AEROSPACE STANDARD

AS58091™ REV. B

Issued 1999-08
Revised 2023-07

Superseding AS58091A

(R) Circuit Breakers, Trip Free, Aircraft, General Specification for

RATIONALE

This revision includes clarification of how to set up the vibration tests, information on how to test circuit breakers with spade blades and how to test the strength of the blade terminal, and performance output clarifications.

1. SCOPE

1.1 Scope

The primary function of this specification is to cover the general requirements of one-, two-, and three-phase (often referred to as poles) trip-free circuit breakers for use in aircraft electric systems conforming to MIL-STD-704. As a secondary function, this specification may possibly cover the general requirements of one-, two- and three-phase circuit breakers for use in primary vehicles, other than aircraft, when mounted directly to the structure.

1.2 Classification

Circuit breakers shall be classified into types and styles. Variations from the basic style of each circuit breaker shall be indicated by the part number from the appropriate detail specification (see 3.1).

1.2.1 Types

Circuit breakers shall be of the following types as specified (see 6.2).

Type I - Thermal type.
Type II - Magnetic type.

1.2.2 Styles

A style of circuit breakers shall consist of all part numbers covered by one SAE Aerospace Standard (AS) detail specification. For example:

a. All part numbers of AS25244 shall be the same style.

b. All part numbers of AS22073 shall be the same style.

The same style classification applies to all detail specification.

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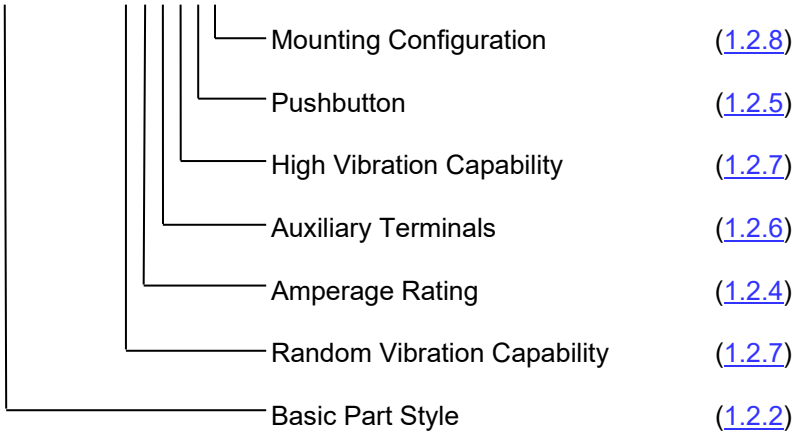
For more information on this standard, visit
https://www.sae.org/standards/content/AS58091B/

1.2.3 Part Numbers

The part numbers for circuit breakers in accordance with this specification shall conform to the example below. Alpha numeric characters shall be used to designate variations from the basic style of each circuit breaker.

MS3320 - D5AVLM



When a designator for a variation is not applicable, it shall be omitted from the part number. Specific part numbering can be found in detail specifications.

1.2.4 Amperage Ratings

The amperage rating designator shall be a number specified in each detail specification to indicate the nominal amperage rating.

1.2.5 Pushbuttons

The circuit breaker pushbutton shall be designated as follows. Standard length pushbutton, as specified in the detail specification, shall have no designator letter.

L - Extra length pushbutton

1.2.6 Auxiliary Terminals

The use of auxiliary terminals when allowed by the detail specification shall be designated as follows. Circuit breakers with standard terminals only, as specified in the detail specification, shall have no designator letter.

A - Auxiliary terminals.

1.2.7 Vibration Level

The vibration level of the circuit breaker shall be specified in the detail specification and shall be indicated in the part number by one or more of the following designators. Standard sine vibration capabilities shall have no designator (see 4.7.11.2).

V - High Level Sine capabilities (see 4.7.11.2).
C through K - Random vibration capabilities (see 4.7.11.1).

1.2.8 Mounting Configurations

Unless otherwise specified, the circuit breakers mounting configurations shall be designated as follows. Standard threaded bushing mounted circuit breakers shall have no designator.

P - Cover-plate mount.
M - Conical bushing mount.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1.1 SAE International

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for
AS14105*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 25 thru 35 Amps, Type I, -55 to 121 °C
AS14153*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 3 Phase, 1 thru 35 Amps, Type I
AS14154*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 3 Phase, 1 thru 20 Amps, Type I
AS21984*	Circuit Breaker-Aircraft, Trip Free, Push-Pull, 3-Phase, 5 thru 60 Amps, Type I
AS22073*	Circuit Breaker, Trip Free, Push-Pull, 1/2 thru 20 Amps, Type I
AS22074*	Circuit Breaker, Recycling, Trip Free, Push-Pull, 1/2 thru 5 Amperes, Type I
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
AS24509*	Circuit Breaker - Aircraft, Trip Free, Toggle, 5 thru 15 Amps, Type I
AS24510*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 5 thru 15 Amps, Type I
AS25036	Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell-Mouthed, Type II, Class 1 (for 105 °C Total Conductor Temperature)
AS25244*	Circuit Breaker, Trip Free, Push-Pull, 5 thru 50 Amps, Type I
AS25337*	Circuit Breaker, Aircraft, Trip Free, Toggle, 5 thru 50 Amps
AS25361*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 50 thru 100 Amps, Type I
AS26574*	Circuit Breaker - Trip Free, Push-Pull, 1/2 thru 20 Amps, Type I
AS33201*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, 1/2 thru 20 Amps, Type I, -55 thru +121 °C
AS33202*	Circuit Breaker - Aircraft, Trip Free, Push-Pull, Blade Terminal, 1 thru 25 Amps, Type I, -55 thru +121 °C

AS14154* Circuit Breaker - Aircraft, Trip Free, Blade Terminal, 3 Phase, 1 thru 25 Amps, Type I

AS50861 Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy

AS58091/1 Circuit Breaker, Aircraft, Trip Free, Push-Pull, Type I, Dual Safety, -55 thru +121 °C

AS81044 Wire, Electrical, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy

*AS58091 detail specification.

2.1.2 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

SD-6 Provisions Governing Qualification

MIL-STD-104 Limit for Electrical Insulation Color

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-HDBK-454 Standard General Requirements for Electronic Equipment

MIL-STD-704 Aircraft Electric Power Characteristics

MIL-STD-889 Dissimilar Metals

MIL-STD-1285 Marking of Electrical and Electronic Parts

MIL-S-7742 Screw Threads, Standard, Optimum Selected Series, General Specification for

MIL-E-17555 Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts); Packaging of

MIL-I-24768 Plastic Sheet, Laminated, Thermosetting, and General Specification for

MIL-I-24768/17 Insulation, Plastic, Laminated, Thermosetting, Glass-Cloth, Silicone-Resin (GSG)

MIL-P-15037 Plastic Sheet, Laminated, Thermosetting, Glass-Cloth Melamine-Resin

2.1.3 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM25027 Nut, Self-Locking, 250 Deg. F, 450 Deg. F, and 800 Deg. F

2.1.4 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME Y14.100 Engineering Drawing Practices

2.1.5 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D635 Plastics, Rate of Burning and/or Extent and Time of Burning of Self Supporting Plastics in a Horizontal Position

2.1.6 ASQ Publications

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada), 001-800-514-1564 (Mexico), or +1-414-272-8575 (all other locations), www.asq.org.

ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

2.1.7 National Conference of Standards Laboratories (NCSL) Publications

Available from NCSL International, 2995 Wilderness Place, Suite 107, Boulder, CO 80301, Tel: 303-440-3339, www.ncsli.org.

NCSL Z540-1 General Requirements for Calibration Laboratories and Measuring and Test Equipment

2.1.8 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC 60934 Circuit-breakers for equipment (CBE)

2.1.9 TE Publications

Copies of these documents are available at https://www.te.com/.

640903-1 TE Connectivity - RECEPT, PIDG FASTON 22-18 250

640905-1 TE Connectivity - RECEPT, PIDG FASTON 16-14 250

640907-1 TE Connectivity - RECEPT, PIDG FASTON 12-10 250

2.2 Definitions

AVAILABLE SHORT CIRCUIT AND CLOSE IN INTERRUPTING CAPACITY TESTS: These tests use a voltage regulated circuit in which the calibrated fault current is obtained after the regulator has provided maximum excitation.

CRITICAL DEFECTS: A critical defect is a defect that judgment and experience indicate would result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product, or a defect that judgment and experience indicate is likely to prevent performance of the actual function of a major end item such as a ship, aircraft, tank, missile, or space vehicle.

DEFECT: A defect is any nonconformance of the unit of product with specified requirements.

EXTRA-LENGTH PUSHBUTTON: Unless otherwise specified, a push-pull actuated circuit breaker with a pushbutton nominally 0.375 inch longer than the standard-length pushbutton is designated as an extra-length pushbutton circuit breaker. The standard and extra length of pushbutton for each style circuit breaker is shown in each individual detail specification.

INTERRUPTING CAPACITY: Former revisions referred to this parameter as “rupture capacity.” Interrupting capacity is the maximum potential short circuit current at rated voltage which a circuit breaker is required to interrupt under the operating duty specified and with a normal frequency recovery voltage not less than rated voltage.

LINE TERMINAL: The terminal attached to the isolated stationary contact, with the circuit breaker in the open or tripped position, is considered as the line terminal. When both contacts of a circuit are isolated, only one terminal shall be designated the line terminal.

MAJOR DEFECT: A major defect is a defect, other than critical, that is likely to result in failure, or to reduce the usability of the unit of product for its intended purpose.

MINOR DEFECT: A minor defect is a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit.

MULTIPHASE CIRCUIT BREAKER: A multiphase circuit breaker has two or more phases controlled by a single actuating member. Separately operable breakers in a common case will not be considered as multiphase breakers, but will be treated throughout as single-phase breakers.

NONRECYCLING TRIP-FREE: A circuit breaker so designed that after tripping with the actuator held in a closed position, the breaker will not automatically reclose.

PUSH-PULL CIRCUIT BREAKER: Push-pull circuit breakers are those which can be manually actuated by an actuator moving in a direction perpendicular to the plane of the mounting plate.

RECYCLING TRIP FREE: A circuit breaker so designed that the circuit will automatically recycle, open, and momentarily close, as long as the actuator is maintained in a closed position.

SEPARABLE LINK: A mechanism designed such that it shall be able to open a circuit under current overload condition if the normal tripping mechanism malfunctions.

TOGGLE CIRCUIT BREAKER: Toggle circuit breakers are those circuit breakers which can be manually actuated by an actuator which pivots about a point on or within the breaker.

TRIP FREE: A circuit breaker so designed that the circuit cannot be maintained closed and cannot be held against a fault when any phase is carrying overload currents that would automatically trip the breaker to the open position.

ULTIMATE TRIP CURRENT: Ultimate trip current is the smallest value of current that will cause tripping of the circuit breaker under a given set of ambient conditions.

ULTIMATE TRIP LIMITS: The specified limits of ultimate trip current are maximum ultimate trip current and minimum ultimate trip current. At the maximum specified ultimate trip current the breaker will open within the specified time, and at the minimum specified ultimate trip current the breaker will not open.

3. REQUIREMENTS

3.1 Detail Specification

The individual item requirements shall be as specified herein and in accordance with the applicable detail specification. In the event of any conflict between the requirements of this specification and the detail specification, the latter shall govern.

3.2 Qualification

The circuit breakers furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) (see 4.5 and 6.3).

3.3 Materials

Materials shall be as specified herein. However, when a definite material is not specified, a suitable material shall be used that will enable the circuit breakers to conform to the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.3.1 Fungus

Materials shall be used which are not nutrients for fungus as specified in MIL-HDBK-454.

3.3.2 Metal

All metals used in the construction of circuit breakers shall be corrosion resistant or shall be suitably protected to resist corrosion. The use of dissimilar metals, especially contacts between brass, copper, or steel and aluminum or magnesium alloys, shall be avoided. Where contact between dissimilar metals is unavoidable, the metals shall be protected against electrolytic corrosion. Dissimilar metals are defined on MIL-STD-889. When thermostatic bimetals and trimetals are used, corrosion resulting from tests specified herein shall not adversely affect the performance of the breaker.

3.3.3 Plastics

Plastic materials used in the housing, insulator base, and any internal parts exposed to arcing or surface creepage shall conform to MIL-I-24768/17 or MIL-P-15037. Other types of plastic materials may be used provided the manufacturer submits satisfactory evidence to the activity responsible for qualification that the materials are suitable for the purpose intended. The plastic materials used shall neither support combustion nor give off noxious gases when subjected to arcs, such as those caused by interrupting heavy short circuit currents, or explosions of gaseous vapors to which the materials may be subjected in service. Plastic materials with cellulose fillers will not be permitted in parts that may be subjected to arcing or surface creepage. Plastic materials used shall be certified to exhibit a minimum ignition time of 90 seconds and a maximum extinguishing time of 90 seconds when tested for flammability in accordance with ASTM D635.

3.3.4 Protective Treatment

The use of any protective coating that will crack, chip, or scale will not be permitted.

3.3.5 Cleaning

Prior to final assembly, the circuit breaker shall be thoroughly cleaned of loose, spattered, or excess solder, metal chips, and other foreign material. Burrs, sharp edges, and resin flash shall be removed.

3.4 Design and Construction

3.4.1 General

Circuit breakers shall conform to the applicable detail specification.

3.4.2 Mounting Means

The circuit breaker shall be provided with a suitable mounting means as shown on the applicable detail specification. If self-locking nuts are used, they shall meet the performance requirements of NASM25027.

3.4.3 Actuator of Push-Pull Circuit Breakers

The portion of the actuator visible when the circuit breaker is in closed position shall be black and shall expose a white band when in the open or tripped position. The exterior portion of the actuator shall be insulated from all current-carrying parts. The actuator shall not work out to an intermediate position, give a false trip indication, or be removable from the breaker.

3.4.3.1 Manual Circuit Opening

Push-pull circuit breakers shall be designed to permit manual opening of the circuit by pulling out the actuator.

3.4.4 Toggle Circuit Breakers with Metal Actuators

The exposed portion of the actuator shall be provided with a non-glaring finish and shall be insulated from all current-carrying parts. There shall be a groove in the ball tip of the toggle breaker actuators to identify trip-free breakers.

3.4.5 Terminals

Terminal construction shall be as specified on the applicable detail specification and shall be designed for use with terminal lugs conforming to AS25036 and AS7928. Blade-style terminals shall comply with IEC 60934.

3.4.5.1 Terminal Hardware

Lock washers captive to the terminal screws shall be supplied only when specified in the detail specification.

3.4.6 Housing

The circuit-breaker mechanism shall be enclosed in a housing securely attached to the insulator base and to the mounting plate when one is used. The housing may be integral with the insulator base.

3.4.7 Ratings

The ratings of push-pull and toggle circuit breakers shall be as specified on the applicable detail specification.

3.4.8 Trip Indication and Reset

The circuit breakers shall be so designed that when the breaker contacts open automatically on overload, the actuator shall indicate the operation by moving to the tripped position, as shown on the applicable MS. The white color specified on the applicable detail specification for the trip indicator on push button circuit breakers shall conform to Class 1 of MIL-STD-104. All phases of a multi-phase breaker shall trip free on a single phase fault or overload.

3.4.8.1 Reset Mechanism

The reset mechanism shall be so designed that retaining the actuator in the closed position after automatic tripping occurs shall not adversely affect subsequent performance of the circuit breaker.

3.4.9 Position

Circuit breakers shall operate satisfactorily when mounted in any orientation.

3.4.10 Mounting Screw Clearance

The mounting screws shall be capable of being screwed into the circuit breaker a minimum depth, as shown on the applicable detail specification. The mounting nuts shall be backed or provided with other means to prevent mounting screws of excess length from interfering with the operation of the breaker. Screws of excess length shall not fracture the housing or the explosion-preventive seal.

3.4.11 Creepage and Clearance Distance

The minimum creepage path and the minimum clearance between current-carrying parts and any part of the circuit breaker other than insulating material, and also between current-carrying parts of opposite polarity, shall be 3/16 inch and 1/8 inch, respectively.

3.4.12 Tamper-Proof Calibration

Breakers shall be so constructed that tampering with the calibration is not possible without dismantling the device or breaking a seal.

3.4.13 Ambient Temperature

Unless otherwise specified (see 3.1), circuit breakers shall perform within one of the following ambient temperature conditions, as specified in the detail specification:

Condition A: -55 to 71 °C
Condition B: -55 to 121 °C

3.5 Interchangeability

All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The drawing number requirements of ASME 100 shall govern changes in the manufacturer's part numbers.

3.6 Screw Threads

Screw threads on removable or replaceable threaded parts shall be as specified in MIL-S-7742. Threading of removable or replaceable nonmetallic parts is not permitted.

3.7 Performance

The circuit breakers shall perform satisfactorily when subjected to tests specified in Section 4, and there shall be no breakage, malfunction, or evidence of any damage which would impair ability of the breakers to meet the requirements of subsequent tests.

Microcracks in the stycast are allowed as long as they do not propagate deep enough in order to jeopardize the electrical performance.

3.7.1 Examination of Product

The circuit breakers shall show no defects when examined in accordance with 4.7.1.

3.7.2 Dielectric Withstanding Voltage

The circuit breakers shall withstand the voltages impressed as called out in 4.7.2 with no evidence of breakdown or subsequent malfunction.

3.7.3 Insulation Resistance

Unless otherwise specified, the insulation resistance of circuit breakers shall not be less than 100 MΩ when tested in accordance with 4.7.3.

3.7.4 Strength of Actuator

Circuit breaker actuator shall not show evidence of breaking, cracking or jamming when tested in accordance with 4.7.4.1 and 4.7.4.2. The circuit breaker shall then meet the performance requirements defined when tested in accordance with 4.7.4.3.

3.7.5 Strength of Threaded Parts

The areas that are to be evaluated for damage are limited to the circuit breaker housing and the threaded components or terminals (the epoxy protective coatin [stycast] can be altered cosmetically).

3.7.5.1 Surface Microcracks

Surface microcracks are acceptable on the casing if they do not propagate through the depth of the plastic case halves when the threaded parts are tested in accordance with 4.7.5.

3.7.5.2 Functional Performance

The functional performance of the product shall not be adversely affected after strength of threaded parts testing.

3.7.6 Operating Force

The minimum force necessary for operation of the circuit breaker, when tested in accordance with 4.7.6, shall not be less than 15% of the specified maximum value unless otherwise specified on the detail specification.

3.7.7 Calibration

The circuit breaker's performance shall be within the limits specified on the applicable detail specification when tested and calibrated in accordance with 4.7.7.

3.7.8 Endurance

The circuit breaker shall make and break the specified current without failure, when tested in accordance with 4.7.8 and the applicable detail specification.

3.7.9 Overload Cycling

The circuit breaker shall make and break the specified overload current without failure when tested in accordance with 4.7.9.

3.7.10 Reclosing

When tested in accordance with 4.7.10, manual reset circuit breakers shall show no electrical continuity.

3.7.11 Vibration

Circuit breakers shall be tested in accordance with 4.7.11 with the vibration levels and test conditions specified in the detail specification. If no vibration level is specified in the detail specification, the sine vibration with test condition A shall be performed (see 4.7.11.2). The circuit breakers shall not trip or show any electrical discontinuity in excess of 10 µs. After completion of vibration test circuit breakers shall show no evidence of physical damage and shall meet the requirements of the 200% overload calibration test performed at 25 °C ± 3 °C and the dielectric withstanding voltage tests in accordance with 4.7.7.3 and 4.7.2.

3.7.12 Mechanical Shock

The circuit breaker contacts shall remain in the proper position when tested in accordance with 4.7.12.

3.7.13 Acceleration

The circuit breaker contacts shall remain in the proper position when tested in accordance with 4.7.13.

3.7.14 Interrupting Capacity (Formerly "Rupture Capacity")

The circuit breaker performance shall be as specified in 4.7.14 when tested in accordance with 4.7.14.

3.7.15 Sand and Dust

The circuit breaker performance shall be as specified in 4.7.15 when tested in accordance with 4.7.15.

3.7.16 Corrosion

The circuit breaker performance shall be as specified in 4.7.16 when tested in accordance with 4.7.16.

3.7.17 Moisture Resistance

The circuit breaker performance shall be as specified in 4.7.17 when tested in accordance with 4.7.17.

3.7.18 Explosion

Ignition of the explosive mixture outside the circuit breaker shall constitute failure when tested in accordance with 4.7.18.

3.7.19 Voltage Drop

Voltage drop across the circuit breaker greater than that specified on the applicable detail specification shall constitute failure when tested in accordance with 4.7.19.

3.8 Markings

All circuit breakers shall be permanently and legibly marked as shown on the applicable detail specification. The markings shall remain legible during and after all the tests specified in this specification.

3.8.1 Push-Pull Actuators

The exposed end of the push-pull actuator shall be marked with a white or silver, raised or depressed, number indicating the applicable current rating (detail specification dash number) of the breaker.

3.8.2 Toggle Actuators

The tip of actuator of toggle breakers shall be marked with a raised or depressed number indicating the applicable current rating (detail specification dash number).

3.8.3 Terminals

The line terminals shall be clearly and permanently marked “LINE” adjacent to the terminals, when shown on the applicable detail specification. Terminals shall be marked as described in Figure 1 when shown on the applicable detail specification.

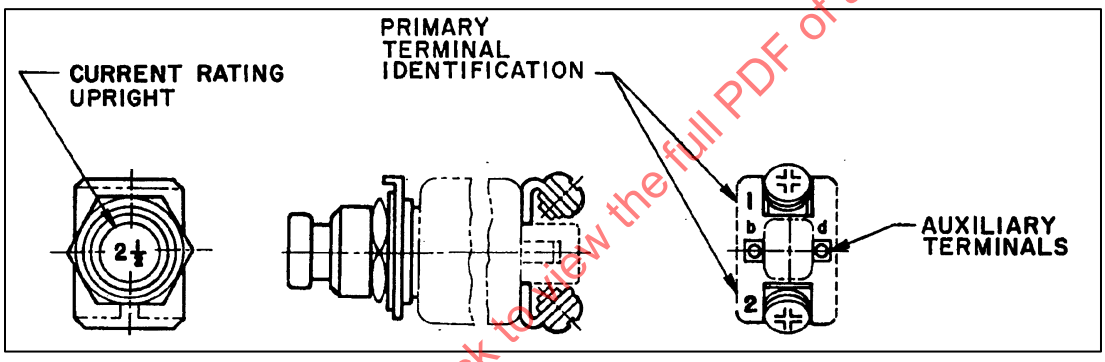


Figure 1A - Terminal identification view

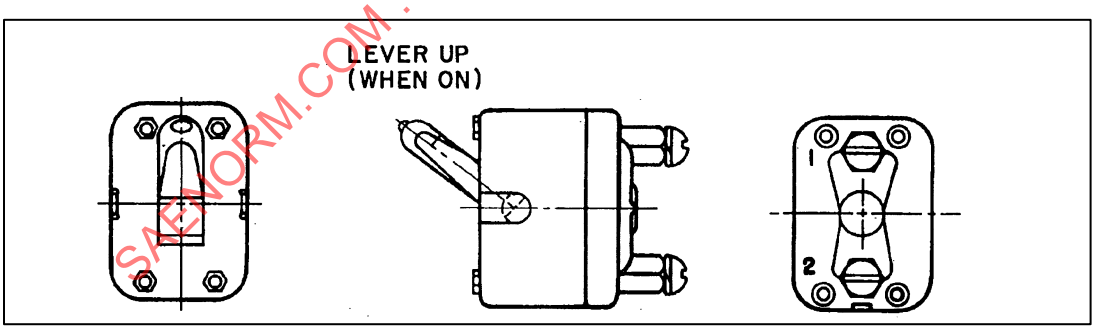


Figure 1B - Terminal identification side view

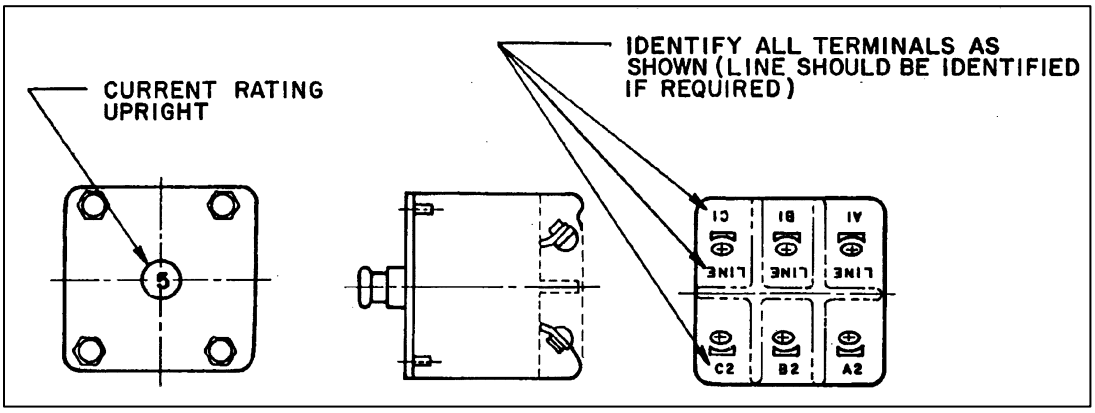


Figure 1C - Terminal identification rear view

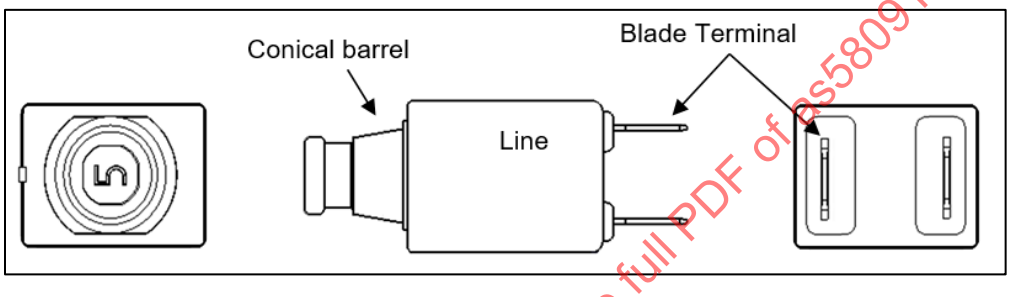


Figure 1D - Blade terminals

Figure 1 - Terminal identification

3.8.4 Multi-Phase Breakers

Primary terminal identification shall be the same as for single phase breakers, as identified above, except that the phase shall be identified by a letter prefix reading consecutively from right to left as viewed from the rear of the breaker (see Figure 1C).

3.9 Identification of Product

Each circuit breaker shall be permanently and legibly marked for identification in accordance with MIL-STD-1285 as follows:

Part No. (see 1.2.3)
Manufacturer's name or trademark and date code

3.10 Workmanship

The circuit breaker, including all parts and accessories, shall be constructed and finished in a careful and workmanlike manner in accordance with good design and sound practice. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies, welding and brazing, painting, riveting, machine screw assemblies, and freedom of parts from burrs and sharp edges (see 4.7.1).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified herein, the contract or purchase order, the manufacturer (supplier) is responsible for the performance of all contract inspection requirements. Except as otherwise specified herein, the contract or purchase order, the supplier may use any facilities suitable for the performance of the inspection requirements. The qualifying activity has the right to perform any of the inspections set forth in the standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance

All items must meet all technical requirements of the product standard. The inspection set forth in this standard shall become a part of the supplier's overall inspection system or quality program. The absence of any inspection requirements in the standard shall not relieve the supplier of the responsibility of assuring that all products comply with all requirements of the contract or purchase order. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the purchaser to acceptance of defective material.

4.1.2 Test Equipment and Inspection Facilities

Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the supplier. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with ANSI/NCSL Z540-1 or equivalent standards.

4.2 Classification of Inspections

The inspections specified herein are classified as follows:

a. Materials inspection (see 4.3).

b. Qualification (see 4.5).

c. Quality conformance inspection (see 4.6).

4.3 Materials Inspection

Material inspection shall consist of certification that the materials are in accordance with the requirements of 3.3.

4.4 Inspection Conditions

Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the general requirements of MIL-STD-202.

4.4.1 Calibration

The supplier shall establish and maintain a calibration system in accordance with ANSI/NCSL Z540-1. Calibration tests of circuit breakers shall be performed at a temperature specified on the applicable detail specification with the current maintained at a constant value. Test sample units with leads and terminals attached in accordance with Figure 2 shall be maintained at the specified ambient temperature for 1 hour prior to application of the specified current during all calibration tests. Test circuit may be in accordance with Figure 2. Calibration tests shall be conducted at all voltages and frequencies shown on the detail specification, where applicable.

4.4.1.1 Production Calibration Tests

For calibration tests performed during production only (not for qualification or quality conformance tests), it will be permissible to use test methods so designed as to expedite calibration testing, provided the supplier can demonstrate that the results are comparable to the calibration tests specified herein.

4.4.2 Thermal Circuit Breakers

Tests of thermal circuit breakers requiring passage of current may be conducted using direct current or alternating current at commercial frequencies.

4.5 Qualification Inspection

4.5.1 Initial Qualification

Initial qualification inspection shall be in accordance with Tables 2A and 2B.

4.5.1.1 Initial Qualification Test Requirements

Initial qualification inspection shall be performed by the qualifying activity test laboratory (see 6.3.1) and the supplier in accordance with Tables 2A (single phase) and 2B (three-phase). Sequential testing is not required, except as specified within the test group. Test sample units shall be produced with equipment and procedures normally used in production. Inspection shall be performed on each circuit breaker type the supplier seeks to qualify, unless qualification by similarity is approved. The extent of qualification by similarity shall be determined by the qualifying activity. The qualifying activity will perform the tests in Group I and Group II of Tables 2A and 2B and the supplier is responsible for performing all other test groups in the applicable test tables. The supplier may do some portion of the Group I testing as required to ensure the basic product functionality prior to completing all the other group testing.

A request for qualification shall be made to the qualifying activity prior to initiating testing. The supplier is recommended to provide the qualifying activity with a test plan based on the applicable detail specification. The qualifying activity has the authority to modify the specification test requirements to resolve test failures/discrepancies and to waive testing to verify specific product manufacturing changes or qualification by similarity. For each device tested, the supplier shall use the same materials, manufacturing procedures and methods of inspection as would be used to provide the component to a purchaser. Any change in the supplier's process control inspections, quality conformance inspections, or manufacturing control drawings (editorials changes are acceptable) without the written express approval of the qualifying activity may result in the loss of qualification for that product.

4.5.1.2 Qualification Inspection by Similarity

The qualifying activity and the supplier may agree on other similarity test samples and sequences not specified herein provided the products and test requirements associated with the agreed upon similarity are specified herein. The qualifying activity may accept data generated under oversight of a user activity, provided the requirements used to generate the data is equal to or greater than the requirements specified herein.

4.5.1.3 Sample Size

The combination of specimen samples to be tested shall be determined by the qualifying activity based upon the supplier's desired listing. For initial planning purposes, 31 single-phase circuit breaker specimens or ten three-phase circuit breaker specimens as defined in any one detail specification shall constitute a sample size. The qualifying activity reserves the right to request additional untested samples to be submitted with the qualification test report.

4.5.1.4 Test Routine

The qualification testing samples for one- and three-phase circuit breakers shall be subjected to the tests specified in Tables 2A and 2B, respectively. At the option of the qualifying activity, the environmental tests consisting of vibration, mechanical, shock, acceleration, sand and dust, corrosion, and moisture resistance (see 4.7.11, 4.7.12, 4.7.13, 4.7.15, 4.7.16, and 4.7.17) may be omitted when qualifying additional ratings under a detail specification, provided that two amperage ratings of the same sample style have previously completed these tests satisfactorily. Qualification of additional circuit breaker styles or amperage ratings by similarity to circuit breakers previously qualified may be determined by the qualifying activity.

4.5.1.5 Initial Qualification Test Report

The qualifying activity laboratory shall submit the required test results in a data package to the supplier. The supplier shall furnish the qualifying activity one certified test report containing the following information:

a. The quantitative results for the tests specified in Tables 2A and 2B and the authorization letter. Upon request from the supplier, the qualifying activity will provide certified Tables 2A and 2B test results for the test report.

b. Material and detail specification certifications.

c. The supplier may combine the supplier laboratory test results with the qualifying activity laboratory results into a final test report with all required certifications and signatures for final submission to the qualifying activity.

The supplier shall maintain both reports for a minimum of 6 years and provide the reports to qualifying activity upon request.

4.5.2 Retention of Qualification

Retention of qualification is required at 36-month intervals.

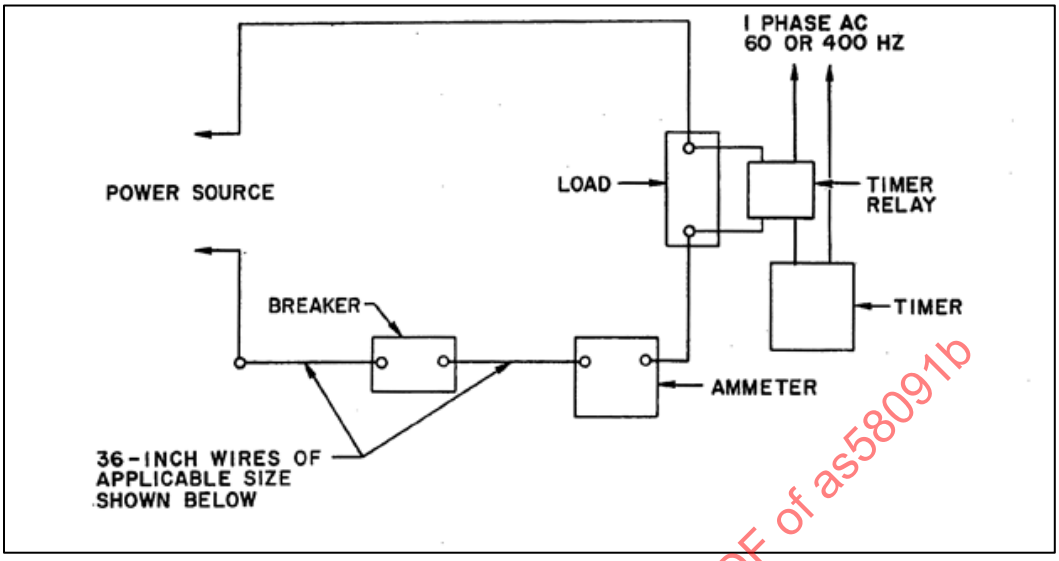


Figure 2 - Calibration test circuit

Table 1 - Calibration test circuit (see Figure 2)

Circuit Breaker Capacity (Amperes)	Wire Size Designation	Insulated Terminal Lug (AS7928 Part No.)	Insulated Blade Receptacle (TE Connectivity Part No. or Equivalent)
1 and below	20	MS25036-103	640903-1
2 to 6, incl	18	MS25036-103	640903-1
7 to 10, incl	16	MS25036-108	640905-1
11 to 15, incl	14	MS25036-108	640905-1
16 to 20, incl	12	MS25036-112	640907-1
21 to 25, incl	10	MS25036-112	640907-1
26 to 40, incl	8	MS25036-115	N/A
41 to 50, incl	6	MS25036-119	N/A
51 to 60, incl	6	MS25036-121	N/A
61 to 90, incl	4	MS25036-124	N/A
91 to 120, incl	2	MS25036-127	N/A
121 to 150, incl	0	MS25036-133	N/A
151 to 200, incl	00	MS25036-136	N/A

Test wires shall conform to AS50861, AS22759, or AS81044. Test terminals shall conform to AS7928 or IEC 60934. Ammeter: Accuracy within 0.5% at full scale.

a. For circuit breakers with nominal amperage rating between steps of Table 1, use the wire of the next larger physical wire size.

b. For Group A or B quality conformance tests, terminal lead lugs may be the spade or electrical spring clamp type provided the electrical resistivity and thermal conductivity are equivalent to AS25036 ring-type terminals.

c. Circuit breakers using blade-style terminals shall be tested on wires as sized above with quick connect terminations sized as specified (blades are not compatible with 8 gage and smaller wires and their associated currents).

Table 2A - Qualification inspection (single phase circuit breakers)

Tests and Sample Units	Requirement Paragraph	Test Paragraph
Test Group I - 19 sample units		
Examination of product	3.7.1	4.7.1
Dielectric withstanding voltage	3.7.2	4.7.2
Insulation resistance	3.7.3	4.7.3
Minimum limit of ultimate trip	3.7.7	4.7.7.1
Maximum limit of ultimate trip	3.7.7	4.7.7.2
Overload calibration	3.7.7	4.7.7.3
Test Group II - 5 sample unit		
Voltage drop	3.7.7, 3.7.19	4.7.7.5, 4.7.19
Temperature/altitude dielectric strength	3.7.2	4.7.2.2
Trip-free calibration	3.7.7	4.7.7.4
Strength of threaded parts	3.7.5	4.7.5
Mechanical cycling (endurance)	3.7.8	4.7.8.3
Operating force	3.7.6	4.7.6
Test Group III - 1 sample unit		
Voltage drop	3.7.19	4.7.19
Reclosing	3.7.10	4.7.10
Overload cycling	3.7.9	4.7.9
Vibration	3.7.11	4.7.11
Corrosion	3.7.16	4.7.16
Test Group IV - 1 sample unit		
Ambient effect on calibration	3.7.7	4.7.7.5
Trip-free calibration	3.7.7	4.7.7.4
Acceleration	3.7.13	4.7.13
Sand and dust	3.7.15	4.7.15
Test Group V - 1 sample unit		
Endurance		
Inductive load (AC)	3.7.8	4.7.8.1.1
Operating force	3.7.6	4.7.6
Test Group VI - 1 sample unit		
Endurance		
Resistive load (AC)	3.7.8	4.7.8.1.2
Operating force	3.7.6	4.7.6
Test Group VII - 1 sample unit		
Mechanical shock	3.7.12	4.7.12
Moisture resistance	3.7.17	4.7.17
Operating force	3.7.6	4.7.6
Impact force on push button	3.2.4	4.7.4.3
Strength of actuator	3.7.4	4.7.4
Test Group VIII - 1 sample unit		
Interrupting capacity (available current short circuit AC)	3.7.14	4.7.14
Dielectric withstanding voltage	3.7.2	4.7.2

Table 2A - Qualification inspection (continued)

Tests and Sample Units	Requirement Paragraph	Test Paragraph
Test Group IX - 1 sample unit		
Interrupting capacity (available current close-in AC)	3.7.14	4.7.14, Table VII-B
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group X - 1 sample unit		
Interrupting capacity (available intermediate current interrupting AC)	3.7.14	4.7.14, Table VII-E
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XI - 1 sample unit		
Interrupting capacity (available intermediate current interrupting DC)	3.7.14	4.7.14, Table VII-F
Dielectric withstanding voltage	3.7.2	4.7.2
Explosion (AC)	3.7.18	4.7.18.1
Test Group XII - 1 sample unit		
Interrupting capacity (available current close-in AC)	3.7.14	4.7.14, Table VII-B
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XIII - 5 sample units		
Strength of actuator	3.7.4	4.7.4
Impact force on push button	3.7.4	4.7.4.3
Test Group XIV - 1 sample unit		
Interrupting capacity (available current short circuit DC)	3.7.14	4.7.14, Table VII-C
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XV - 1 sample unit		
Interrupting capacity (available current close-in DC)	3.7.14	4.7.14, Table VII-D
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XVI - 1 sample unit		
Interrupting capacity (available intermediate current interrupting AC)	3.7.14	4.7.14, Table VII-E
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XVII - 1 sample unit		
Interrupting capacity (available intermediate current interrupting DC)	3.7.14	4.7.14, Table VII-F
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group XVIII - 2 sample units		
Explosion (AC)	3.7.18	4.7.18.1
Test Group XIX - 2 sample units		
Explosion (DC)	3.7.18	4.7.18.2
Test Group XX - extra sample units		
These breakers may be used for repetition of any test considered advisable by the activity responsible for qualification		

Table 2B - Qualification inspection (three-phase circuit breakers)

Tests and Sample Units	Requirement Paragraph	Test Paragraph
Test Group I - 12 sample units		
Examination of product	3.7.1	4.7.1
Dielectric withstanding voltage	3.7.2	4.7.2
Insulation resistance	3.7.3	4.7.3
Minimum limit of ultimate trip	3.7.7	4.7.7.1
Maximum limit of ultimate trip	3.7.7	4.7.7.2
Overload calibration	3.7.7	4.7.7.3
Test Group II - 5 sample units		
Ambient effect on calibration	3.7.7	4.7.7.5
Voltage drop	3.7.19	4.7.19
Temperature/altitude dielectric strength	3.7.2	4.7.2.2
Trip-free calibration	3.7.7	4.7.7.4
Strength of threaded parts	3.7.5	4.7.5
Mechanical cycling (endurance)	3.7.8	4.7.8.3
Operating force	3.7.6	4.7.6
Test Group III - 1 sample unit		
Voltage drop	3.7.19	4.7.19
Reclosing	3.7.10	4.7.10
Overload cycling	3.7.9	4.7.9
Vibration	3.7.11	4.7.11
Corrosion	3.7.16	4.7.16
Test Group IV - 1 sample unit		
Ambient effect on calibration	3.7.7	4.7.7.6
Trip-free calibration	3.7.7	4.7.7.4
Acceleration	3.7.13	4.7.13
Sand and dust	3.7.15	4.7.15
Test Group V - 1 sample unit		
Endurance		
Inductive load (AC)	3.7.8	4.7.8.1.1
Operating force	3.7.6	4.7.6
Test Group VI - 1 sample unit		
Endurance		
Resistive load (AC)	3.7.8	4.7.8.1.2
Operating force	3.7.6	4.7.6
Test Group VII - 1 sample unit		
Mechanical shock	3.7.12	4.7.12
Moisture resistance	3.7.17	4.7.17
Operating force	3.7.6	4.7.6
Strength of actuator	3.7.4	4.7.4
Impact force on push button	3.2.4	4.7.4.3
Test Group VIII - 1 sample unit		
Interrupting capacity (available current short circuit AC)	3.7.14	4.7.14, Table VII-G
Dielectric withstanding voltage	3.7.2	4.7.2
Test Group IX - 1 sample unit		
Interrupting capacity (available current close-in AC)	3.7.14	4.7.14, Table VII-H
Dielectric withstanding voltage	3.7.2	4.7.2

4.5.2.1 Retention of Qualification Test Requirements

Retention of qualification testing consists of Groups I and II of Tables 2A and 2B. Additional tests shall be considered in Table 3, if design or process changes have occurred (see 4.5.2.2). Testing is only performed by the qualifying activity. Testing cannot begin until the supplier receives an authorization letter. The qualifying activity is authorized to establish an alternate due date to accommodate testing schedules. Failure to submit to retention of qualification shall result in a loss of qualification for that product. The supplier shall provide untested specimens to the qualifying activity. The qualifying activity shall perform the tests and provide certified data to the supplier.

4.5.2.2 Retention of Qualification Sample Size

Ten breakers representative of each style (see 1.2.2) shall be selected at random each year. Sample representation may be limited by breakers in production during that year. Sample units shall be subjected to and have passed sampling plans for Group A and B testing (Tables 4 and 5). The breakers shall be submitted to the qualifying activity for retention of qualification testing.

4.5.2.3 Retention of Qualification Test Report

The qualifying activity shall provide the result of the Group I and II results as a certified data package to the supplier. The supplier shall furnish the qualifying activity one certified test report containing the following information:

a. Material and detail specification certifications.

b. A summary of the results of the quality conformance tests in Tables 4 and 5 indicating at a minimum, the number of lots which passed and the number which failed, including the corrective actions performed during retention of qualification interval.

4.5.2.4 Retention of Qualification as a Result of Process or Design Changes

For design or process modifications to products listed on the qualified parts listing the supplier shall recommend and the qualification activity shall consider the tests specified in Table 3 depending on the type of process or design request. The number and combination of samples to be tested shall be determined by the qualifying activity based upon the supplier's desired listing and the proposed test plan. One or more test sample groups shall be performed by the qualifying activity depending on the extent of the changes made by the supplier. The supplier may also be required to perform certain tests. The qualifying activity laboratory shall submit the required test results in a data package to the supplier. The supplier shall furnish the qualifying activity one certified test report containing the following information:

a. The quantitative results for the tests specified. Upon request from the supplier, the qualifying activity will provide certified test results for the test report (see 4.5.2.3.d).

b. Material and detail specification certifications.

c. A summary of the results and quality conformance tests in Table 5 indicating as a minimum, the number of lots that passed and the number of lots that failed.

d. The supplier may combine the supplier laboratory test results with the qualifying activity laboratory results into a final test report with all required certifications and signatures for final submission to the qualifying activity.

Table 3 - Process and design change tests

Sample Group	Sample Size Units		Tests	Requirement Paragraph	Test Paragraph
	Single Phase	Three Phase			
1	3	1	Ambient effect on calibration Mechanical cycling (endurance)	3.7.7 3.7.8	4.7.7.5 4.7.8.3
2 2/	3	1	Voltage drop Endurance	3.7.19 3.7.8	4.7.19 4.7.8.2.1
3	3	3	Vibration Mechanical shock Moisture resistance	3.7.11 3.7.12 3.7.17	4.7.11 4.7.12 4.7.17
4 2/	3	1	Interrupting capacity (formerly rupture capacity) 1/	3.7.14	4.7.14, Table VII-C or G
5 2/	3	1	Interrupting capacity (formerly rupture capacity) 1/	3.7.14	4.7.14, Table VII-D or H
6	5	1	Strength of threaded parts Strength of actuator	3.7.5 3.7.4	4.7.5 4.7.4
7	3	1	Reclosing Overload cycling	3.7.10 3.7.9	4.7.10 4.7.9
8	3	1	Temperature-altitude dielectric withstanding voltage Corrosion	3.7.2 3.7.16	4.7.2.2 4.7.16

1/ This test is to be run at one-half of the maximum current level specified on the applicable detail specification for rupture test designations (A) and (B) or at a level of 500 A, whichever is less.

2/ For sample groups 2, 4 and 5, three three-phase circuit breakers shall be tested using AC current and single phase breakers shall be tested using DC current.

4.5.2.5 Qualification Non-Compliance

If a sample fails to pass qualification requirements, the supplier shall take corrective action and submit a corrective action report to the qualifying activity. The corrective action samples shall be subjected to the Groups A and B (see Tables 4 and 5) requirements, unless otherwise specified by the qualifying activity. The qualifying activity shall determine and perform the test necessary to confirm the corrective action.

4.6 Quality Conformance Inspection

4.6.1 Inspection of Product for Delivery

Inspection of product for delivery shall consist of Group A inspection. Delivery of products which passed Group A inspection shall not be delayed pending the results of Groups B inspection.

4.6.2 Inspection Lot

An inspection lot shall consist of all the circuit breakers covered by a single style (see 1.2.2) offered for inspection at one time.

4.6.3 Group A Inspection

Group A inspection shall consist of the examinations and tests specified in Table 4 and shall be made on the same set of sample units, in the order shown.

Table 4 - Sampling Plan A tests

Test	Inspection Level	Requirement Paragraph	Test Paragraph	AQL Percent Defective		
				Critical	Major	Minor
Examination of product	II	3.7.1	4.7.1	0.25	0.65	4.0
Dielectric with-standing voltage	II	3.7.2	4.7.2	N/A	1.0	N/A
Calibration (overload at minimum and maximum limit of ultimate trip and 200% rated current only at room temperature)	II	3.7.7	4.7.7	N/A	1.0	N/A

4.6.3.1 Sampling Plan

A random sample shall be selected from each inspection lot in accordance with Level II of ANSI/ASQ Z1.4 for general inspection based on the specified AQL in Table 4. The acceptable quality level (AQL) shall be as specified in Table 4. Classification of defects shall be as specified in Table 4 and definitions in herein. A supplier's normal quality control tests and production tests may be used to fulfill Group A inspection provided they at least equal the quality required by Table 4.

4.6.3.2 Rejected Lots

If an inspection lot is rejected, the supplier may rework it to correct the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.6.4 Group B Inspection

Circuit breakers shall be tested as specified in Table 5 in the order shown.

Table 5 - Group B inspection

Test	Requirement Paragraph	Test Paragraph
Insulation resistance	3.7.3	4.7.3
Trip-free calibration	3.7.7	4.7.7.4
Operating force (at room ambient temperature)	3.7.6	4.7.6

4.6.4.1 Sampling Plan

Three sample units shall be selected at random out of every 1000 units or every 3 months, whichever occurs first, from each style (see 1.2.2) manufactured. Group B inspection shall be performed on sample units which have passed Group A inspection.

4.6.4.2 Failures

If one or more sample units fail to pass Group B inspection, the sample shall be considered to have failed.

4.6.4.3 Disposition of Sample Units

Sample units which have passed Group B inspection may be delivered on the contract.

4.6.4.4 Group B Non-Compliance

If a sample fails to pass Group B inspection, the supplier shall take corrective action on the materials or processes, or both, as warranted, and on all units or processes which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the breakers representative of the Group B samples shall be discontinued until corrective action has been taken. After the corrective action has been taken, the Group B inspection test which failed shall be repeated on additional sample units. Group A may be reinstituted; however, final acceptance shall be withheld until the Group B re-inspection has shown that the corrective action was successful. In the event of a Group B failure, information concerning the failure and the corrective action taken shall be provided to the purchaser(s) of the lots represented by Group B inspection.

4.6.5 Preparation for Delivery

Sample packages or packs and the inspection of the preservation, packaging, packing and marking for shipment and storage shall be in accordance with the requirements of Section 5.

4.7 Test Inspection

4.7.1 Examination of Product

Circuit breakers shall be inspected to verify that the materials, design, construction, weight, physical dimensions, marking and workmanship conform to the applicable requirements. Circuit breakers shall be visually inspected with no magnification and lighting no greater than 1000 lx.

4.7.2 Dielectric Withstanding Voltage

The circuit breaker shall withstand 1000 Vrms plus twice maximum rated voltage AC at commercial frequency (1500 V minimum) and shall show no evidence of breakdown, flashover, or current flow in excess of 1.0 mA:

a. Between line and load terminals with the circuit breakers in the OFF or TRIPPED position.

b. Between terminals and parts normally grounded (such as frame, shell, mounting plate, etc.) with the circuit breakers in both CLOSED (or RESET) and OFF (or TRIPPED) positions.

The potential shall be applied at a maximum rate of increase of 250 V/s, until the test potential is reached, and shall be maintained for 1 minute during qualification tests. During quality conformance tests, a potential equal to 120% of the above values may be applied for a duration of 5 seconds.

4.7.2.1 Dielectric Withstanding Voltage Following Another Test

Where the dielectric withstanding voltage is called for following another test, the dielectric test voltage shall be reduced to 75% of the value specified.

4.7.2.2 Temperature-Altitude Dielectric Withstanding Voltage

Qualification test sample units shall be subjected to the dielectric withstanding voltage test in accordance with 4.7.2 at the maximum operating altitude and temperature specified on the applicable detail specification. The potential applied shall be 500 Vrms. The temperature and altitude conditions shall be maintained prior to and during application of the test potential.

4.7.3 Insulation Resistance

Circuit breakers shall be tested in accordance with Method 302 of MIL-STD-202. The following details shall apply:

a. Test condition letter: B.

b. Points of measurement: Between mutually insulated metal parts.

4.7.4 Strength of Actuator

There shall be no malfunction, breakage, or evidence of damage during the following tests.

4.7.4.1 Strength of Actuating Lever Pivot and Lever Stop

The lever pivot and stop shall be subjected to a 25-pound load applied for 1 minute to the tip of the actuating lever, as follows:

a. Perpendicular to the lever axis and parallel to the line of lever travel at each end position of the lever.

b. Same as condition (a), but in both directions perpendicular to the line of travel at each position of the lever.

c. Coaxial with the lever axis toward the lever pivot throughout the entire range of travel of the lever.

d. Coaxial with the lever axis away from the lever pivot throughout the entire range of travel of the lever.

4.7.4.2 Strength of Pushbutton

A 25-pound force shall be applied for 1 minute in both directions, along the line of pushbutton travel. With the pushbutton in the fully extended position, a force of 25 pounds shall be applied at the extremity for 1 minute in two mutually perpendicular directions, each normal to the line of pushbutton travel.

4.7.4.3 Impact Force on Pushbutton

The circuit breaker shall be subjected to an impact force as specified in Table 6.

a. With the pushbutton in the closed or reset position, the circuit breaker shall be mounted by its normal mounting means to a rigid panel with the pushbutton in the upright or longitudinal direction. The impact force shall be applied by dropping a specified weight (see Table 6) from a designated height onto the extremity of the pushbutton. One circuit breaker sample shall be used for each height specified. Each sample shall receive three impacts.

b. When similarity of design actuators and latching systems exist, five sample units shall be tested to the requirements of Table 6. Circuit breakers with the highest and lowest ampere ratings must be two of the five sample units selected to qualify all the other amperage ratings by similarity.

c. During or after the impact tests the circuit breaker shall meet the requirements of the overload calibration of 4.7.7.3 and the requirements of 4.7.6 operating forces or the circuit breaker may fail in a safe manner. A failsafe circuit breaker in this application is defined as a breaker with a broken or jammed pushbutton.in either the open or closed position with the contacts either in the open position unable to carry current, or in the closed position capable of being tripped to the open position by a 200% overload condition within the prescribed time limits shown on the applicable detail specification (a jammed push button is a push button exhibiting high pullout or reset forces in excess of specification limits).

d. When five or more three-phase ratings are being qualified, one unit from each rating is sufficient to satisfy Table 6 requirements, provided all ratings have identical actuator and latch systems.

Table 6 - Impact force

Sample No.	Weight (Pounds)	Height (Inches)
1	3	1.5
2	3	2.5
3	3	3.5
4	3	4.0
5	3	5.0

4.7.5 Strength of Threaded Parts

Unless otherwise specified on the applicable MS, the force levels shown in Table 7 shall be applied to the nuts and screws or bolts for terminals and mounting means. If terminals are tested with lead lugs, the lugs shall conform to the type described in Figure 2.

Table 7 - Strength of threaded parts

Terminals		
Stud or Screw Size	**Tensile Load (Pounds)**	**Torque (in-lb)**
No. 6	25	10
No. 8	25	15
1/4 inch	50	60
5/16 inch	70	80
Mounting Means		
Stud or Nut Size	**Axial Loads (Pounds)**	**Torque (in-lb)**
No. 6	30	10
No. 8	35	20
7/16 inch	N/A	40
15/32 inch	N/A	50

4.7.5.1 Strength of Terminals

The tensile load shall be applied to each terminal successively, in a direction most likely to cause failure, for a period of 1 minute; then the torque value specified shall be applied to the screw head about the thread axis for 1 minute without damage to the terminals.

4.7.5.1.1 Blade-Style Terminals

For blade-style terminals, a perpendicular load of 5 pounds shall be applied to each terminal successively in increments of 1 pound in both directions, applying the load for a period of 1 minute at each increment. After removing the load, the terminal shall have a permanent displacement of no more than 0.020 inch from its initial position.

Position of the application of the load should be at least 0.2 inch from the shoulder of the blade shown in Figure 3.

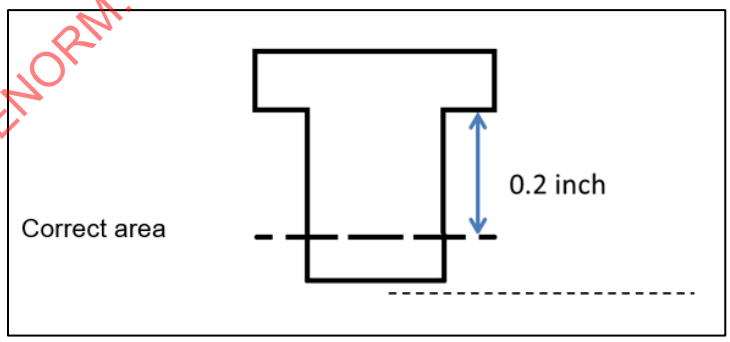


Figure 3 - Application of load

4.7.5.1.2 Areas of Evaluation

The areas that are to be evaluated for damage are limited to the circuit breaker housing and the threaded components or terminals and the inspection is to be conducted visually, with no magnification.

4.7.5.2 Strength of Mounting Means

The axial load shall be applied for a period of 1 minute, after which the specified torque shall be applied to the screw head or mounting nut about the thread axis for 1 minute without damage to the mounting means.

NOTE: Not applicable for conical bushing.

4.7.6 Operating Force

The force necessary for operation of the circuit breaker shall be determined. For toggle breakers, the force shall be applied at the ball tip of the actuator, and in the direction of operation. For push-pull breakers, the force shall be applied parallel to the line of travel of the actuator. The forces required for operation of the circuit breakers either during or as a result of the tests shall be as specified on the applicable detail specification. The specified operating force shall be applicable with the breaker carrying rated load under rated room ambient conditions.

4.7.7 Calibration

Single phase circuit breakers shall be subjected to calibration tests specified in 4.7.7.1 to 4.7.7.5. Each section of multiphase breakers shall be subjected to the calibration current specified, with the remaining phase or phases passing no current. Multiphase breakers shall also be subjected to tests in which each of the phases is carrying the specified current simultaneously. Minimum limit of ultimate trip (see 4.7.7.1) and maximum limit of ultimate trip (see 4.7.2.2) shall be treated as separate tests. Circuit breakers shall be stabilized at room ambient while carrying no current for a minimum of 1 hour before proceeding to the next test.

4.7.7.1 Minimum Limit of Ultimate Trip

The circuit breaker shall be subjected to the minimum limit of ultimate trip current for the time specified on the applicable detail specification. For qualification tests only, the temperature rise of the breaker terminals shall be obtained by the use of a suitable thermocouple. The breaker shall be monitored to determine that it does not trip and unless otherwise specified (see 3.1), the temperature rise shall be measured at the terminals for a rise not to exceed 75 °C. The thermocouple shall be attached to the terminals outside but adjacent to the breaker case. Each phase of multiphase breakers shall be tested with each of the phases carrying the current specified in the specification sheet.

4.7.7.2 Maximum Limit of Ultimate Trip

The circuit breaker shall be subjected to the maximum limit of ultimate trip current specified on the applicable detail specification and shall be monitored for tripping within the time limits specified. Each phase of multiphase breakers shall be tested with each of the phases carrying the current specified in the specification sheet.

4.7.7.3 Overload Calibration

The circuit breaker shall be subjected to the overload calibration values shown on the applicable detail specification, and shall be monitored for operation within the limits specified. Each phase of multiphase breakers shall be tested separately with the remaining phase or phases carrying zero current.

4.7.7.4 Trip-Free Calibration

The circuit breaker shall be in the closed position and subjected to the calibration test at maximum ultimate trip current. The test shall be repeated, using the values of overload calibration current shown on applicable detail specification. The actuator shall be held in for 10 minutes after tripping occurs. For recycling trip-free breakers, the breaker may close momentarily during this waiting period, but subsequent performance shall not be adversely affected. During this test, the breaker shall be tested with each major axis held in the vertical plane and in any other position likely to cause malfunctioning. The breaker shall be monitored for automatic tripping within the specified limits and subsequent performance which is adversely affected.

4.7.7.5 Ambient Effect on Calibration

The circuit breaker shall be tested at the ambient temperatures and loads specified on the applicable detail specification and shall be monitored for operation within the time limits specified. Tests shall be performed in chambers with the air flow adjusted to the still air environment specified in 4.7.7.5.1.

4.7.7.5.1 Still Air Environment

Still air environment is the area surrounding the circuit breakers within a given chamber where any reduction in air velocity within the area of the circuit breakers would cause a maximum 2 °C rise in temperature. The still air environment for temperature chambers 4 ft^3 and larger shall be obtained by using the fixture shown on Figure 4A. Fixture dimensions are shown on Figures 4B and 4C. The test fixture shall be placed in the temperature chamber so that the rear lead port of the fixture is facing away from the direct air flow created by the chamber circulating fan. A typical installation is shown on Figure 4D. The distance of the rear lead port from the chamber wall shall be determined by first placing a fully loaded fixture beginning at 1 inch from the chamber wall and performing the minimum limit of ultimate trip test at both extremes of temperature. The temperature rise inside the fixture shall be monitored during the test. If the internal temperature exceeds the 2 °C limit, the test shall be stopped and the fixture moved away from the chamber wall in small increments until the fixture internal temperature maintains the temperature gradient of +2 °C within the area of the circuit breakers. During the performance of all calibration tests, a minimum of 18 inches of lead length shall be kept inside the chamber to cancel any of the effects of heat conduction from the circuit breakers through the leads. Room ambient tests shall be performed inside a temperature chamber set at 25 °C ± 3 °C. Alternate means of obtaining the still air environment must be approved by the qualifying activity.

For chambers that are less than 4 ft^3 in volume, the fixture dimensions stated for the chambers that are 4 ft^3 and larger can be modified and the number of circuit breakers that can be tested at one time can be reduced in order to meet the still air requirements.

4.7.8 Endurance

The circuit breaker shall be subjected to the number of cycles of make-and-break operation specified in the applicable detail specification and shall make and break the specified current throughout the cycling period. Operating cycle is defined as the mechanical opening and closing of the breaker. At the option of the manufacturer, operation shall be performed at a minimum rate of 2 cpm or at a faster rate, and the ratio of the ON time to OFF time shall be approximately 1:5. The mechanical operation shall simulate manual operation, including overtravel. Each phase of multiphase breakers shall be simultaneously subjected to the required load tests. The test for operating forces shall be performed at the approximate midpoint and again at completion of the test; the breaker shall calibrate within the limits of 90% of the specified minimum ultimate trip current and 110% of the maximum ultimate trip current (see 4.7.7). Upon completion of endurance cycling the breaker shall pass the dielectric withstanding voltage test (see 4.7.2).

4.7.8.1 Alternating Current

During the alternating-current endurance tests, the voltage and frequency shall be as specified on the applicable detail specification.

4.7.8.1.1 Inductive Load

The power factor during this test shall be between 0.6 and 0.7 lag unless otherwise specified by the applicable MS. The load shall be the rating of the circuit breaker unless otherwise specified by the applicable detail specification.

4.7.8.1.2 Resistive Load

Resistive operation shall be accomplished at rated load with a power factor between 0.9 and unity.

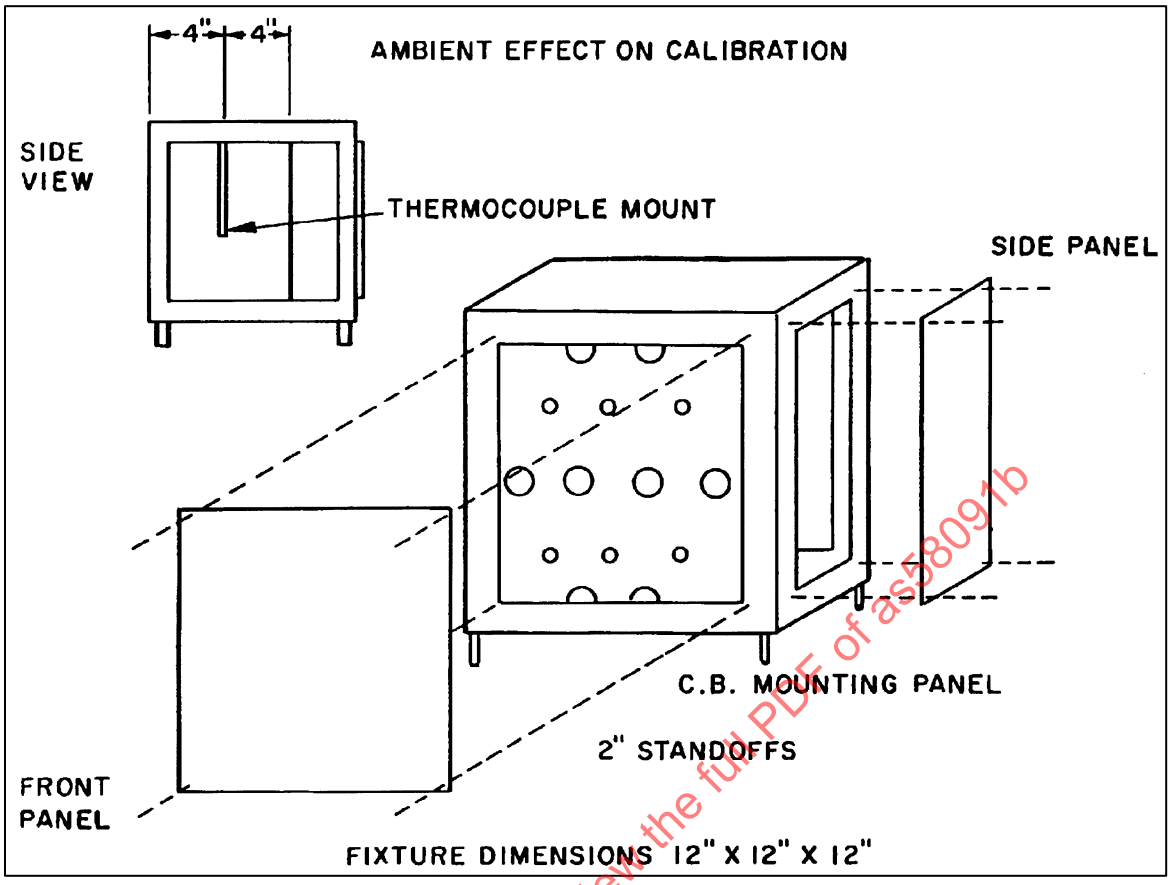


Figure 4A - Sample fixture

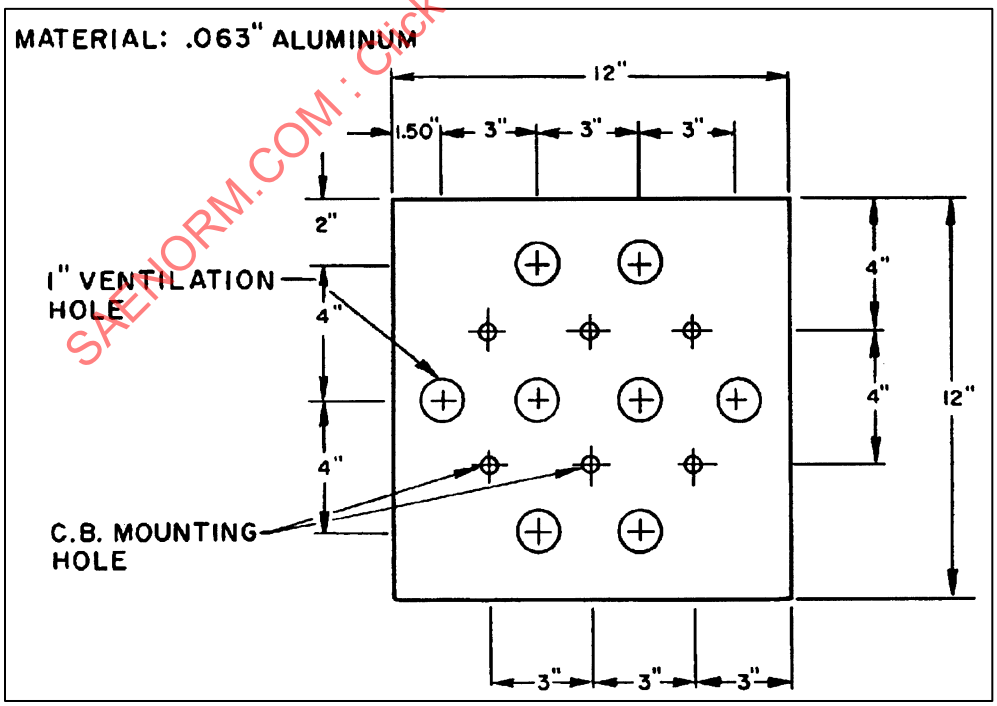


Figure 4B - Mounting panel

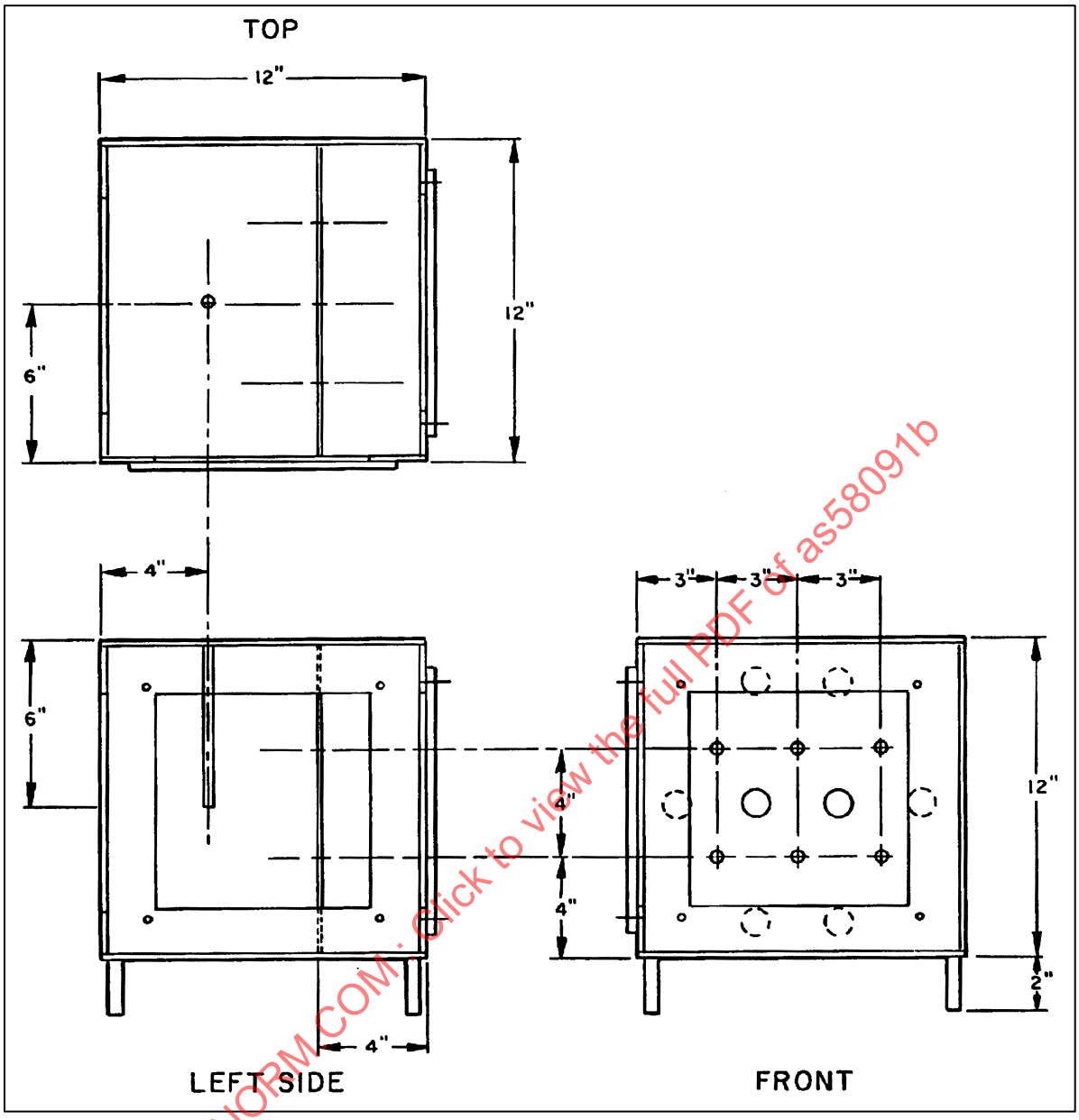


Figure 4C - Fixture dimensions

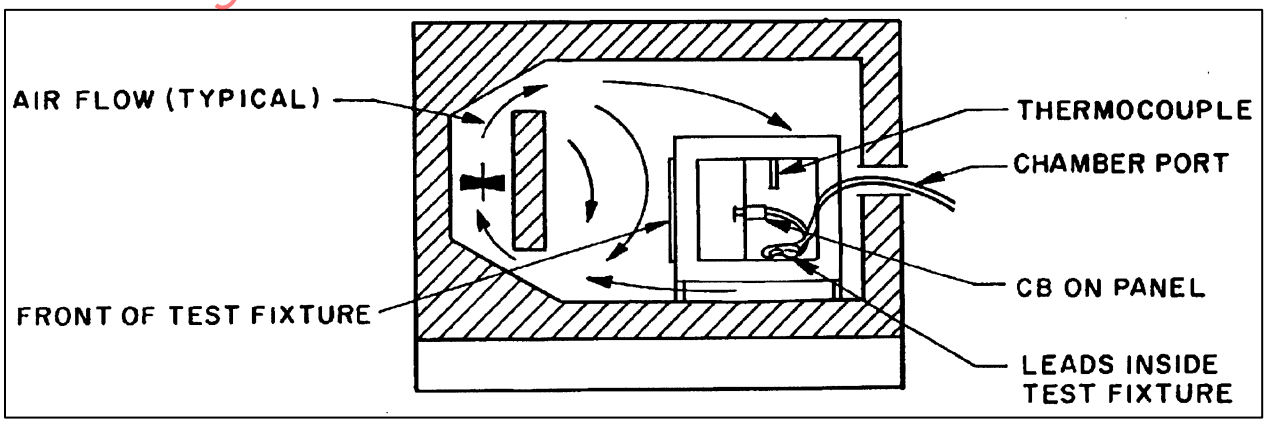


Figure 4D - Typical chamber installation

4.7.8.2 Direct Current

During the direct current endurance tests, the voltage shall be within the limits specified on the applicable detail specification.

4.7.8.2.1 Inductive Load

Twenty-eight VDC loads shall be computed in accordance with the formula $W = 0.14\ I^{1.18}$, in which "W" is the energy in joules which must be delivered to the electric contacts under test and the "I" is the DC inductive current rating of the contacts. Unless otherwise specified on the applicable MS, the DC inductive current rating shall be 10 A for circuit breaker ratings of 10 A and above and rated current for ratings below 10 A. The energy delivered to the contacts shall be measured as follows: A shunt capacitor shall be placed across the contacts to absorb the arc energy. The voltage drop across this shunt capacitor shall be measured upon circuit interruption by means of an oscilloscope. The voltage drop across the capacitor during circuit interruption shall be taken as the peak value of the first oscillation. The voltage drop and the value of capacitance shall be substituted in the formula:

$$W = (1/2)CE^2 \quad \text{(Eq. 1)}$$

where:

W = energy in joules

C = capacitance of shunt capacitor in farads

The energy thus calculated is the energy which would be dissipated by the contacts if the capacitor were removed. The energy shall be within +10% of the energy calculated by the formula $W = 0.14\ I^{1.18}$. This method of energy measurement requires the use of a capacitor having a working voltage of 1000 V. The size of the capacitor shall be such that the peak voltage measured shall be not less than 200 nor greater than 900 V.

4.7.8.2.2 Resistive Load

Resistive operations shall be accomplished at rated load.

4.7.8.3 Mechanical Cycling

The circuit breaker shall be subjected to the number of cycles of opening and closing specified on the applicable detail specification. The rate of cycling shall be 6 to 7 cpm.

4.7.9 Overload Cycling

At 200% rated current resistive load, the circuit breaker shall be subjected to manual-make and automatic-break applied as follows: Single-phase breakers shall be subjected to 50 cycles of normal tripouts from the closed position and 50 cycles of trip-free trip-outs while the reset actuator is held in the closed position. Three-phase breakers shall be subjected to 25 cycles of normal tripouts from a balanced three-phase overload. Each phase of the breaker shall then be individually subjected to 25 trip-free tripouts. These tests shall be run at a manual cycling rate of 2 to 3 minutes per operation. Failure to trip automatically within the maximum limit specified on the applicable detail specification throughout the test shall constitute failure. Following this test, the breaker shall meet the requirements of the minimum and maximum ultimate trip of 4.7.7.1 and 4.7.7.2. The breaker shall also meet the 200% calibration requirement of 4.7.7.3 at 25 °C ± 3 °C. For three-phase breakers, each phase must be tested separately, while other phases carry zero current.

4.7.10 Reclosing

Manual reset circuit breakers shall remain open after being tripped automatically and subjected to the maximum and minimum ambient temperature specified on the applicable detail specification for 1 hour. Continuity shall be checked during both of these exposures. This test may be waived if the design of the breaker precludes automatic closing.

4.7.11 Vibration

Circuit breakers shall be tested in accordance with one or more of the test paragraphs listed below. The following details shall apply for all vibration tests:

a. Mounting: Circuit breakers shall be mounted as designed in normal application. The mounting apparatus shall be free from resonance as described in Mil-STD-202 Method 201A.

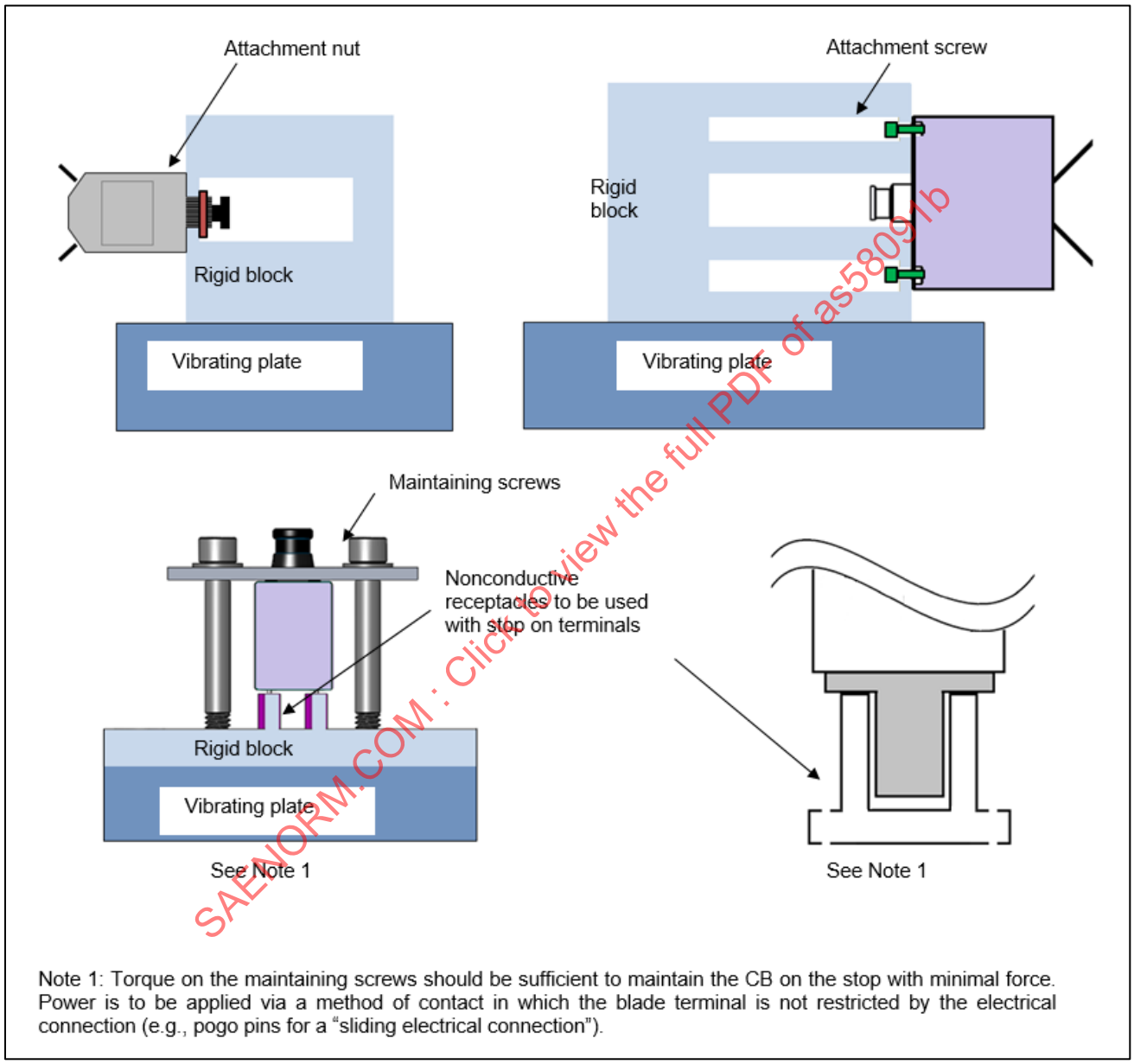


Figure 5 - Test mounting process

b. Electrical load: Unless otherwise specified, circuit breakers shall carry their rated current load in the ON position at room ambient temperature.

c. Measurements: Circuit breakers shall be continuously monitored by a continuity tester capable of detecting electrical discontinuities of 10 µs or less.

d. Post-test measurements: Following vibration testing, circuit breakers shall be visually examined for physical damage, then subjected to the 200% overload calibration at 25 °C ± 3 °C and the dielectric withstanding voltage test specified in 4.7.7.3 and 4.7.2.

4.7.11.1 Random Vibration

Circuit breakers shall be subjected to the vibration test method 214, test conditions C through K, of MIL-STD-202. Circuit breakers shall be vibrated 3 hours in each of the three principle axes. During the first 1-1/2 hours of vibration in each axis, the circuit breakers shall be monitored for discontinuity. During the remaining time, the circuit breakers shall be monitored for tripping only.

4.7.11.2 Sine Vibration

Circuit breakers shall be subjected to the vibration test Method 204, condition A, of MIL-STD-202.

4.7.11.3 High Level Sine Vibration

Circuit breakers shall be subjected to vibration testing in accordance with Method 204 of MIL-STD-202. The following test conditions shall apply:

a. Test condition B: No electrical load.

b. Test condition C: Rated electrical load.

4.7.12 Mechanical Shock

Circuit breakers shall be tested in accordance with Method 213 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting by normal mounting means.

b. Test condition letter A, or as specified.

c. Electrical load conditions.

Three separate shocks shall be applied to each of the three principal axes with the breaker contacts in the closed position, and three separate shocks shall be applied to each of the axes with the breaker contacts in the open position. All sections of the breaker shall be carrying rated current. A chronoscope, an oscilloscope or other device capable of detecting momentary opening or closing periods not exceeding 1/2 ms duration, shall be used to determine that the breaker contacts in the closed position remain closed, and circuit breaker contacts in the open position remain open. Following the test, the breaker shall meet the requirement of the 200% overload calibration of 4.7.7.3 at 25 °C ± 3 °C. For three-phase breakers, each phase must be tested separately while other phases carry zero current.

4.7.13 Acceleration

The circuit breaker shall be mounted by its normal mounting means on a centrifuge in a position most likely to cause malfunctioning. The centrifuge shall be brought up to the radial speed required to produce a radial acceleration of 10 G. The rates of centrifuge acceleration and deceleration shall be controlled so that the vector components (radial and tangential) or their vector sum shall not exceed 10 G. Once the specified radial acceleration is obtained, it shall be stabilized and maintained for a period of not less than 1 minute. All phases of the breaker shall be carrying rated current during, and for 30 minutes prior to test. The test shall be repeated with the breaker contacts in the open position. An oscilloscope or oscillograph shall be used to determine the ability of the breaker contacts to remain in the proper position. There shall be no opening or closing of contacts and there shall be no damage caused by acceleration. Following the test, the breaker shall be subjected to the 200% overload calibration (see 4.7.7.3) at 25 °C ± 3 °C. For three-phase breakers, each phase must be tested separately while other phases carry zero current.

4.7.14 Interrupting Capacity (Formerly “Rupture Capacity”)

For the interrupting capacity tests, the circuit breaker shall be so connected to the power source that currents specified on the applicable detail specification are provided at the circuit breaker terminals. The test circuit of Figure 6 may be used. The open circuit voltage before application of the interrupting current shall be as specified on the applicable detail specification. The open circuit recovery voltage shall be the value specified on the applicable detail specification. Oscillographic records of current, voltage, and time shall be obtained. The circuit breaker shall be subjected to the interrupting capacity tests of Table 8 as specified on the applicable detail specification and shall close on and open with the interrupting currents and voltages specified. When the detail specification list multiple current levels under test designation “E” and “F,” tests shall be conducted consecutively at listed current levels “a,” then “b,” then “c,” in accordance with the applicable detail specification. After each interruption, the open circuit voltage specified by the applicable detail specification shall be maintained across the breaker for a minimum of 5 seconds. There shall be sufficient time to permit proper cooling and reset between each cycle of operation. Interrupting tests shall not be repeated within 5 min of the previous test. Failure of circuit breaker to reset after 10 minutes shall be cause for rejection. Following the last operation of each test, the circuit breaker shall meet the requirements for dielectric withstanding voltage (see 4.7.2) and 200% overload calibration at 25 °C ± 3 °C. The breaker tripping time shall be within 120% of the upper limit, specified in 4.7.7.3, and there shall be no dielectric breakdown. Each phase of multiphase breakers in turn shall be subjected to this test while the other phase or phases are carrying rated current. For multiphase circuit breakers, one operation shall be performed for each test altitude specified. Upon completion, the breaker shall again be subjected to this test while each of the phases is simultaneously carrying 60 +10 -0% of the single phase fault current specified on the applicable detail specification.

4.7.14.1 Fail-Safe Operation

Failure of the breaker to complete all fault current interruptions as specified may be permitted if the breaker fails in a safe manner. For the purpose of this test, a breaker which has failed safe is a part which is unable, because of electrical damage, to carry an electrical load. In addition, the leakage current between the load and line terminal(s) shall be less than 1 mA at 300 VAC with the breaker in any attainable pushbutton position.

4.7.15 Sand and Dust

While in the ON position and mounted on a dummy panel, the circuit breaker shall be subjected to sand and dust in accordance with the sand and dust test, Method 100, test condition A, of MIL-STD-202, with no evidence of mechanical or electrical failure. At the conclusion of this test, the breaker shall be held in at 500% of rated load, thus causing the breaker to trip free. On three-phase breakers, each phase shall be tested separately. Failure to trip within 10 seconds shall constitute failure. The circuit breaker shall meet the requirements for 200% overload calibration at room ambient as specified in 4.7.7.3. Toggle type circuit breakers shall be operated for 2500 cycles (no load) at approximately 7 cpm during Part I of test condition A of the sand and dust test.

4.7.16 Salt Spray (Corrosion)

The circuit breaker in the closed (ON) position with all hardware shown on the applicable detail specification installed finger tight shall be subjected to the salt spray test Method 101, test condition B, of MIL-STD-202, with a 5% salt solution. Within 10 minutes after the test, the breakers shall be washed for 5 min under running water not warmer than 37.8 °C accompanied by a slight brushing, and dried for 6 hours in a forced-draft oven at approximately 57 °C. At the conclusion of this test, the breaker shall be held in at 500% of rated load, thus causing the breaker to trip free. On three-phase breakers, each phase shall be tested separately. Failure to trip within 10 seconds shall constitute failure. The breaker shall then meet the requirements for 200% overload calibration at room ambient at 25 °C ± 3 °C, except that the tripping time shall be within 80% of the lower limit and 120% of the upper limit specified. All hardware shall be removable without damage to the circuit breaker or hardware.