



SURFACE VEHICLE RECOMMENDED PRACTICE

J2685

DEC2014

Issued 2006-05
Stabilized 2014-12

Superseding J2685 MAY2006

Positive Temperature Coefficient Overcurrent Protection Devices (PTCs)

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1. **Scope**

This SAE Recommended Practice defines the test conditions, procedures, and performance requirements for PTC (positive temperature coefficient of resistance) overcurrent protection devices. PTCs are typically either polymeric (PPTC) or ceramic (CPTC). It is important to note battery voltages versus powernets/system voltage versus max battery voltages: (12 V/14 V/16 V, 24 V/28 V/32 V, and 36 V/42 V/58 V). All voltages are DC. These devices are typically rated with a maximum operating voltage, which for vehicular systems need to be 16 V (for 12 V batteries), 32 V (for 24 V batteries), and 58 V (for 36 V batteries/42 V powernets). PTC devices are considered to be self-resetting after responding to overcurrent conditions and after such condition has been removed from the affected circuit containing the PTC.

- 1.1** The test and evaluation requirements of this document are sufficient to determine relative performance regardless of maximum voltage rating. The suitability of any given PTC device for 42 V electrical systems is dependent upon the manufacturer's design and performance characteristics in higher voltage applications. Whereas electrical arc generation in live circuits poses a hazard to equipment and operators, it is also the recommendation of the Circuit Protection Task Force that vehicular electrical applications employ adequate safety measures to prevent live engage or disengage occurrences of these electrical devices.

Not applicable.

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, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1211—Recommended Environmental Practices for Electronic Equipment Design

SAE J1455—Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)

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 PUBLICATION

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

SAE TSB 002—Preparation of SAE Technical Reports

2.2.2 U.S. GOVERNMENT PUBLICATIONS

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-2179, <http://assist.daps.mil> or <http://stinet.dtic.mil>.

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

MIL-STD-810D—Environmental Test Methods and Engineering Guidelines

ANSI/J-STD-002—Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

2.2.3 ISO PUBLICATIONS

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 7637-1—Road vehicles—Electrical disturbance by conduction and coupling—Part 1: Passenger cars and light commercial vehicles with nominal 12 V supply voltage—Electrical transient conduction along supply lines only

ISO 7637-2—Road vehicles—Electrical disturbance by conduction and coupling—Part 2: Commercial vehicles with nominal 24 V supply voltage—Electrical transient conduction along supply lines only

2.2.4 UNDERWRITERS LABORATORIES PUBLICATIONS

Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 1077—Standard for Supplementary Protectors for Use in Electrical Equipment

UL 94—Tests for Flammability of Plastic Materials for Parts in Devices and Appliances (V-0 or V-1)

2.2.5 AUTOMOTIVE ELECTRONICS COUNCIL PUBLICATION

Available from the Automotive Electronics Council electronically at www.aecouncil.com.

AEC-Q200—Stress Test Qualification for Passive Components

3. Definitions

3.1 PTC—Positive Temperature Coefficient Devices

Are overcurrent protection devices, responsive to electric current and to temperature. PTC is defined as a device that is normally low resistance, and is tripped by overcurrent and/or overtemperature and remains latched in a high resistance tripped state as long as a minimum voltage and current is available to the affected circuit (as established in this document).

The resistance typically increases by several orders of magnitude. This increased resistance protects the equipment in the circuit by reducing the amount of current that can flow under the fault condition to a low, steady state level. The device will remain in its latched (high resistance) position until the fault is cleared and power to the circuit is removed – at which time PTC cools, restoring to a low resistance state and the circuit and the affected equipment to normal operating conditions.

NOTE—There is no implied restriction on PTC design as to component form provided the PTC exhibits performance characteristics within the scope of this document. This document has been developed for use by the ground transportation industry, however other users of solid-state protection components may find the test and performance requirements of benefit. PTCs that are installed into terminated housings or enclosures solely for facilitating use as an overcurrent protection device are to be evaluated as part of the assembled format provided. Other circuit protection application guidelines for PTCs exist in Appendix A.

3.2 PTC Form-Factors, Operational Mode, and Types

3.2.1 RADIAL LEADED PTCs

Are defined as PTC devices manufactured with radial-leaded connections of a specified diameter and length, such as is common to electronic components.

3.2.2 SURFACE MOUNT (SMT) PTCs

Are defined as a chip format PTC that is manufactured with solderable end sections that will permit assembly operations to circuit boards or related formats requiring direct mounting.

3.2.3 OTHER PTC FORMATS

Other manufacturer designs such as axial-leaded or those with terminal type leads, are allowable provided that termination methods are defined along with performance specifications necessary for evaluation under this test and performance specification.

3.2.4 There is essentially one operational mode of PTC, defined as follows:

There is essentially one type of PTC performance mode, defined similar to a modified reset (Type 2) circuit breaker and it is sometimes called self-resetting – a PTC device exhibits positive temperature coefficient of resistance, non linear characteristics, such that it reverts from a low resistance state to a high resistance state in response to overcurrent conditions at a specified switch temperature and reverts back to the low resistance state when the temperature of the PTC matrix drops far enough below the switch temperature.

3.2.5 TYPES OF PTCs

Polymer-based (PPTC)
Ceramic-based (CPTC)

3.3 Lot

Unless otherwise specified, a lot shall consist of devices manufactured to the same part drawing number, assembled at the same location, in the same production run, using the same production techniques, materials, controls, and design.

3.4 For definitions of Resistance, Steady State, Power Dissipation, Trip, Voltage Rating, Maximum System Voltage, and I_{rated} , I_{hold} , I_{trip} , I_{max} , and others – please refer to Appendix B.

4. Test Requirements

4.1 Test Equipment

4.1.1 POWER SUPPLIES

A current and voltage regulated DC power supply shall be used for all tests as specified in the test specifications. Voltage and current settings shall be accurate to within $\pm 2\%$ 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 PTCs (especially more vulnerable lower amperage rated devices). For this reason, it is necessary to buffer the output by placing low resistance power resistors (generally $1\ \Omega$ or less) in series with the DC power supply output as part of the overall PTC test circuit.

4.1.2 OVEN

Variable controlled temperature oven able to vary temperature at a rate of 1 °C per minute and control temperature to ± 3 °C.

4.1.3 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.

NOTE—Use of current regulated power supply would make it possible to use fixed resistors and achieve adjustment via the supply; however, voltage must be allowed to rise to the maximum system voltage during portion of tests when voltage rise is specifically required.

NOTE—Unless otherwise specified, the test loads required in rating tests shall have a tolerance of $\pm 1.0\%$.

4.1.4 TEST POWER SOURCE

Unless otherwise specified, the standard open circuit test voltage shall be at the maximum operating voltage per Manufacturer's Specification. Unless otherwise required, the power source shall be capable of delivering the current required to perform the test. Whenever required, current delivered to the device shall be determined based on initial resistance at room temperature. This may be achieved by measuring the initial resistance at room temperature immediately preceding the test and calculating the necessary load resistance to deliver the current required by the specification.

4.2 Test Instrumentation

4.2.1 VOLTMETER

0 to maximum system voltage minimum range, accuracy $\pm 1/2\%$.

NOTE—A digital meter having at least a 3½ digits readout with an accuracy of $\pm 1\%$ plus 1 digit is recommended for millivolt readings.

4.2.2 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 3½ 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.

4.2.3 THERMOCOUPLE AND METER

0 °C to 150 °C minimum range, accuracy $\pm 1\%$, maximum thermocouple wire size – 0.22 mm² (24 AWG).

4.2.4 DIGITAL OHMMETERS

4-Wire Resistance Measurement Instrument: A digital ohmmeter or multimeter measuring to at least 1% accuracy is required. The instrument shall be capable of applying the test current at the point of resistance measurement for accurately compensating for the test lead resistance.

4.3 Test Conditions

4.3.1 AMBIENT CONDITIONS

Environmental conditions have been selected for this document to help assure satisfactory operation under general customer use conditions. If not otherwise specified, all tests shall be performed at a room temperature of 23 °C $\pm$ 3 °C (68 °F – 79 °F), uncontrolled air pressure and relative humidity.

4.3.2 TEST ENVIRONMENT

Electrical performance verification tests (Resistance, I_{HOLD} and I_{TRIP}) shall be performed at the minimum, room, and maximum rated temperatures – per manufacturer's specification, usually -40 °C, 25 °C, and 85 °C or 125 °C. The devices shall be tested, unless otherwise specified, in a non-forced air environment. The test chamber temperature shall be monitored and controlled at a location that reasonably represents the general test chamber temperature and result in the ability to control the chamber temperature as required. Test samples shall be divided into three equal groups except when the samples are not equally divisible, the remaining one or two devices shall be included in the room temperature test group. The groups that are selected to be in a certain temperature group shall remain in the same temperature group for pre- and post-stress tests.

4.3.3 MOUNTING OF DEVICE FOR ELECTRICAL TEST

4.3.3.1 *Leaded*

Where applicable and unless otherwise specified, devices shall be mounted for electrical testing to the test apparatus via a pair of spring loaded clips. Leaded devices with formed leads shall be clipped within 5 mm from the base of the form away from the device body. Leaded devices with non-formed leads shall be clipped at 5 mm to 10 mm from the bottom of the body of the part.

4.3.3.2 *Surface-Mount*

Where applicable and unless otherwise specified, devices shall be mounted for electrical testing on printed circuit boards where the power dissipation of the mounted device is consistent with the typical power dissipation value found in Manufacturer's Specification. Devices shall be reflowed on to test boards using a reflow oven, or equivalent, and an appropriate reflow temperature-time profile. Devices shall be left at room temperature for a minimum of 24 h prior to starting pre-stress tests.

4.3.3.3 Other Devices

Other devices that do not fit within surface-mount or radial-leaded, need to be tested within the context of their individual application, in which case the test fixturing should be developed to the applications unique requirements.

4.3.3.4 For other mounting suggestions, see Appendix C.

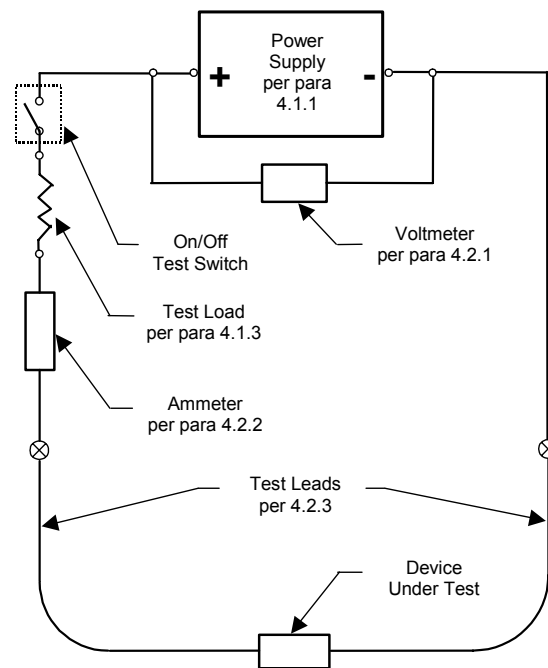


FIGURE 1—TEST CIRCUIT EXAMPLE

4.3.4 TEST SEQUENCE

Test sequences are listed in Table 1. The basic test sequence covers all core requirements. Sample size and sample group distributions for tests are indicated accordingly.