shall be recharged immediately after the circuit breaker closes.

b. The nominal control voltage and their ranges, when measured at the terminals of the operating motors or solenoids with full operating current, shall be as specified in table III. The closing springs shall be recharged immediately after the circuit breaker closes.

c. The circuit breaker shall fully close the main contacts, close the slowest auxiliary switch “a” contact, and open the slowest auxiliary switch “b” contact within 0.100 second of the electrical remote CLOSE signal.

d. The device to charge a stored energy system shall be able to sustain an undervoltage condition for 15 seconds without sustaining damage or a need for realignment.

e. All wiring and control devices necessary for electric operation, including rectifiers used to supply closing energy, shall be installed on the circuit breaker.

TABLE III. Voltages for electric closing devices.

Direct current		Alternating current	
Nominal voltage	**Operating voltage range**	**Nominal voltage**	**Operating voltage range**
-	-	120	90-135
125	90-130	-	-

3.3.11.4 Shunt trip device. A trip device shall be provided. When specified (see 6.2), dual trip coils shall be provided. The trip device shall have a remote control and be compatible with an external control relay. The trip device shall have the capability of manual and electrical operation. The nominal voltages and their operating ranges shall be as specified in table IV.

3.3.11.4.1 Opening response time. The circuit breaker shall fully open the main contacts, open the slowest auxiliary switch “a” contact, and close the slowest auxiliary switch “b” contact at less than or equal to 50 milliseconds of the electrical remote OPEN signal.

TABLE IV. Voltages for trip devices.

Direct current		Alternating current	
Nominal voltage	**Operating voltage range**	**Nominal voltage**	**Operating voltage range**
-	-	120	90-130
125	70-140	-	-

3.3.11.5 Auxiliary switches. Auxiliary switches shall have the following characteristics:

a. Unless otherwise specified (see 6.2), circuit breakers shall be provided with an auxiliary switch having a minimum of 10 sets of contacts.

b. When the circuit breaker main contacts are closed, auxiliary switch "a" contacts shall be closed and auxiliary switch "b" contacts shall be open. When the circuit breaker main contacts are open, auxiliary switch "a" contacts shall be open and auxiliary switch "b" contacts shall be closed.

c. A means shall be provided that an "a" contact shall be changeable to a "b" contact, and a "b" contact shall be changeable to an "a" contact.

d. Auxiliary switches shall have a minimum continuous current rating of 15 amps at a rated voltage of 120 volts AC and 10 amps at a rated voltage of 125 volts DC.

3.3.11.6 Secondary disconnecting devices. Unless otherwise specified (see 6.2), each circuit breaker shall be furnished with a secondary disconnecting device consisting of a minimum of 24 sets of contacts. Each contact shall consist of a stationary and movable component, and each component shall be provided with a terminal for fastening of the control wiring. All parts of the circuit breaker which require connection to external wiring shall be connected to the secondary disconnecting devices of the circuit breaker. The voltage and current rating of each secondary disconnect contact and its associated wiring for those applications internal to the circuit breaker shall be adequate to their intended use. Secondary disconnect contacts that access the circuit breaker auxiliary switches shall have a continuous current rating equal to the auxiliary switch.

3.3.11.7 Operations counter. Circuit breakers shall be equipped with a non-resettable device which indicates the number of close – open operations. The device may be operated on either the close or open portion of the cycle. The read-out shall be plainly visible from the front of the circuit breaker, but is not required to be mounted on the escutcheon plate. Failure of the operations counter shall not affect circuit breaker operation.

3.3.11.8 Mechanical position indicators. Circuit breakers shall be provided with mechanical position indicators that show whether the main contacts of the circuit breaker are opened or closed. The indicators shall be plainly visible at a minimum angle of 45 degrees from either side of the indicator when the circuit breaker is installed in its specified enclosure. The word "open" in contrasting letters shall be displayed on a green background and the word "closed," in contrasting letters, shall be displayed on a red background.

3.3.12 Operating mechanisms.

3.3.12.1 Simultaneous operation. All poles of the circuit breaker shall be operated from a common shaft.

3.3.12.2 Closing.

3.3.12.2.1 Manual closing. Circuit breakers shall be provided with a means for manual operation. The force necessary to manually operate the circuit breaker shall not exceed that which can be quickly and readily exerted by a human operator. When the handle is used to charge a closing spring, the position of the charging spring shall be readily discernible.

3.3.12.2.2 Electric closing. Circuit breakers shall be electrically operated by means of electric closing device. See 3.3.11.3 for requirements.

3.3.12.2.3 Manual operating close control. The manual control shall be easily accessible and located on the front panel, but shall have provisions to prevent unintended operation.

3.3.13 Withdrawal interlock mechanism. Circuit breakers shall be provided with an interlock interface to the cradle or switchboard which prevents the circuit breaker from being withdrawn or inserted in the closed position.

3.3.14 Racking mechanism positions. The circuit breaker shall be provided with an interface to the cradle or switchboard for connect, test, disconnect, and withdrawn positions or any combination thereof and shall meet the applicable requirements specified herein. Racking positions shall be verified during MIL-DTL-32483 switchboard first article testing.

3.3.14.1 Connect position. In the connect position, the circuit breaker shall operate manually and electrically, and the circuit breaker main contacts and control circuitry shall be energized.

3.3.14.2 Test position. In the test position, the circuit breaker shall operate manually and electrically without energizing the circuit breaker main contacts. Control circuitry shall remain energized.

3.3.14.3 Disconnect position. In the disconnect position, the circuit breaker main contacts and control circuitry shall not be energized. The circuit breaker shall be capable of manual operation.

3.3.14.4 Withdrawn position. In the withdrawn position, the circuit breaker shall be fully extended on the rails/tray. The circuit breaker main contacts and control circuitry shall not be energized. The circuit breaker shall be free to move in the withdrawn position to permit removal of the circuit breaker from the switchboard.

3.3.15 Trip-free. Circuit breakers shall be mechanically and electrically trip-free in any position and under all conditions of operation as described in IEEE C37.04.

3.3.16 Anti-pump. In any position and under all conditions of operation, a repeated manual or electrical closing (pumping action) of the circuit breaker during a short-circuit, overload condition, or other trip signal shall not be permitted.

3.3.17 Contact integrity. The circuit breaker shall be designed such that contact force, stroke, and wear can be verified as acceptable for continued use. The circuit breaker shall be equipped with a visible contact erosion indicator for the movable contact of the vacuum interrupter.

3.3.18 Grounding contact. The circuit breaker shall be grounded to the stationary component by a dedicated ground contact. The contact shall engage before primary or secondary power can be present in the circuit breaker. The grounding contact shall electrically connect the circuit breaker to the switchboard when the circuit breaker is in the test and connect positions and all points between. The circuit breaker grounding contact shall connect to the switchboard prior to the switchboard secondary disconnects making contact with the circuit breaker when racking the circuit breaker from the disconnect position to the test position.

3.3.19 Designation and marking. Identification plates and other designating marking for circuit breakers shall be in accordance with MIL-STD-130 and Type A, B, or C of MIL-DTL-15024 and MIL-P-15024/5. Plates shall be installed on and furnished as part of the circuit breaker. Plates shall be attached to the part of the circuit breaker which will not ordinarily be renewed during normal service life, and be located in a readily accessible position where they can be read at all times without danger to personnel.

3.3.19.1 Markings for attachments and small components. Markings for attachments and small components shall be in accordance with MIL-STD-1285.

3.3.19.2 Identification plates. Identification plates shall be marked as shown in table V.

3.3.19.2.1 Additional attachment identification plate. To readily access attachment information, an additional attachment identification plate shall be installed on the front of the circuit breaker and marked as follows:

a. Rated nominal voltage
b. Rated current
c. Frequency rating
d. Auxiliary switch configuration

TABLE V. Identification plates.

Information required	On vacuum circuit breaker	On components [1/]
Nomenclature of the item	X	
Manufacturer's name and catalog number	X	X
Manufacturer's type	X	X
Date of manufacture	X	X
Manufacturer's serial number	X	X
Rated voltage and frequency	X	
Current rating(s)	X	
National stock number (NSN)	X	
Standard identifier (SI)	X	
Blank space for Government inspector's stamp	X	
Technical manual number	X	
Certification data (CD) sheet number (if applicable)	X	

NOTE:
[1/] Components include attachments and other VCB parts such as, but not limited to, charging device, opening device, closing device.

3.3.19.3 Warning plate.

a. Circuit breakers shall be provided with a plate to warn that if the power source is connected to the circuit breaker bottom studs, most of the current-carrying parts are alive, even though the circuit breaker is in the open position.

b. The circuit breaker shall be provided with a warning plate to identify that voltage may be present in internal components when the circuit breaker is in the connect (closed) or test positions. The warning plate shall also identify that the voltage may exist on the secondary contacts even though the circuit breaker is open.

c. A warning plate shall be provided that warns the operator that the opening and closing springs must be discharged prior to performing circuit breaker maintenance.

d. The word "WARNING" shall be in prominent red letters and shall be located where it can be easily read by an operator.

3.3.20 Lifting. Circuit breakers shall be provided with construction suitable for overhead lifting using lifting yokes or other means.

4. VERIFICATION

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

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

c. Comparison inspection (see 4.4).

4.2 Qualification inspection. The following criteria shall be met for qualification inspection:

a. One circuit breaker sample shall be subjected to the examination and tests in the order specified in table VI. Explanation of any exceptions or changes to the test order shall be provided as specified (see 6.2).

b. Test sample shall include one attachment of each type and rating.

c. Unless otherwise specified herein, no adjustments shall be made to circuit breakers and attachments during or between qualification tests. One or more failures shall be cause for refusal to grant qualification approval.

4.2.1 Test enclosures. Test enclosures shall be in accordance with ANSI C37.54.

4.2.2 Periodic retention of qualification. At a maximum of five-year intervals after qualification, the manufacturer shall provide sample production circuit breakers with all attachments and conduct a comparison inspection (see 4.4).

TABLE VI. Qualification sequence.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Creepage and clearance distances	3.3.4	4.5.2
3	Attachment operating characteristics and control power removal (circuit breaker in connect position and in normal vertical/horizontal orientation)	3.3.11	4.5.3
3A	Electric closing device operation	3.3.11.3	4.5.3.1
3A(1)	Operation voltage range/closing time	3.3.11.3.b 3.3.11.3.c	4.5.3.1.1
3A(2)	Charging mechanism stall test	3.3.11.3.d	4.5.3.1.2
3B	Shunt trip device operating voltage range/opening time	3.3.11.4	4.5.3.2
3C	Operation of operations counter, mechanical position indicator operation, and auxiliary switch	3.3.11	4.5.3.3
3C(1)	Operations counter	3.3.11.7	4.5.3.3.a
3C(2)	Mechanical position indicator	3.3.11.8	4.5.3.3.b
3C(3)	Auxiliary switch	3.3.11.5	4.5.3.3.c
4	Trip-free operation and anti-pump operation	3.3.15 3.3.16	4.5.4
4A	Mechanical	3.3.15 3.3.16	4.5.4.1
4B	Electrical	3.3.15 3.3.16	4.5.4.2
5	Lightning impulse withstand voltage (BIL)	3.3.10.6	4.5.5
6	Power frequency withstand voltage (full voltage)	3.3.10.5	4.5.6
7	X-radiation	3.3.9.5	4.5.7

TABLE VI. Qualification sequence - Continued.

Test number	Inspection	Requirement	Verification
8	Endurance	3.3.10.13	4.5.8
	Tests performed during circuit breaker electrical endurance:		
8A	Electric closing device and trip device endurance	3.3.10.13 3.3.11.2	4.5.8.2
8B	Electric closing device and trip device temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.1
8C	Auxiliary switch temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.2
8D	Operations counter check	3.3.11.7	4.5.8.2
9	Power frequency withstand voltage (full voltage)	3.3.10.5	4.5.6
10	Contact integrity	3.3.17	4.5.9
11	Conductivity of current path	3.3.6.2	4.5.10
12	Circuit breaker temperature rise (pre-interruption at rated current)	3.3.9.1.2	4.5.11.1
	Tests performed during circuit breaker temperature rise:		
12A	Auxiliary switch rating	3.3.11.5.d	4.5.3.4
12B	Auxiliary switch temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.2
12C	Secondary disconnecting device rating	3.3.11.6	4.5.3.4
12D	Secondary disconnecting device temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.2
12E	Operation at stabilized temperature	3.3.9.1.1	4.5.11.2
13	Circuit breaker temperature rise (pre-interruption at 150% rated current)	3.3.9.1.2	4.5.11.3
14	Short-time current duty cycle performance (withstand rating)	3.3.10.12	4.5.12
15	Manual cycling	3.3.10.13	4.5.12.1
16	Conductivity of current path	3.3.6.2	4.5.12.1
17	Interrupting current duty cycle performance	3.3.10.11	4.5.13
18	Power frequency withstand voltage (reduced voltage)	3.3.10.5	4.5.6
19	Circuit breaker temperature rise (post-interruption at rated current)	3.3.9.1.2	4.5.11.1
	Tests performed during circuit breaker temperature rise:		
19A	Auxiliary switch rating	3.3.11.5.d	4.5.3.4
19B	Auxiliary switch temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.2
19C	Secondary disconnecting device rating	3.3.11.6	4.5.3.4
19D	Secondary disconnecting device temperature rise	3.3.9.1.2 3.3.11.1	4.5.11.4.2
20	Shock	3.3.9.2	4.5.14

TABLE VI. Qualification sequence - Continued.

Test number	Inspection	Requirement	Verification
21	Attachment operation checks [same as test numbers 3A through 3C(3)].	See tests above as noted	4.5.14.3
22	Power frequency withstand voltage (reduced voltage)	3.3.10.5	4.5.14.3 4.5.6
23	Contact integrity	3.3.17	4.5.14.3 4.5.9
24	Vibration	3.3.9.3	4.5.15
25	Attachment operation checks [same as test numbers 3A through 3C(3)].	See tests above as noted	4.5.15.3
26	Power frequency withstand voltage (reduced voltage)	3.3.10.5	4.5.15.3 4.5.6
27	Contact integrity	3.3.17	4.5.14.3 4.5.9
28	EMI (circuit breakers with electronic devices only)	3.3.9.4	4.5.16
29	Voltage spike (circuit breakers with electronic devices only)	3.3.10.7	4.5.17

4.3 Conformance inspection. Unless inspection sampling is otherwise specified (see 6.2), each manufactured unit shall be subjected to the inspection specified in table VII.

TABLE VII. Conformance inspection.

Inspection	Requirement	Verification
General examination	-	4.5.1
Power frequency withstand voltage (full voltage)	3.3.10.5	4.5.6
Conductivity of current path	3.3.6.2	4.5.10
Attachment operating characteristics (Same as test numbers 3A through 3C(3) in table VI)	Same as test numbers 3A through 3C(3) in table VI	Same as test numbers 3A through 3C(3) in table VI

4.4 Comparison inspection.

4.4.1 Comparison test sequences. At intervals of not more than 5 years, the manufacturer shall provide sample production circuit breakers with all attachments and conduct comparison test sequences as described in 4.4.1.1, 4.4.1.2, and 4.4.1.3. At an interval of 5 years after comparison test sequence 3 has been completed, the test cycle shall start over with comparison test sequence 1. Any exceptions or changes to the test order shall be addressed in the qualification package. Circuit breakers of a type which have not been supplied within the 5-year period shall be tested as a part of the subsequent order for production line units. Failure of a sample to meet the requirements of this specification shall be cause for removal from the Qualified Products List (QPL). NAVSEA reserves the right to invoke test sequences at intervals less than those specified below in the event of design changes, parts changes, or problems noted in the field.

4.4.1.1 Comparison test sequence 1. Tests shall be conducted in the order shown in table VIII at an interval of 5 years after the initial qualification.

4.4.1.2 Comparison test sequence 2. Tests shall be conducted in the order shown in table IX at an interval of 5 years after circuit breaker has been subjected to comparison test sequence 1.

4.4.1.3 Comparison test sequence 3. Tests shall be conducted in the order shown in table X at an interval of 5 years after circuit breaker has been subjected to comparison test sequence 2.

4.4.2 Rotation of attachments. The manufacturer shall rotate accessories of different available operating voltages over periodic comparison testing test efforts. As an example, consider that a manufacturer offers trip devices in ratings of 120 VAC and 125 VDC for a particular circuit breaker design. The 120 VAC trip device would be included for comparison test sequence 1 and the 125 VDC shunt trip device would be included for comparison test sequence 2 and so on.

TABLE VIII. Comparison test sequence 1.

Inspection	**Test number (see table VI)**
General examination	1
Creepage and clearance	2
Attachment operating characteristics	3 through 3C
Lightning impulse withstand voltage (BIL)	5
Power frequency withstand voltage (full voltage)	6
Endurance – circuit breaker (mechanical and electrical)	7 through 7D
Vacuum interrupters integrity	9
Conductivity of current path	10
Circuit breaker temperature rise (pre-interruption at rated current)	11 through 11D
Circuit breaker temperature rise (pre-interruption at 150% rated current)	12
Shock	19
Attachment operation checks	20
Power frequency withstand voltage (reduced voltage)	17
Vacuum interrupters integrity	9

TABLE IX. Comparison test sequence 2.

Inspection	Test number (see table VI)
General examination	1
Creepage and clearance	2
Attachment operating characteristics	3 through 3C
Power frequency withstand voltage (full voltage)	6
Short-time duty cycle performance (withstand)	13
Conductivity of current path	10
Interrupting current duty cycle	16
Power frequency withstand voltage (reduced voltage)	17
Vacuum interrupters integrity	9
Temperature rise (post interruption at rated current)	18 through 18D
Attachment operational checks	20
Voltage spike (circuit breaker with electronic devices only)	28

TABLE X. Comparison test sequence 3.

Inspection	Test number (see table VI)
General examination	1
Creepage and clearance	2
Attachment operating characteristics	3 through 3C
Conductivity of current path	10
Power frequency withstand voltage (full voltage)	6
Shock	19
Vibration	23
Attachment operation checks	24
Power frequency withstand voltage (reduced voltage)	25
Vacuum interrupters integrity	9
EMI (circuit breaker with electronic devices only)	27

4.5 Tests. All tests shall be conducted with the circuit breaker and all applicable attachments installed in the circuit breaker. In areas where this specification remains silent, the requirements of IEEE C37.09 shall apply.

4.5.1 General examination. Circuit breakers and attachments shall be subjected to a thorough examination to determine that the material, workmanship, safety to operating personnel, design, and construction are in conformance with this specification and applicable drawings. Examination shall include, but need not be limited to, the following:

a. Electrical connections and wiring in conformance with applicable drawings. An operational check of all circuit breaker and all attachment operation with a ring out of auxiliary switch settings.

b. Painting and insulation is as specified.

c. Circuit breaker frame is as specified.

d. All electric closing devices are mounted on the removable element of the circuit breaker.

e. Control transformer (if applicable) is located as specified.

f. All attachments are provided as specified.

g. Manual operating handle (if applicable) is provided.

h. Mechanical position indicator is provided.

i. Secondary disconnects are provided as specified.

j. Outline and mounting dimensions are in conformance with applicable drawings.

k. Designation and marking including safety warnings are as specified.

l. Weights and centers of gravity are in conformance with applicable drawings.

m. Contact erosion indicator is provided.

4.5.2 Creepage and clearance distances.

4.5.2.1 Creepage and clearance distances for non-primary conductors. Creepage and clearance distances for non-primary conductors shall be demonstrated by actual measurement in accordance with MIL-E-917.

4.5.2.2 Creepage and clearance distances for primary conductors. Creepage and clearance distances for primary conductors shall be demonstrated by actual measurement. Recommended minimum creepage and clearance distances shall be provided for primary conductors after successful completion of the BIL test.

4.5.3 Attachment operating characteristics. Electric closing devices, trip devices, auxiliary switches, secondary disconnecting devices, operations counters, and mechanical position indicators shall be tested to verify they operate in accordance with requirements specified herein. See table VI for details on when to test attachments.

4.5.3.1 Electric closing device operation.

4.5.3.1.1 Voltage range/closing time. With the circuit breaker initially in the open position, the rated minimum, nominal, and maximum operating voltages in the specified range shall be applied to the electric closing device during three separate checks. The electric closing device shall close the circuit breaker during each check. Closing time shall not exceed 0.100 second during any check. Closing time shall be measured from the initial rise in the close signal voltage to the first indication of continuity across the circuit breaker poles and auxiliary switches.

4.5.3.1.2 Charging motor stall test. The circuit breaker shall be electrically operated by reducing the charging mechanism operating voltage below the rated minimum voltage in increments of 2 volts until the charging mechanism fails to operate. This voltage shall be held for 15 seconds, and it shall be verified that the circuit breaker is not damaged and does not become misaligned in any of its parts.

4.5.3.2 Shunt trip device voltage range/tripping current. With the circuit breaker in the closed position, the rated minimum, nominal, and maximum rated operating voltage in the specified range shall be applied to the shunt trip device during three separate checks. The circuit breaker shall trip during each check and the opening time shall not exceed 0.050 second during any check.

4.5.3.3 Operations counter, mechanical position indicator, and auxiliary switch operation. The circuit breaker shall be cycled electrically and the following criteria met:

a. The operations counter shall be visually verified to have advanced as the circuit breaker is cycled.

b. The mechanical position indicator shall be visually verified to have shown the proper position of the main contacts (open/closed) as the circuit breaker is cycled.

c. One “a” and one “b” auxiliary switch shall be verified by measurement to have changed state with the circuit breaker main contacts when the circuit breaker is cycled.

4.5.3.4 Auxiliary switch and associated secondary disconnecting device rating verification. One “a” (normally closed) auxiliary switch and its associated secondary disconnecting device contact shall have rated voltage and current applied. The current and voltage shall be applied for the duration of the circuit breaker pre-interruption temperature rise test at rated current and the post-interruption temperature rise test at rated current. There shall be no pitting or burning noted on the auxiliary switch at the end of the test.

4.5.4 Trip-free operation and anti-pump operation.

4.5.4.1 Mechanical. The following tests shall be performed:

a. With the circuit breaker closed, press and hold the manual open (trip) button; the circuit breaker shall open. Then press and hold the close button; the circuit breaker contacts shall not close, even momentarily. The lack of a contact closure shall be verified with an appropriate detection circuit and oscilloscope connected across the main contacts.

b. With the circuit breaker open and the open (trip) button held, apply and remove the electrical close signal; the circuit breaker contacts shall not close, even momentarily. The lack of a contact closure shall be verified with an appropriate detection circuit and oscilloscope connected across the main contacts.

c. With the circuit breaker open, press and hold the close button; the circuit breaker shall close. While holding the close button, press and release the open (trip) button; the circuit breaker shall open and remain open.

d. Release the close button and then press it again; the circuit breaker shall close and remain closed.

4.5.4.2 Electrical. The following tests shall be performed:

a. Apply control power to the circuit breaker. With the circuit breaker closed, apply and maintain an open (trip) signal to the breaker; the circuit breaker shall open.

b. With the open signal still applied, apply a close signal to the circuit breaker; the circuit breaker shall not close. During this test it is acceptable if the circuit breaker main contacts and auxiliary contacts make contact momentarily.

c. With the circuit breaker open, apply and maintain a close signal to the circuit breaker; the circuit breaker shall close. While maintaining the close signal, apply and remove an open signal; the circuit breaker shall open and remain open.

d. Remove the close signal and re-apply; the circuit breaker shall close and remain closed.

4.5.5 BIL. BIL testing shall be conducted in accordance with ANSI/NEMA C37.54

4.5.6 Power frequency withstand voltage.

4.5.6.1 Test equipment. Tests for power frequency withstand voltage shall be made with an alternating potential or power source having a sinusoidal wave shape. Semiconductors shall be shunted or disconnected for protection during tests. Circuit breakers shall be installed in a minimum volume test compartment.

4.5.6.2 Voltage magnitude.

4.5.6.2.1 Full voltage. The applicable voltage magnitude specified in table II shall be applied.

4.5.6.2.2 Reduced voltage. Sixty five percent of the applicable voltage magnitude specified in table II shall be applied.

4.5.6.3 Voltage application/duration and pass/fail criteria. The voltage shall be applied for a period of 1 minute without insulation breakdown between the test points and under the conditions specified in 4.5.6.3.1. The applied potential shall be increased gradually until the correct test value is reached.

4.5.6.3.1 Circuit breaker and attachments. The circuit breaker shall have all applicable attachments installed.

4.5.6.3.1.1 Circuit breaker poles and ground used as test points. The voltage shall be applied between the points marked with an “X” in tables XI and XII with the circuit breaker in the state (open, closed) specified in tables XI and XII.

TABLE XI. Power frequency withstand voltage test points (circuit breaker poles and ground) with circuit breaker open.

Circuit breaker open		**Load side terminals on test enclosure**			**Ground**		
Line side terminals on test enclosure		**Left pole**	**Center pole**	**Right pole**			
	Left pole	X			X		
	Center pole		X			X	
	Right pole			X			X
Ground		X					
			X				
				X			

TABLE XII. Power frequency withstand voltage test points (circuit breaker poles and ground) with circuit breaker closed.

Circuit breaker closed		**Circuit breaker load side terminals on test enclosure**		
Circuit breaker line side terminals on test enclosure		**Left pole**	**Center pole**	**Right pole**
	Left pole		X	X
	Center pole			X
	Right pole			
Ground		X		
			X	
				X

4.5.6.3.1.2 Control wiring and ground used as test points.

4.5.6.3.1.2.1 Charging motor. All charging motor leads shall be tied together and voltage shall be applied between lead bundle and charging motor housing.

4.5.6.3.1.2.2 All other secondary disconnect control wiring. With the circuit breaker closed, the voltage shall be applied between secondary disconnect control wiring and ground.

4.5.7 X-radiation. One (1) vacuum interrupter shall be subjected to ANSI C37.85 X-radiation testing for new interrupters with the following modifications, additions, and clarifications:

a. The text fixture shall be the vacuum circuit breaker qualification inspection test sample. The manufacturer may choose on which pole testing will be conducted. X-radiation testing may be performed during test number 6 (power frequency withstand voltage) of table VI with the circuit breaker in the open position.

b. Voltage shall be applied between the line and load terminals of the test enclosure or circuit breaker as applicable with the circuit breaker in the open position.

c. Power-frequency test voltages shall be in accordance with table II.

d. Power-frequency test voltages shall be applied for 1 minute.

e. The distance in air between the radiation instrument and the vacuum interrupter shall not be blocked or impeded by any barriers.

f. Testing at rated maximum voltage is not required.

4.5.8 Endurance.

4.5.8.1 Circuit breakers. Circuit breakers shall be subjected to the endurance tests of 4.5.8.1.1 and 4.5.8.1.2 without failure or operating irregularities. At the completion of each endurance test, the circuit breakers shall be closely examined to identify any evidence of undue wear or development of operating irregularities in any part.

4.5.8.1.1 Mechanical endurance.

4.5.8.1.1.1 Test setup and method of cycling. No power shall be applied to the circuit breaker primary studs. Circuit breakers shall be electrically operated with applicable attachments as discussed in 4.5.8.2.

4.5.8.1.1.2 Number and rate of operations. Circuit breakers shall be operated at any speed of operation for 5,000 close-open cycles. If the circuit breaker has dual trip coils, the first one-third of total cycles shall have both trip coils energized at the same time to trip the circuit breaker. For the second one-third of total cycles, one of the two trip coils shall be energized to trip the circuit breaker. For the last one-third of total cycles the second of the two trip coils shall be energized to trip the circuit breaker.

4.5.8.1.2 Electrical endurance.

4.5.8.1.2.1 Test setup and method of cycling. Rated voltage and rated continuous current shall be applied to the circuit breakers at the power factor specified in 3.3.10.13. Circuit breakers shall be electrically operated with applicable attachments as discussed in 4.5.8.2.

4.5.8.1.2.2 Number and rate of operations. Circuit breakers shall be operated for 2,000 close-open cycles. For the first 10 minutes, the circuit breaker shall be operated three times a minute. The remainder of the test shall be conducted at no less than one close-open operation every 2 minutes. For the last 100 cycles, the source and load connections to the circuit breaker shall be reversed (setup time is not included in the 2 minute cycle rate). The circuit breaker shall operate properly following the source and load connection reversal (i.e., bidirectional operation).

4.5.8.2 Attachments. Electric closing devices and trip devices shall be used to cycle the circuit breaker during electrical and mechanical endurance. An auxiliary switch shall be operated at rated voltage and rated current under resistive load throughout the mechanical and electrical endurance test. The switch shall be validated to be operational at the end of endurance testing. The operations counter shall indicate the correct number of cycling operations at the conclusion of mechanical and electrical endurance testing.

4.5.8.3 Maintenance. Minor maintenance, to include lubrication as necessary, may be performed at approximately every 2,000 cycles mechanical endurance and 1,000 cycles electrical endurance.

4.5.9 Contact integrity. Tests shall demonstrate inspection methods and acceptance criteria for contact force, stroke, and wear. Specifics for inspection methods and acceptance criteria shall be provided.

4.5.10 Conductivity of current path. The circuit breaker contacts shall be in the closed position. The resistance of the current path shall be determined with a direct current of 100 amperes flowing through the current conducting members of one phase. Circuit breakers shall be considered to be in acceptable condition if the test values are within the maximum values established. The test shall be repeated for each phase.

4.5.11 Temperature rise.

4.5.11.1 Circuit breaker temperature rise at rated current (pre-interruption and post-interruption).

4.5.11.1.1 Test circuit. At 50±5 °C ambient, circuit breakers shall be operated in their specified enclosures at any convenient voltage and maximum rated continuous current on all main and auxiliary contacts. Circuit breakers shall be installed in a minimum volume test compartment. Circuit breaker enclosures shall be protected from drafts and from abnormal heat convection by a shield, if necessary. Copper bus bars shall be used for connecting to the top studs, and cable shall be used for connecting to the bottom studs. Size of the bus bar and cable shall be as specified in table XIII. The copper cross-section of leads shall remain constant for at least 3 feet from each stud on the circuit breaker.

4.5.11.1.2 Sensor locations.

4.5.11.1.2.1 Ambient chamber. The ambient temperature of the chamber shall be determined by three temperature sensors (thermometers, thermocouples, or other approved method). The sensors shall be located at the top, middle, and bottom of the chamber. A fan may be used to maintain the chamber ambient that does not direct air directly on the enclosure.

4.5.11.1.2.2 Ambient compartment. The ambient temperature of the compartment shall be determined by a temperature sensor (thermometers, thermocouples, or other approved method). The 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.

4.5.11.1.2.3 Circuit breaker. Temperature rise shall be measured at the hottest point where the following current-carrying parts are in touch with the insulating material:

a. Circuit breaker line and load side terminals on each phase.

b. Circuit breaker main contact stems on each phase.

c. Conducting mechanical joints on each phase.

4.5.11.1.3 Temperature stabilization and temperature rise determination. All temperature readings 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 2 °C per hour. Ambient temperature shall be maintained at room temperature ±5 °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 monitoring points specified in 4.5.11.1.2.2.

4.5.11.1.4 Pass/fail criteria. Temperature rise shall not exceed the limits specified in table I.

4.5.11.2 Operation at stabilized temperature. The circuit breaker shall be electrically cycled to validate proper operation at stabilized temperature.

4.5.11.3 Temperature rise above rated current. Immediately following the pre-interruption temperature rise test at rated continuous current, an additional test of 5 minutes duration shall be conducted with the current increased to 150 percent on all main contacts and spare auxiliary contacts. At the end of this test, the temperature rise of the hottest terminal and mechanical conducting joint shall not exceed the applicable values in table I.

4.5.11.4 Attachment temperature rise.

4.5.11.4.1 Electric closing and trip devices. The temperature rise of electric closing and trip devices shall be measured during electrical endurance testing while the attachments are used to cycle the circuit breaker. Sensors shall be located on the housing of the electric closing and trip devices to determine the temperature rise. The temperature rise shall not exceed the pre-interruption (rated current) limits for insulation as specified in table I.

4.5.11.4.2 Auxiliary contacts, trip device, and secondary disconnecting device contacts. During electrical endurance testing, a sensor shall be located on insulation material nearest to the “a” auxiliary contact used as the trip device cut-off switch. The temperature rise shall not exceed the pre-interruption (rated current) limits for insulation as specified in table I. During pre-interruption and post-interruption temperature rise testing at rated current, sensors shall be located on the insulation material nearest to an “a” auxiliary contact and an associated secondary disconnecting contact. The temperature rise shall not exceed the pre-interruption (rated current) limits for insulation as specified in table I.

TABLE XIII. Temperature rise cable and bus bar requirements.

Continuous current rating	Cable quantity per terminal 1/	Cable size	Bus bar quantity per phase	Bus bar size (inches) 2/
900	3	300 MCM	1	2.5 x 1/4
1,600	4	400 MCM	5	3.0 x 1/4
2,000	5	400 MCM	2	4.0 x 1/4
3,200	8	400 MCM	2	6.0 x 1/4
4,000	10 3/	400 MCM	4	6.0 x 1/4

NOTES:
1/ Information regarding cable is contained in MIL-DTL-915. If three-phase cable is used for this test, the cable jacket shall be stripped for a minimum of 2 feet.
2/ Information regarding bus bars is contained in MIL-DTL-16036.
3/ Connect with bus adapter of minimum length.

4.5.12 Short-time duty cycle performance (withstand rating). Circuit breakers shall be subjected to their rated short-time duty cycle current for the time duration under the conditions specified in 3.3.10.12. The circuit breaker shall not be damaged during the test and shall not require repairs or replacement of parts.

4.5.12.1 Post short-time current duty cycle performance. After the test, the circuit breaker shall be manually cycled and subjected to conductivity of current path testing of 4.5.10.

4.5.13 Interrupting current duty cycle performance. Circuit breakers shall be subjected to their rated short circuit interruption current under the conditions specified in 3.3.10.11. No repairs or replacement of parts shall be required after the test.

4.5.13.1 Interrupting current characteristics. The short-circuit current is expressed in rms symmetrical amperes calculated in accordance with IEEE C37.09. The test circuit shall demonstrate that circuit breakers perform their short-circuit duty cycle with all degrees of current asymmetry produced by three-phase circuits having a short-circuit power factor in accordance with 3.3.10.12.

4.5.13.2 Post-interrupting current duty cycle performance. See table VI for testing required after interrupting current duty cycle. The limits of temperature rise are shown in table I.

4.5.14 Shock. Circuit breakers with attachments shall be installed in the appropriate representative vertical section bottom compartment of switchgear and shall withstand the Grade A, Type I shock requirements of MIL-S-901. Circuit breakers shall be tested in both the closed and open positions in accordance with MIL-S-901. All testing shall be conducted on one sample.

4.5.14.1 Test setup. The following criteria shall be met:

a. All continuous current duty attachments shall be energized to simulate actual operating conditions.

b. Circuit breakers shall be energized at 12 VDC and any convenient current level.

c. A recording oscillograph or other means shall be used to check the status of the contacts under shock.

4.5.14.2 Performance during shock tests. Circuit breakers shall meet the following criteria during shock:

a. Shall not open when closed. Momentary opening of the main and auxiliary contacts of not more than 0.02-second duration shall be acceptable.

b. Shall not close when open.

c. Shall complete a close/open operation after each shock blow.

4.5.14.3 Post-shock performance. See table VI for testing required after shock.

4.5.15 Vibration. Circuit breakers with attachments shall be subjected to Type I vibration tests of MIL-STD-167-1. The switchgear unit shall be supported at each corner near the top of the circuit breaker compartment by a 0.375-inch by 4-inch angle iron brace extending diagonally on a 30-degree angle to the platform of the vibration machine. The tests shall be performed with the circuit breakers in the open position and repeated with the circuit breakers in the closed position. Circuit breakers shall be tested in the closed position while energized at 12 VDC and any convenient current level. Attachments shall be energized during all tests to simulate actual operating performance.

4.5.15.1 Test setup. The following criteria shall be met:

a. All continuous current duty attachments shall be energized to simulate actual operating conditions.

b. Circuit breakers shall be energized at 12 VDC and any convenient current level.

c. A recording oscillograph or other means shall be used to check the status of the contacts under vibration.

4.5.15.2 Performance during vibration tests. The criteria of 4.5.14.2 shall be met with the exception that no contact opening or chatter shall be acceptable during the tests.

4.5.15.3 Post-vibration performance. See table VI for testing required after vibration.

4.5.16 EMI. Circuit breakers with electronic devices shall meet and demonstrate compliance with the requirements of MIL-STD-461 for surface ship, below deck, metallic hull installations.

4.5.17 Voltage spike. Circuit breakers with electronic devices shall be tested in accordance with MIL-STD-1399-300. Voltage spikes shall not cause failure or mal-operation of the circuit breaker or attachments.

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. Circuit breakers and their attachments covered by this specification are intended for use in naval shipboard applications, as a device which:

a. Maintains a closed circuit when closed.

b. Maintains an open circuit when open.

c. Interrupts the circuit under normal operation (current not in excess of the rated continuous current of the circuit breaker) and under abnormal conditions (currents in excess of the rated continuous current of the circuit breaker, such as a short circuit) in accordance with the intended operation of the protective relay.

6.2 Acquisition requirements. Acquisition documents should specify the following:

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

b. Identification of non-preferred materials (see 3.3.1.3).

c. Creepage and clearance set spacing and enclosure type, if other than set C spacing and enclosed type of enclosure (see 3.3.4.1).

d. Dual trip coils required (see 3.3.11.4).

e. Auxiliary switches, quantity required (see 3.3.11.5).

f. Secondary disconnecting devices, quantity required (see 3.3.11.6).

g. Explanation of any exceptions or changes to the test order (see 4.2).

h. Conformance inspection sampling requirements, if required (see 4.3).

i. Packaging requirements (see 5.1).

j. Requirements for Provisioning Technical Documentation (PTD), spare parts, and repair parts (see 6.5).

k. Requirements for rework and suspension of shipment of circuit breakers when circuit breakers do not meet acceptance criteria (see 6.6).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 32485 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.dla.mil.

6.4 Definitions. Unless otherwise noted below, refer to IEEE C37.100 for definitions.

6.4.1 Electronic devices. Involves active electrical components such as transistors, diodes and integrated circuits, and associated passive interconnection technologies as would typically be found on a printed circuit board.

6.5 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified (see 6.2). When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

6.6 Rejected units. If a unit is rejected, the contractor should rework the unit to correct the defects and resubmit the unit for inspection, as specified (see 6.2). Such units should be separate from new units and should be clearly identified as a resubmitted unit for inspection. The contractor should also determine if the identified defect is likely to exist in other in-process and completed units, and inspect and disposition these units if appropriate.

6.7 Subject term (key word) listing.

Interruption rating

Lightning impulse withstand voltage (BIL)

Power frequency withstand voltage

Trip-free

Withstand rating

Custodians:
Army – AV
Navy – SH
Air Force – 85

Review activities:
Army – CR, MI
Navy – AS, CG
Air Force – 03, 19, 99
DLA – CC

Civil agencies:
GSA – FAS
MISC – MDA
NASA – NA

Preparing activity:
Navy – SH
(Project 5925-2012-017)

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