

	SURFACE VEHICLE STANDARD	
		J1625 MAY2013
	Issued Cancelled	1993-07 2013-05
Superseding J1625 SEP2004		
Heavy-Duty Circuit Breakers		

RATIONALE

The test specification for SAE J553 and SAE J1625 are almost identical with variation only in the test lead sizes and interrupt test currents that change as the value of the circuit breaker amperage increases.

Manufacturers have adopted the SAE J553 spec in their literature in practice.

One standard will fully support all 12V/24V circuit breaker requirements up to 200A. This will simplify the research for the engineer using SAE standards and remove the possibility of one spec not matching the other.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2013 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
 Tel: +1 724-776-4970 (outside USA)
 Fax: 724-776-0790
 Email: CustomerService@sae.org
 SAE WEB ADDRESS: <http://www.sae.org>

Full document details: SAE J1625_201305

SAE values your input. To provide feedback
 on this Technical Report, please visit
http://www.sae.org/technical/standards/J1625_201305

1. Scope

This SAE Standard defines the test conditions, procedures, and performance requirements for circuit breakers in ratings from 50 to 200 A. This document covers automatic reset, modified reset and manual reset types of circuit breakers for low voltage DC systems (12 V and 24 V).

NOTE—It is technically feasible for circuit breakers in this general class to be provided in amperage ratings below 50 A. In those instances, the procedures as detailed herein may be used provided compensation is made for test currents, test leads, and power supply requirements. Additional guidance may be obtained from SAE J553 – Circuit Breakers.

- 1.1** Operational requirements for 42V vehicular electrical systems are under development as of this revision. The electrical environment is not completely defined, particularly as it relates to other components that would influence circuit breaker function (such as storage battery technology, charging system design and operational characteristics). The test and evaluation requirements of this standard are sufficient to determine relative performance concerning current carrying capability, environmental durability, and general requirements regardless of maximum voltage rating. It is anticipated that a separate technical document will be created to capture requirements unique to 42V electrical system architecture and load characteristics.

2. References

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J537—Storage Batteries
SAE J1127—Battery Cable
SAE J1128—Low Tension Primary Cable
SAE J1171—External Ignition Protection of Marine Electrical Devices
SAE J1211—Recommended Environmental Practices for Electronic Equipment Design
SAE J1428—Marine Circuit Breakers

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J258—Circuit Breaker—Internal Mounted—Automatic Reset
SAE J554—Electric Fuses (Cartridge Type)
SAE J1284—Blade Type Electric Fuses
SAE J1888—High Current Time Lag Electric Fuses
SAE TSB 002—Preparation of SAE Technical Reports

2.2.2 CSA PUBLICATIONS

Available from CSA Sales Department, 178 Rexdale Boulevard, Etobicoke, Ontario, M9W 1R3.

CSA C22.2 No. 14-M1987—Industrial Control Equipment
CSA C22.2 No. 235-M89—Supplementary Protectors

2.2.3 U.S. GOVERNMENT PUBLICATIONS

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

2.2.4 UNDERWRITERS LABORATORIES PUBLICATIONS

Available from Underwriter Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

U.L. 1077—Standard for Supplementary Protectors for use in Electrical Equipment

2.2.5 APPENDICES

Appendix A Circuit Protection Application Guidelines

Appendix B Glossary of Document Terminology

3. Definitions

3.1 Circuit Breakers – are overcurrent protective devices, responsive to electric current and to temperature.

NOTE—There are no implied restrictions on circuit breaker design as to component form or ornamental housing designs provided the circuit breaker exhibits performance characteristics within the scope of this standard. This standard has been developed for use by the ground transportation industry, however other users of DC circuit protection may find the test and performance requirements of benefit.

3.2 Externally Mounted Circuit Breakers – are defined as self-contained devices, which are mounted individually or in assemblies via brackets, bus bars, electrical centers, compatible fuse holders, or mechanically in or through panels.

3.3 Internally Mounted Circuit Breakers – are defined as protection sub-assemblies that are most often integrated with other electrical devices, such as part of a switch with circuit breaker function or in a motor housing to provide overload protection to the motor windings.

3.4 There are three general classes of breaker, defined as follows:

3.4.1 Type 1 – Automatic reset – is defined as cycling or continuously self-resetting unit, which is opened by overcurrent. The terms “cycling” and “continuously self-resetting” refer to the functional characteristic in which the reset feature is not dependent upon any deliberate action or intervention by the user or user’s application system to initiate the reset of the tripped circuit breaker. These terms do not imply that the trip and reset function can continue unabated without consequence to either the life of the circuit breaker or potentially adverse effects to an electrical system wiring and/or components, if a fault condition persists undetected and uncorrected.

NOTE—Type 1 automatic reset circuit breakers are best utilized in applications that provide for other self-limiting or non-resettable means (such as after a main fuse, main manual reset circuit breaker, or momentary switch). Intermittent electrical short circuit operation, which may be observed during a cycling event on a Type 1 automatic reset circuit breaker after overload or short, could be misinterpreted as loose connections by operators if self-limiting means are not in place, which in turn may lead to delayed service of a fault.

3.4.2 Type 2 – Modified Reset – is defined as a device that is opened by overcurrent and remains open as long as a minimum voltage and current is available to the affected circuit (as established in this standard). A sequence of trip and reset cycles may occur prior to achieving the steady-state open condition as defined in the test and performance requirements.

NOTE—As of this revision, there are no commercially available Type 2 heavy-duty circuit breakers. There are no specified tests or requirements in this standard. Type 2 tests and requirements are published in SAE J553, which may be relied upon as a general guideline for evaluation until such time that specifications would be included in this document.

- 3.4.3 Type 3 – Manual Reset – is defined as a non-cycling unit that is opened by overcurrent. A manual reset circuit breaker, once opened by overcurrent requires manual actuation of a reset mechanism in order to re-establish continuity.

NOTE—Trip free designation on manual reset circuit breakers as it applies to this standard - indicates a manual reset circuit breaker in which any forced restriction of the reset mechanism in the operating mode does not prevent cycling under fault current, or causes the circuit breaker to keep passing electrical current in lieu of any form of trip function.

- 3.4.3.1 Type 3 – Manual Reset with Switchable Feature - Functions as a conventional manual reset circuit breaker as defined in 3.4.3, but also has a mechanism, which when exercised at the discretion of the user, permits opening of the breaker's internal circuit to stop current flow. The breaker is reset to its normal operating condition by the manual reset function, whether tripped unattended by a real fault condition or by the user.
- 3.4.3.2 Type 3 – Manual Reset/Switch – an integrated switch design that provides both switching function for on-off activations and includes a circuit breaker feature to “toggle” the switch to an off position in the event of overcurrent or short circuit. Reset function is likely to be incorporated into the on/off activating mechanism, permitting reset of the circuit breaker portion of the device. Circuit breakers of this type could be considered externally or internally mounted units as defined in paragraphs 3.2 and 3.3. Additional or alternate test requirements may be noted elsewhere in this standard.

4. Test Requirements

4.1 Test Equipment, Instrumentation, and Conditions

4.1.1 POWER SUPPLIES

- 4.1.1.1 A current and voltage regulated DC power supply shall be used for all tests except 4.2.6 Interrupt Test.

The power supply shall be capable of delivering 14.0 VDC during open circuit portion of tests and have sufficient current output capacity to meet highest load requirements. Voltage and current settings shall be accurate to within $\pm 1\%$ of set point or better. Power transient response shall be such that when a 30% step increase in power is demanded by the load, the transient in the regulation output shall typically recover to within 3% of the final value within 100 ms or better. The power supply shall be operated with controlling circuitry to achieve all necessary test conditions.

NOTE—DC power supplies used for testing could have large storage capacitors in the DC output section. Load switching may induce current spikes, which while brief in duration, may be significant enough to bias test results or affect reset and re-trip activity of circuit breakers (especially more vulnerable lower amperage rated devices). For this reason, it is necessary to buffer the output by placing low resistance power resistors (generally one ohm or less) in series with the DC power supply output as part of the overall circuit breaker test circuit. See Figure 1 Current Rating Test Circuit.

- 4.1.1.2 Storage batteries specified in Table 1 shall be used as the power supply for 4.2.6 Interrupt Test. Open circuit voltage as specified shall be maintained by a battery charger or power supply with voltage regulated per Table 1 and charging current output restricted to 100 A or less.

TABLE 1—STORAGE BATTERIES

Voltage Rating	Cold Cranking Amperage (CCA)	Open Circuit Voltage
12 V	1100 - 1200 A	14.0 ± 0.5V DC

4.1.2 VOLTMETER

0 to 30 VDC maximum range, accuracy $\pm 1/2\%$.

NOTE—A digital meter having at least 3-1/2 digits readout with an accuracy of $\pm 1\%$ plus 1 digit is recommended for millivolt readings.

4.1.3 AMMETER

Capable of displaying full load current with an accuracy of $\pm 1\%$. A calibrated shunt shall be used in series with the test circuit to minimize circuit resistance (use of an inductive ammeter is permissible in lieu of an ammeter/shunt set-up, provided accuracy and stability of load current reading is assured).

NOTE—A digital meter having at least a 3-1/2 digit readout with an accuracy of $\pm 1\%$ plus 1 digit is recommended for amperage readings when used in conjunction with a millivolt output calibrated shunt.

4.1.4 HIGH-VOLTAGE BREAKDOWN TESTER

Capable of providing 500 VAC RMS - 60 Hz, accuracy $\pm 5\%$, with 5 mA leakage.

4.1.5 THERMOCOUPLE AND METER

0 to 200 °C minimum range, accuracy $\pm 2\%$, maximum thermocouple wire size - 0.22 mm² (#24 gage); J or K style.

NOTE—A digital thermometer with thermocouple input is recommended, with an accuracy of ± 1 °C.

- 4.1.5.1 Two ambient observations are necessary during test cycles: ambient of test room and ambient of test chamber containing breakers under test.

- 4.1.5.2 Delta heat rise of terminations shall be calculated during 4.2.2.1 testing (at the tester's discretion).

4.1.6 OVEN

Variable controlled temperature oven shall be able to vary temperature at a rate of 1 °C per minute and control temperature ± 1 °C of set point accurate to ± 2 °C.

4.1.7 TEST LOAD

Any combination of fixed and/or variable resistor(s) capable of varying circuit load to specified test requirements in conjunction with a power supply. A test circuit by-pass may be employed to verify current settings.

4.1.8 TEST LEADS

Circuit breakers shall be tested using copper stranded wire sizes listed in Table 2 that conform to wire specifications as found in SAE J1127. The wire length shall be 1.22 m (48.0 in) for all voltages tested and insulation shall be rated 105 °C, or better.

TABLE 2—TEST LEAD SIZES

Rated Current	SAE Wire Size No.	ISO Cable Size mm ²
50A to 60A	# 6	13mm ²
>60A to 90A	# 4	19 mm ²
>90A to 120A	# 2	32 mm ²
>120A to 150A	# 0	50 mm ²
>150A to 200A	# 00	62 mm ²

NOTE—ISO metric cable sizes are not exact equivalents to the SAE wire sizes. Tests and requirements in this Standard are based on SAE wire. Use of ISO metric cable may require shortening of the test leads from 1.22 m in length for SAE to 1.0 m in length for resistive and thermal compensation.

4.1.8.1 Termination of Test Leads

All test leads shall use standard commercially available terminals suitable for the range of wire gages and threaded circuit breaker terminations. To avoid secondary heat generation and/or adverse millivolt drop, it is recommended that test lead terminals be crimped and soldered when practical; also, connections to breakers must be repeatable and uniform. Terminals shall be attached to breakers with screw threads to a specified torque value that is generally recommended for the particular thread size. For custom terminations, consult the circuit breaker manufacturer.

4.1.9 TEST ENCLOSURE

Provide for a draft and convection air current free test chamber with volume of approximately 7.08 x 10⁴ cm³ (2.5 ft³). Chamber must allow for test lead access, internal chamber temperature monitoring, and indirect venting if needed to ensure requirements of 4.2.1 are met.

4.1.10 AMBIENT CONDITIONS

Environmental conditions have been selected for this document to help assure satisfactory operation under general customer use conditions. Circuit breakers shall be tested in still air at the temperatures indicated and allowed a 30 min soak without electrical load before testing (and repeated 30 min soaks for individual breakers that are involved in more than one test condition). Equipment listed in 4.1.9 fulfills the still air requirement. If not otherwise specified, all tests shall be performed at room temperature (23 ± 3) °C (68 – 79 °F) at a relative humidity (RH) of 45 % to 75 % (standard condition). If room ambient is unstable or unregulated and an environmental chamber is employed, breakers under test must be isolated from chamber forced air currents. Paragraph 4.1.9 test enclosure shall be used within the chamber compartment and temperatures monitored per 4.1.5.1.

NOTE—Breakers stored in environments below 15 °C (59 °F) or above 35 °C (95 °F) shall be allowed a minimum of 1 h soak at the specified test temperature prior to initiation of any testing.

4.1.10.1 Test leads and terminations subject to thermal rise from test operations shall be allowed to re-stabilize to ambient conditions before starting a new test. Alternating between multiple sets of leads is suggested.

4.2 Test Procedures

4.2.1 CURRENT RATING TEST PROCEDURE

The circuit breaker shall be electrically connected with a pair of test leads described in 4.1.8 in series with the power supply as described in 4.1.1.1, a voltmeter as described in 4.1.2, a shunt with ammeter as described in 4.1.3, and an appropriate test load as described in 4.1.7 to provide the required current pass through the circuit breaker. Refer to Figure 1 for all tests except 4.2.5 and 4.2.6. Refer to Figure 2 for 4.2.5 and 4.2.6 only.

4.2.1.1 *Maximum Voltage Drop Test Procedure*

With the circuit breaker connected as described in 4.2.1, the voltage drop across the circuit breaker shall be measured while the breaker is passing full rated current and has achieved equilibrium (typically after 15 to 20 min of continuous operation at 100% of rated current, exhibited by no appreciable increase in voltage drop). Continue operation at 100% of rated current until 1 h elapses. If after 30 minutes of continuous operation at 100% of rated current, equilibrium has not been attained, continue testing until equilibrium has been attained and voltage drop is within acceptable limits, or, unit exceeds voltage drop limits and/or trips out.

NOTE—For applications sensitive to heat-rise at the circuit breaker terminations, thermocouple leads may be affixed to the terminations. General practice is to place the thermocouple lead on that portion of the terminal that is likely to come in contact with the wire lead insulation. Benchmark maximum values for delta heat rise (observed thermocouple temperature minus ambient temperature) at 65 °C delta for factory wired terminations and 50 °C delta for field wired terminations, which is based on 90°C rated wire insulation. Test temperature readings should be compared with the rating of application wire. Results of this testing will assist the user with circuit design and proximity considerations for breaker installation.

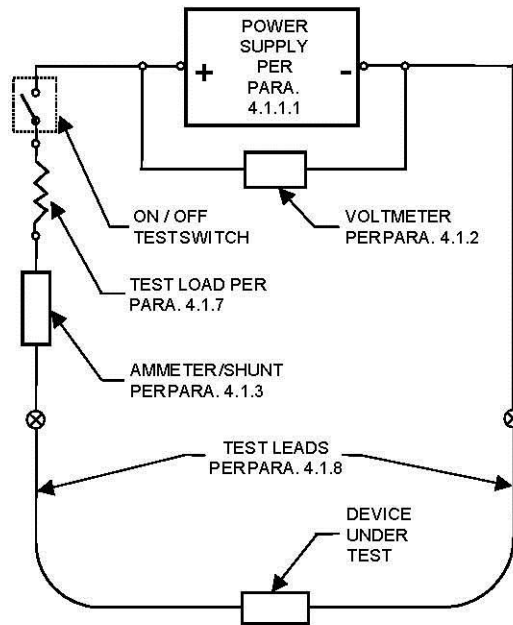


FIGURE 1—CURRENT RATING TEST CIRCUIT

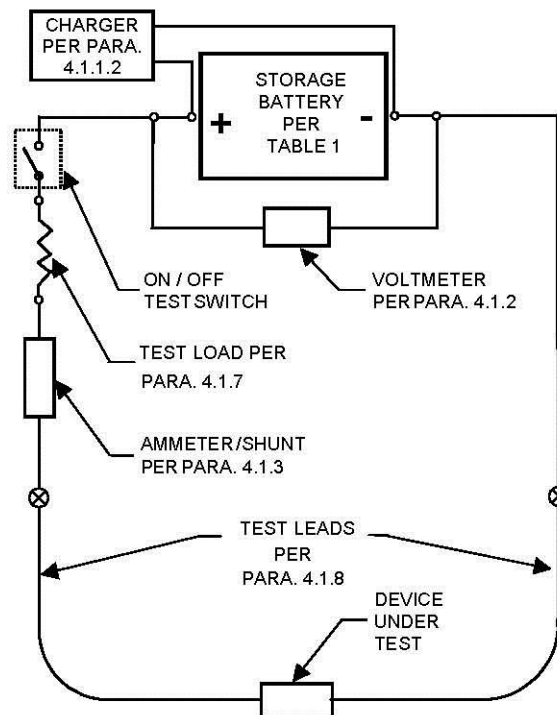


FIGURE 2—INTERRUPT CYCLING TEST CIRCUIT

4.2.2 OVERLOAD TRIP RATING TEST PROCEDURE

After a 30 min soak, reconnect the breaker as described in 4.2.1. Operate at 135% of rated current and record the elapsed time in seconds for the breaker to trip. If breaker has not opened after 1 h, discontinue the test. Repeat 30 min soak, operate at 200% of rated current and record elapsed time for the breaker to trip. If breaker has not opened after 2 min, discontinue the test.

4.2.3 VOLTAGE BREAKDOWN TEST PROCEDURE

4.2.3.1 With the circuit breaker connected as described in 4.2.1, adjust the current to 400% of the circuit breaker rating and allow the breaker to cycle. At the end of 10 min, check the continuity at 500 VAC between each terminal of the circuit breaker individually and the cover of the breaker (if cover is metallic) with the breaker in both an open and closed circuit condition.

4.2.4 HIGH AMBIENT DE-RATING TEST

4.2.4.1 With the circuit breaker connected as described in 4.2.1, place the circuit breaker in a temperature controlled environmental chamber heated to $85\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ with 30.5 cm (1 ft) of each lead inside the chamber along with the breaker. Apply 70% of rated current continuously for 1 h. End the test when 1 h is attained or if the breaker opens.

4.2.5 ENDURANCE (OVERLOAD) TEST PROCEDURE

4.2.5.1 *Type 1 circuit breakers.*

4.2.5.1.1 With the circuit breaker connected as described in 4.2.1, Type 1 externally mounted circuit breakers shall be cycled for 1h at 600% of rated current. Following the 1h of cycling at 600% of rated current, perform a millivolt drop test in accordance with paragraph 4.2.1.1, at 80% of rated current.

4.2.5.1.2 Using the circuit breaker from 4.2.5.1.1 (unless 4.2.5.1.1 requirements were not met), reconnect as described in 4.2.1 and cycle Type 1 circuit breaker at 600% of rated current for an additional 6 h, after which terminate the test.

4.2.5.2 *Type 3 circuit breakers.*

4.2.5.2.1 With the circuit breaker connected as described in 4.2.1, Type 3 circuit breakers shall be cycled for 100 on-off cycles at 600% of rated current utilizing the trip indicating/reset mechanism of the breaker. Cycle time shall be adjusted to accommodate the reset characteristics of the circuit breaker and to facilitate actuation of the reset mechanism for initiation of repetitive cycles. Following the 100 on-off cycles, perform a millivolt drop test in accordance with paragraph 4.2.1.1, at 80% of rated current.

4.2.5.2.2 Cycling Endurance Test for Switchable Type 3 Circuit Breakers (as defined by 3.4.3.1). At the option of the tester, a cycling endurance test shall be performed as is described herein. With the circuit breaker connected as described in 4.2.1, apply a current cycling waveform as shown in Figure 3 through the breaker for 1000 cycles at 80% of rated current. Upon start of test, a pre-conditioning cycle of 60s is applied followed by initiation of the repetitive cycle pattern.