UL 1434

STANDARD FOR SAFETY

Thermistor-Type Devices

UL Standard for Safety for Thermistor-Type Devices, UL 1434

First Edition, Dated April 3, 1998

Summary of Topics

The revisions of UL 1434 dated May 18, 2021 include the following changes in requirements:

- ***Matching Table 11.3 and Table 22.1 to IEC 60730-1 Table J.7.***

- ***For a sensing thermistor, corrections to use the same temperature terminology in the document; 12.2, 14.4, 15.1, 17.2***

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal (s) on this subject dated November 11, 2020 and March 9, 2021.

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Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to discrete thermistor-type devices constructed of ceramic or polymeric semiconductor material.

1.2 These thermistors are intended for use as:

a) Self-limiting devices such as heaters;

b) Control devices such as current limiters and inrush-current limiters; or

c) Sensing devices.

1.3 These requirements apply to positive temperature coefficient (PTC) and negative temperature coefficient (NTC) type devices.

1.4 Control devices, such as current limiters are not intended to replace current interrupting devices such as fuses, but are intended to provide a level of overcurrent protection complying with the end-use equipment requirements.

1.5 These requirements do not apply to heating cables, such as self-regulating pipe heating cable, that are constructed with thermistor-type material.

1.6 *Deleted*

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

2.1.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.1.5 *Deleted*

2.1.6 *Deleted*

2.1.7 *Deleted*

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

2.3 Units of measurement

2.3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Glossary

3.1 For the purpose of this standard, the following definitions apply.

3.2 AMBIENT, ROOM – 25 ±2°C (77 ±3.6°F) or as specified by the manufacturer.

3.3 B VALUE – A NTC thermistor's index, which expresses the degree of resistance change when calculated from any two points specified by the manufacturer on the resistance/temperature (R/T) curve.

3.4 CIRCUIT, ISOLATED-LIMITED-ENERGY SECONDARY – A circuit derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and an open-circuit secondary voltage rating not exceeding 1000 volts. A circuit derived from a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is not an isolated-limited-energy secondary circuit.

3.5 CIRCUIT, LINE-VOLTAGE – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of a low-voltage or isolated-limited-energy secondary circuit.

3.6 CIRCUIT, LOW-VOLTAGE – A circuit involving a potential of not more than 30 volts (42.4 volts peak) or 60 volts dc and supplied by a primary battery, by a standard Class 2 transformer, or by a combination of a transformer and a current limiting impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is not a low-voltage circuit.

3.7 CIRCUIT, SAFETY – A primary or secondary circuit that contains a control relied upon to reduce a risk of fire, electric shock, or injury to persons. Examples include a circuit that limits the wattage to a limited-energy level or a circuit designed to limit temperatures.

3.8 CONTROL, SAFETY – An automatic control or interlock (including relays, switches, and other auxiliary equipment used to form a system) that is intended to reduce a risk of improper operation of the controlled equipment.

3.9 CURRENT, HOLD (I_h) – The maximum current a current limiting PTC thermistor is able to maintain in a low resistance "on" state at rated ambient for a period of time specified by the manufacturer.

3.10 CURRENT, INRUSH – As related to a PTC heater, the peak current measured following energization at rated voltage and at 25 ±2°C (77 ±3.6°F) or at the manufacturer's specified temperature.

3.11 CURRENT, FUNCTIONING (I_{fun}) OR TRIP (I_t) – For a current-limiting PTC thermistor, the minimum current value declared by the manufacturer at which a PTC thermistor switches from low to high resistance at a specified temperature or temperature range. I_t = Y x I_h, where Y is the trip current multiplier declared by the manufacturer.

3.12 CURRENT, MAXIMUM (I_{max}) – The current value assigned by the manufacturer that complies with all the requirements of this standard. For the various devices, the associated current designated as I_{max} is shown in Table 3.1.

Table 3.1
Maximum current

Device	Associated current designated I_{max}
PTC heater	Maximum steady-state current[a]
PTC control:	
Motor starting	Maximum start winding current
Other than motor starting	Maximum trip current[b]
NTC control	Maximum steady-state current
PTC or NTC sensor	Not applicable

[a] For devices rated in watts by the manufacturer, I_{max} is calculated.

[b] For devices assigned a time-to-trip versus current curve by the manufacturer, the maximum current (I_{max}) shall be identified.

3.13 CURRENT, SHORT-CIRCUIT (I_{sc}) – The maximum current available from the impedance limited source (such as a power supply).

3.14 CURRENT, STEADY-STATE (I_{ss}) – The current measured after a thermistor's temperature stabilizes in still air at 25 ±2°C (77 ±3.6°F) ambient, or at an ambient specified by the manufacturer while connected to rated voltage and while operating in its high-resistance state for PTC thermistors or low-resistance state for NTC thermistors. For some NTC thermistors, I_{ss} is the same as I_{max}.

3.15 ENVIRONMENT, CONTROLLED – An environment free of conductive contaminants– such as carbon dust, resulting from the end-use equipment in which the thermistor is installed or due to the environment of the end-use equipment– and provided with protection against humidity and the formation of condensation. A temperature and humidity controlled indoor area free of conductive contaminants is a controlled environment. An equivalent environment is provided by means of:

a) A hermetically sealed enclosure;

b) Encapsulation;

c) A conformal coating;

d) A gasketed, tight-fitting enclosure; or

e) A filter system that reduces the level of contamination used in conjunction with a system that reduces the level of condensation (for example, maintaining the surrounding air at constant temperature and low relative humidity).

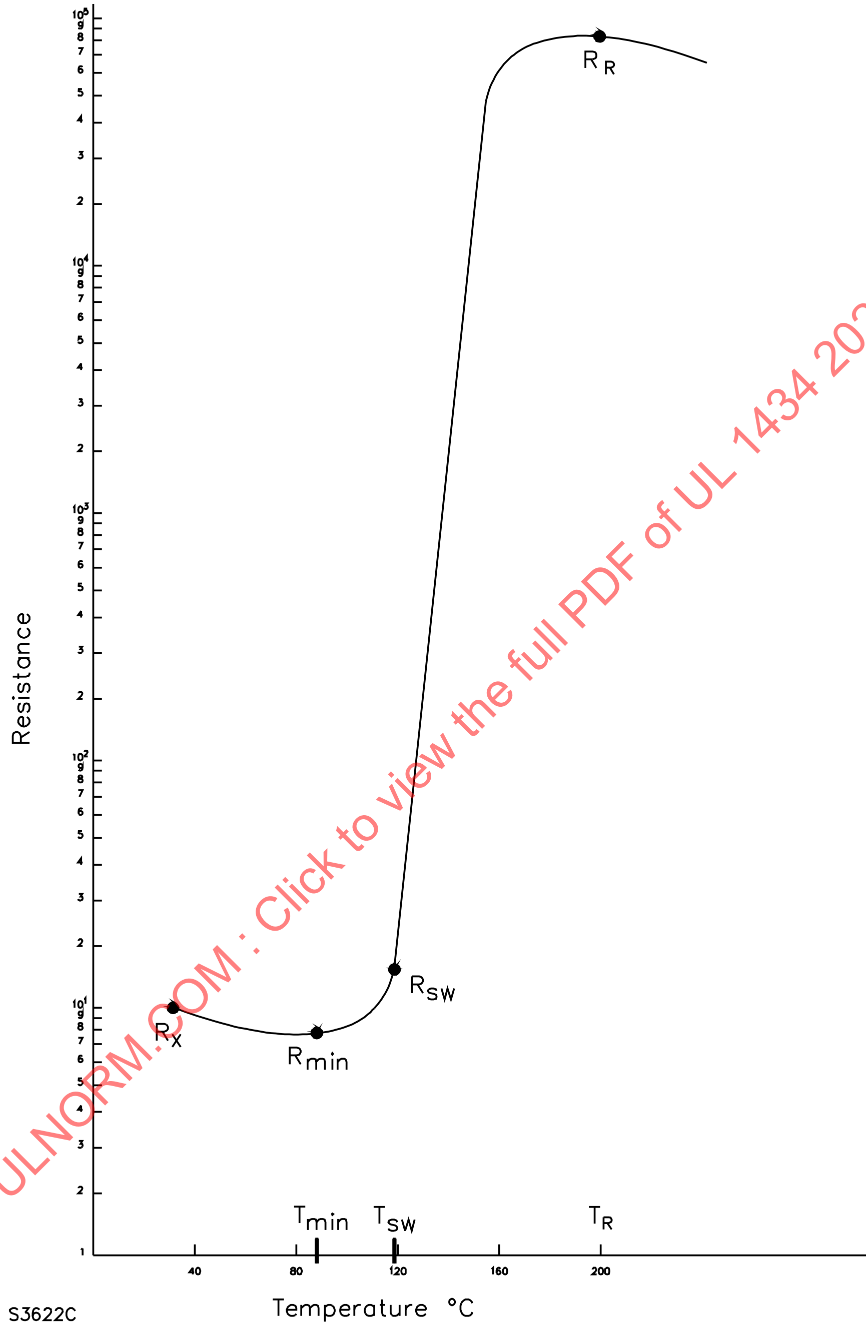
3.16 ENVIRONMENT, GENERAL – An environment that is not controlled in accordance with 3.15.

3.17 POLARITY, OPPOSITE – The relationship between two live parts such that an interconnection between the parts results in a flow of current which is limited only by the impedance of the circuit.

3.18 RESISTANCE/TEMPERATURE (R/T) CURVE – The graphical representation of the characteristics of resistance versus temperature. See Figure 3.1 and Figure 3.2 for typical curves. The significant portion of the curve for a PTC thermistor, as illustrated in Figure 3.1, is usually that portion of the curve representing the range of temperature over which the product is used. The R/T curve of some PTC thermistors has a negative slope from R_x (R_{25}) to R_{min} before the resistance begins to increase.

Figure 3.1

Typical R/T curve for a ceramic PTC thermistor



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NOTES:

R_{min} – The point of minimum resistance.

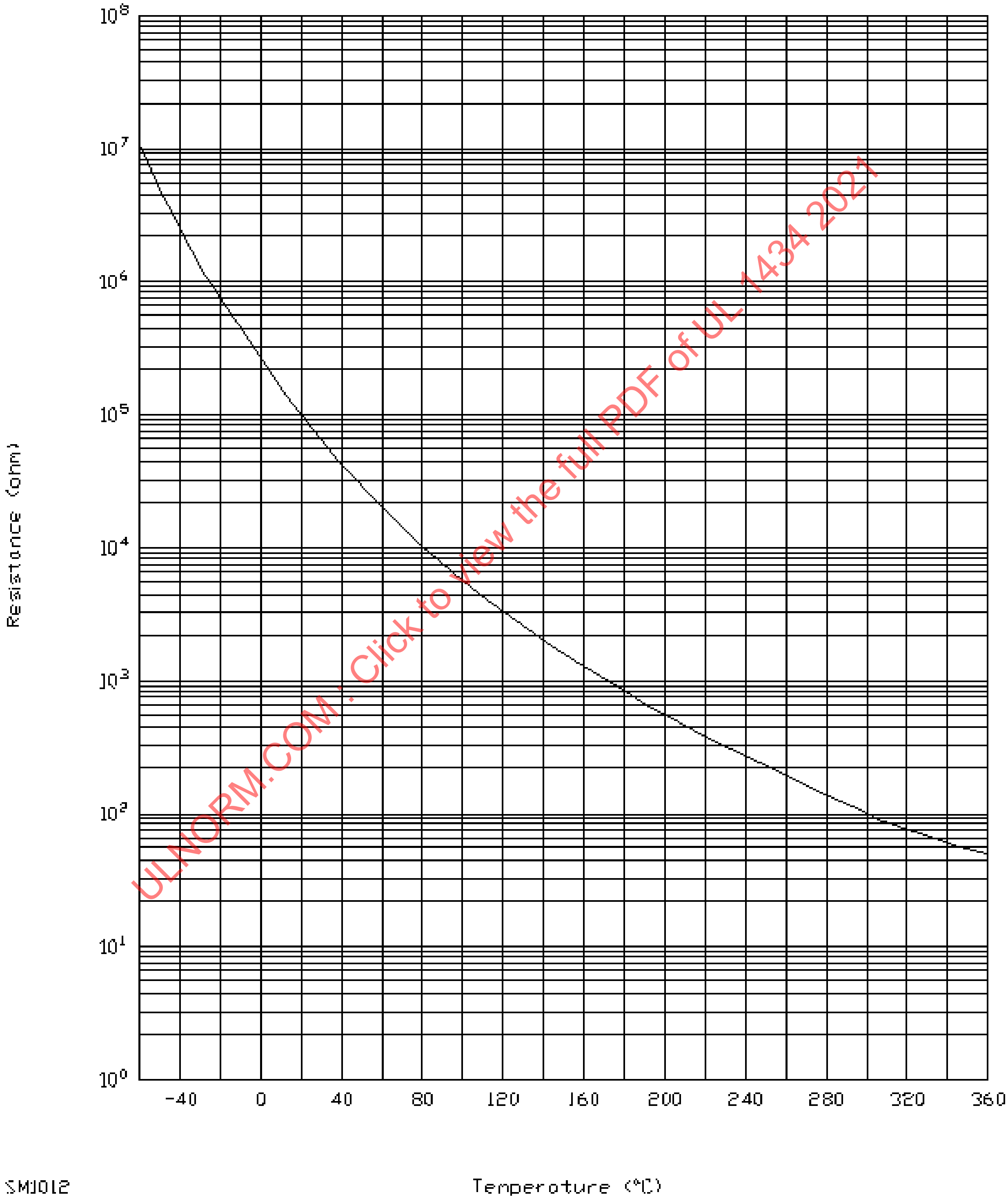
R_x (R_{25}) – Resistance at a temperature specified by the manufacturer for R_x or at 25 ±2°C (77 ±3.6°F) for R_{25}

T_{sw} – Switching temperature at which the resistance (R_{sw}) begins to increase sharply with temperature increases.

T_R – Thermal runaway temperature where resistance R_R starts to decrease.

Figure 3.2

Typical R/T curve for a NTC thermistor



3.19 RESISTANCE (R_{min}) – For a ceramic PTC thermistor, the point of minimum resistance on the R/T curve.

3.20 RESISTANCE, R_x (R_{25}) – The rated resistance at a temperature specified by the manufacturer for R_x or at 25 ±2°C (77 ±3.6°F) for R_{25}.

3.21 RESISTANCE, SWITCHING (R_{sw}) – For a ceramic PTC thermistor, the resistance value at which the resistance begins to increase sharply with temperature increase. For this Standard, R_{sw} is the value where the resistance is twice R_{min}; unless the manufacturer specifies R_{sw} with reference to R_{min} with a multiplying factor other than two, or with reference to R_x.

3.22 RESISTANCE, TRIPPED (R_{tr}) – For a PTC control thermistor, the resistance value of the thermistor in its tripped state at maximum voltage (V_{max}). R_{tr} is calculated by dividing the voltage drop across the thermistor by the steady-state current (I_{ss}) flowing through the thermistor.

3.23 TEMPERATURE, INDOOR – Relative to indoor use, nominal 25 ± 2°C (77±3.6°F) or as specified by the manufacturer.

3.24 TEMPERATURE, OUTDOOR – Relative to outdoor use, a temperature of 0°C (32°F) or less.

3.25 TEMPERATURE, SWITCHING (T_{sw}) – For a ceramic PTC thermistor, the temperature at which the resistance is at R_{sw}.

3.26 *Deleted*

3.27 TEMPERATURE, SURFACE (T_s) – The temperature of the surface of a thermistor while the thermistor is energized under normal operating conditions. Typical normal operating conditions for thermistors are specified in Table 3.2.

Table 3.2
Normal operating conditions

Type of Thermistor	Voltage	Current
PTC – Heater	V_{max}	I_{ss}
PTC – Motorstarting	V_{max}	I_{ss}
PTC – Degausser	V_{max}	I_{ss}
PTC – Current-Limiter	V_{max}	I_h and I_{ss}[a]
NTC – Inrush-current limiter	V_{max}	I_{max}

[a] Surface temperature measured at I_{ss} reflects the abnormal condition (tripped state).

3.27.1 TIME-TO-TRIP – The time required for a PTC thermistor to limit the manufacturer's declared trip current (I_t) to 50 percent of its value when energized at the rated voltage and ambient temperature.

3.28 TEMPERATURE, THERMAL RUNAWAY (T_R) – The high temperature point on the R/T curve at which a PTC thermistor's resistance no longer increases with increasing temperature.

3.29 *Deleted*

3.30 THERMISTOR – A thermally sensitive semiconductor resistor that has, over at least part of its R/T curve, a significant nonlinear change in its electrical resistance with a change in temperature. Typically, a change in temperature occurs due to the flow of current through the thermistor, as a result of a change in the ambient temperature, or a combination of both.

3.31 THERMISTOR, CONTROL – A NTC or PTC thermistor which directly controls a load by being connected in series with the load. A control thermistor is not intended for across-the-line use. Typical uses are current limiters, inrush-current limiters, degaussing coil-current limiters, and motor starting-current limiters.

3.32 THERMISTOR, NTC – A thermistor that exhibits a negative temperature coefficient (NTC) as indicated by a decrease in resistance with increasing temperature over the significant portion of the R/T curve. See Figure 3.2.

3.33 THERMISTOR PACKAGE – A thermistor pellet with leads, terminals, heatsink, housing, or any other additions.

3.34 THERMISTOR PELLET – A thermistor without any leads, terminals, heatsink, housing, or other additions.

3.35 THERMISTOR, PTC – A thermistor that exhibits a positive temperature coefficient (PTC) as indicated by an increase in resistance with increasing temperature over the significant portion of the R/T curve. See Figure 3.1.

3.36 THERMISTOR, SELF-CONTROLLED HEATER – A PTC heater which has no additional temperature limiter and which is used as a heater element because of its self-heating effect. It is typically used across-the-line.

3.37 THERMISTOR, SENSING – A NTC or PTC thermistor used as a sensor. A sensing thermistor does not carry a load current.

3.38 VOLTAGE, MAXIMUM (V_{max}) – The maximum voltage of a thermistor as declared by the manufacturer. V_{max} is higher than rated voltage (V_r) when a higher operating voltage occurs under certain conditions in the end-use equipment such as for motor starting-coil limiters.

3.39 VOLTAGE, RATED (V_r) – The input voltage of a thermistor as declared by the manufacturer. V_r is typically equal to the supply source voltage.

CONSTRUCTION

4 General

4.1 A thermistor shall be constructed so that it has the strength and rigidity to:

a) Withstand conditions encountered during intended use;

b) Resist the abuses to which it is subjected during intended use; and

c) Reduce the risks of fire, electric shock, and injury to persons.

5 Protection Against Corrosion

5.1 Corrosion protection shall be provided for iron and steel parts of enclosures. Iron and steel springs and other iron and steel parts, upon which the intended mechanical or electrical operation depends, shall also be provided with corrosion protection. The corrosion protection shall be by means of enameling, galvanizing, plating, or other equivalent means.

Exception: Corrosion protection is not required for stainless steel parts or small minor parts of iron or steel, such as washers, screws, and bolts, that are not current-carrying parts.

6 Insulating Material

6.1 An insulating material, used in a barrier or liner between parts of opposite polarity and a coating of a pellet, shall be rated for the intended conditions of use and shall comply with the requirements for internal barriers in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: No further evaluation is required for mica or a refractory material used as direct support of live parts.

7 Spacings

7.1 Line-voltage circuits

7.1.1 The spacings for a thermistor shall not be less than the applicable values specified in Table 7.1 and 7.1.2 – 7.1.4.

Exception: For other than spacings for field wiring terminals and spacings to a dead metal enclosure, the spacing requirements in Alternative Spacings – Clearances and Creepage Distances, Section 8, meet the intent of these requirements.

Table 7.1
Minimum spacings at a thermistor (regardless of polarity)

			Potential involved, volts (peak)		
Use	**Location**		**0 – 50 (0 – 70.7)**	**51 – 300 (72.1 – 424.2)**	**301– 600 (425.6 – 848.4)**
In a general environment	Over surface[a]	mm	1.0	1.5	2.0
		(Inch)	(0.04)	(0.06)	(0.08)
	Through air	mm	1.0	1.5	1.5
		(Inch)	(0.04)	(0.06)	(0.06)
In a controlled environment	Over surface[a]	mm	1.0	1.0	1.0
		(Inch)	(0.04)	(0.04)	(0.04)
	Through air	mm	1.0	1.0	1.0
		(Inch)	(0.04)	(0.04)	(0.04)
Sealed or encapsulated	Over surface[a]	mm	0.40	0.80	0.80
		(Inch)	(0.016)	(0.032)	(0.032)
	Through air	mm	0.40	0.80	0.80
		(Inch)	(0.016)	(0.032)	(0.032)

[a] Including the edge surfaces of the thermistor.

7.1.2 The spacings between an uninsulated live part and the wall of a metal enclosure, including fittings for connection of conduit or armored cable, shall not be less than 6.4 mm (1/4 in).

7.1.3 The spacings between terminals intended for field wiring, regardless of polarity, and between a field wiring terminal and a dead metal part (including an enclosure that is grounded when the end-use equipment is installed) shall not be less than 6.4 mm (1/4 in).

7.1.4 The spacings between uninsulated live parts and a dead metal part, (other than an enclosure), shall not be less than 3.2 mm (1/8 in). The construction of the parts shall be such that spacings are permanently maintained.

7.1.5 An insulating barrier or liner that is used to provide spacings, including spacings in conjunction with the required over surface spacings, shall not be less than 0.71 mm (0.028 in) thick.

Exception No. 1: A barrier or liner that is used in conjunction with at least one-half the required through-air spacing shall not be less than 0.33 mm (0.013 in) thick. Such a barrier or liner shall:

a) Be an insulating material complying with Insulating Material, Section 6;

b) Be resistant to moisture;

c) Have the mechanical strength required for the application when it is exposed or otherwise subjected to mechanical stress;

d) Be mechanically held in place; and

e) Be located so that it is not adversely affected, including the effects of arcing, by operation of the equipment during intended service.

Exception No. 2: See 7.1.7 and 7.1.8.

7.1.6 An insulating barrier or liner used as the sole separation between an uninsulated live part and a grounded part or between live parts of opposite polarity shall be of such thickness and supported so that deformation of the barrier or liner does not reduce the spacings to less than the required spacings. In any case, the thickness shall not be less than 0.71 mm (0.028 in). Otherwise, a barrier or liner shall be used in conjunction with not less than 0.8 mm (1/32 in) air spacing.

Exception: See 7.1.7 and 7.1.8.

7.1.7 An insulating barrier or liner having a thickness less than that specified in 7.1.5 and 7.1.6 complies with the requirements when it is investigated and found to:

a) Be rated for the intended conditions of use; and

b) Be equivalent mechanically and electrically to a barrier or liner of the thickness specified in 7.1.5 and 7.1.6.

7.1.8 Mica shall not be less than 0.4 mm (1/64 in) thick when it is used in place of the through-air spacing specified in Table 7.1. The mica shall be permanently fixed in position.

7.2 Low-voltage and isolated-limited-energy secondary circuits

7.2.1 Safety circuits

7.2.1.1 The spacings in safety circuits shall be as specified in 7.2.1.2 – 7.2.1.5 where a short circuit between the parts involved results in operation of the controlled device along with a risk of fire, electric shock, or injury to persons.

7.2.1.2 The spacings between an uninsulated live part and the wall of a metal enclosure, including fittings for connection of conduit or armored cable, shall not be less than 3.2 mm (1/8 in).

7.2.1.3 The spacings between terminals intended for field wiring, regardless of polarity, and between a field wiring terminal and a dead metal part (including an enclosure that is grounded when the end-use equipment is installed) shall not be less than 6.4 mm (1/4 in).

7.2.1.4 The spacings between an uninsulated live part and a dead metal part (other than an enclosure) shall not be less than 0.8 mm (1/32 in). The construction of the parts shall be such that the spacings are permanently maintained.

7.2.1.5 The spacing between uninsulated live parts, regardless of polarity, shall not be less than 0.4 mm (1/64 in).

Exception: For sealed or encapsulated parts, the spacings shall not be less than 0.20 mm (0.008 in).

7.2.2 Other than safety circuits

7.2.2.1 The spacings between uninsulated live parts of opposite polarity and between such parts and dead metal that is grounded when the end-use equipment is installed are not specified for parts of a thermistor intended for use in a low voltage or an isolated-limited-energy secondary circuit. The spacings shall be based on compliance with the applicable dielectric voltage-withstand and overload tests performed on the end-use equipment.

8 Alternative Spacings – Clearances and Creepage Distances

8.1 For spacings other than at field wiring terminals and to a dead metal enclosure, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, apply as an alternative to the spacing requirements in Spacings, Section 7.

8.2 When applying the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the degree of pollution used shall be as specified in Table 8.1.

Table 8.1
Degrees of pollution

End-use equipment	Pollution Degree
Hermetically sealed or encapsulated equipment or a printed wiring board assembly with a protective coating[a].	1
Equipment for nonhazardous locations, indoor use, and nonsafety applications for installation on or in appliances.	2
All safety applications, equipment for outdoor use, and equipment influenced by surrounding environment.	3
Pollution that generates persistent conductivity through conductive dust or rain and snow.	4

[a] Complying with the protective coating test in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

8.3 When applying the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the requirements shall be based on the overvoltage categories indicated in Table 8.2.

Table 8.2
Overvoltage categories

End-use equipment	Overvoltage Category
Power-limited and safety[a]	I
Portable and stationary cord-connected applications	II
Intended for fixed wiring application	III

[a] Applicable to isolated-limited-energy secondary and low-voltage circuits where a short circuit between the parts involved results in operation of the controlled equipment along with an increased risk of fire, electric shock, or injury to persons.

8.4 In order to evaluate clearances on the basis that the levels of overvoltage are controlled, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the end-use equipment. The equipment shall be evaluated for the rated impulse withstand voltage specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

8.5 Printed wiring boards constructed of Types XXXP, XXXPC, G-10, FR-2, FR-3, FR-4, FR-5, CEM-1, CEM-3, GPO-2, or GPO-3 industrial laminates in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, are rated as having a minimum comparative tracking index of 100 without further investigation.

9 Live Parts

9.1 Deleted December 15, 2000.

9.2 Current-carrying parts shall have the mechanical strength and ampacity, and be constructed of material that is rated for the intended conditions of use.

9.3 Uninsulated live parts, including terminals, shall be secured to their supporting surfaces by a method other than friction between surfaces to prevent turning or shifting in position where such motion results in reduction of spacings to less than those specified in Table 7.1. The securement of contact assemblies shall be such that alignment of contacts is maintained.

PERFORMANCE – PTC THERMISTORS

10 General

10.1 Unless otherwise specified, representative samples as indicated in Table 10.1 shall be subjected to the tests specified in Sections 11 – 20. New samples are to be used for all tests other than the Overload and Endurance Tests.

Table 10.1
Test sample distribution and test program

		Test (section reference)							
		Aging (12)	Heat-cold-humidity cycling (13)	Overload (14)	Endurance (15)	Cold operational cycling (16)	Cold thermal cycling (17)	Limited short-circuit (18)	Thermal run-away (19)
Number of samples per test		3	3	3[a]	3[a]	3	3	3	3
Thermistor application	Heater	X	X	X	X	X	–	–	X
	Control	X	X	X	X	X	–	X	X
	Sensing	X	X	X	X	–	X	–	–
Test samples	Pellet	X	–	–	–	–	–	–	–
		OR							
	Package	X	X[b]	X[b]	X[b]	X[b]	X[b]	X[b]	X[b]

NOTE – The resistance/temperature (R/T) measurement is to be conducted before and after each test in Sections 12, 13, and 15 – 18.

[a] The same three samples are to be used for both the overload and endurance tests.

[b] Tests on pellet samples, when package samples are not provided or when package samples are provided with soldered leads, meet the intent of these requirements.

10.2 Unless otherwise specified, all test temperatures shall be within ± 2°C (± 3.6°F).

10.3 Tests shall be conducted for each temperature and electrical rating unless one temperature or electrical rating is representative of others.

10.4 Unless otherwise specified, the tests are to be conducted at rated frequency and at the voltage specified in Table 10.2. In the event that the thermistor operation changes when the input voltage within the rated voltage (V_r) range is varied, tests are to be conducted at both the high and low values of the rated voltage (V_r) range. For a thermistor with a single voltage rating that has changes in operation as a result of testing at the test potential specified in Table 10.2, a test is also to be conducted at the voltage rating of the thermistor.

Table 10.2
Test voltages

Voltage rating (V_r) of thermistor[a]	Test voltage
110 – 120	120
220 – 240	240
254 – 277	277
440 – 480	480
555 – 600	600

NOTE – See 10.3 and 10.4.

[a] For a thermistor with a single voltage rating that does not fall within any of the indicated voltage ranges, the thermistor is to be tested at its rated voltage. For a thermistor rated with a range of voltages with one or more of the values falling within one of the indicated voltage ranges, the thermistor is to be tested at the test potential specified for the indicated range or at the highest value of the rated range, whichever is greater. For a thermistor rated with a range of voltages with none of the values falling within any of the indicated voltage ranges, the thermistor is to be tested at the highest value in the specified range. For a thermistor with a dual rating, the thermistor is to be tested for both ratings unless testing for one rating is representative of testing for the other rating.

10.5 A temperature is stable when three successive readings measured by thermocouples at intervals of 10 percent of the previously elapsed duration of the test indicate no change greater than ±1°C (±1.8°F). In any case, the interval duration shall not be less than 5 minutes.

11 Calibration Tests

11.1 General

11.1.1 In the "as-received" condition, each thermistor sample shall be subjected to an R/T test and one or more of the applicable calibration tests described in Sections 11.4 – 11.6. Test results shall be within the manufacturer's specified limits.

11.1.2 Following the tests described in Sections 12, 13, and 15 – 18, the previously performed calibration tests are to be repeated. Test results shall be within one of the Classes as specified in Table 11.1, Table 11.2, or Table 11.3 and within the limits specified in the end-product standard. Compliance is to be determined as follows:

a) Heater – Surface Temperature Test, Section 11.6, is to be repeated. The surface temperature (T_s) shall not vary from the initial "as-received" surface temperature (T_s) by more than indicated in Table 11.1, and an insulated thermistor shall comply with Dielectric Voltage-Withstand Test, Section 20.

b) Control – An R/T curve is to be created as described in 11.2. The surface temperature as determined in accordance with Section 11.6, shall not vary from the initial as received temperature by more than indicated in Table 11.2, and an insulated thermistor shall comply with Dielectric Voltage-Withstand Test, Section 20. Additional declarations provided by the manufacturer, such as “hold current” (I_h) and “time-to-trip” ratings shall be within the manufacturer's specifications after conditioning.

c) Sensing – An R/T curve is to be created as described in 11.2. The temperature at R_x (R_{25}), R_{sw}, and at a third intermediate resistance specified by the manufacturer shall not vary from the respective “as-received” temperatures on the “as-received” R/T curve by more than indicated in Table 11.3 and an insulated thermistor shall comply with Dielectric Voltage-Withstand Test, Section 20.

Exception: A dielectric voltage-withstand test is not required for a thermistor identified as uninsulated. See also 20.4.

Table 11.1
Classes for PTC heater thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Surface temperature in °C percent drift	±5	±10	±15	±20

Table 11.2
Classes for PTC control thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature in °C at the tripped resistance (R_{tr}), percent drift	±5	±10	±15	±20

Table 11.3
Classes for PTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature drift, K for a given resistance	±0.5	±1.0	±2.0	±5.0
Temperature values should be "normalized" to the Kelvin scale when determining the temperature drift.				

11.2 R/T measurement for PTC thermistors – all types

11.2.1 Thermistor samples are to be placed in a full draft circulating-air oven or fluid medium, such as silicon oil or flourinert, with the temperature maintained within ±1.0°C (±1.8°F) of the temperature specified for the test. The test is to be conducted at various temperatures starting at room ambient through the switching temperature (T_{sw}) and not exceeding the thermal runaway temperature (T_R) of the R/T curve. The resistance is be measured by an ohmmeter at as many temperatures as required to create a complete R/T curve.

Exception: For PTC heaters, calculation of the resistances as described in 11.3 meet the intent of this requirement.

11.3 R/T measurement for PTC heaters

11.3.1 For PTC heaters only, thermistor samples are to be placed in a full draft circulating-air oven or fluid medium, such as silicon oil or flourinert, with the temperature maintained within ±1°C (±1.8°F) of the temperature specified for the test. The test is to be conducted at various temperatures, starting at room ambient and not exceeding the thermal runaway temperature (T_R) of the R/T curve. The resistance is to be determined at as many temperatures as required to create a complete R/T curve.

11.3.2 Each thermistor is to be connected in series with a resistor (r) located external to the air-oven or fluid medium. The series resistor (r) is to be rated less than, or equal to, 0.02 times the rated resistance of the thermistor. The circuit is to be connected to rated voltage (V_r). The peak voltage (V_p) is to be measured across the series resistor (r) during the first full alternating cycle. The resistance of each thermistor is to be calculated using the equation:

$$R = r\left[\frac{V_r \times 1.414}{V_p} - 1\right]$$

in which:

R is the resistance of the thermistor,

r is the resistance of the series test resistor,

V_r is the rated voltage, and

V_p is the measured peak voltage.

11.4 Hold current (I_h) test for PTC current limiters

11.4.1 A current limiting thermistor shall maintain the specified hold current (I_h) for the time specified by the manufacturer at the ambient temperature specified by the manufacturer without tripping.

11.5 Time-to-trip test for PTC current limiters

11.5.1 A current limiting thermistor with a time-to-trip specification shall trip at the specified trip current (I_t) and corresponding rated voltage (V_r) within the specified time-to-trip. A thermistor with multiple trip currents and times is to be tested at the maximum and minimum specified currents. The current is not to exceed the maximum current (I_{max}) point on the time-to-trip versus current curve.

11.6 Surface temperature test

11.6.1 The surface temperature (T_s) of a PTC thermistor is to be measured using thermocouples or equivalent devices. For a PTC thermistor other than a current limiter, the surface temperature (T_s) is to be measured while the thermistor is operating at maximum voltage (V_{max}) and steady-state current. For a PTC current limiter, the surface temperature (T_s) is to be measured under two conditions:

a) Normal operating condition where the device is to be operated at its rated maximum voltage (V_{max}) and rated hold current (I_h), and

b) Abnormal operating condition where the device is to be operated at rated maximum voltage (V_{max}) and rated steady-state current (I_{ss}).

See Table 3.2.

11.6.2 For constructions where the surface of a PTC thermistor is not accessible due to packaging or coating, the surface temperature (T_s) is to be determined in accordance with 11.6.3. The temperature shall be within the maximum and minimum temperatures specified by the manufacturer and is to be recorded and used for Aging Test, Section 12.

12.4 revised and relocated as 11.6.2

11.6.3 While operating at maximum voltage (V_{max}), the voltage drop (V) across the thermistor and the steady-state current (I_{ss}) flowing through the thermistor are to be measured. The surface temperature (T_s) is to be determined at the point on the R/T curve corresponding to the resistance calculated using the following equation:

$$R = \frac{V}{I_{ss}}$$

in which:

R is the calculated resistance,

I_{ss} is the measured steady-state current as defined in 3.14, and

V is the measured voltage drop across the thermistor.

12 Aging Test

12.1 Following the conditioning specified in 12.2, a thermistor shall comply with 11.1.2.

12.2 For other than a control thermistor with infrequent occurrences of tripping during end use, three unenergized samples of all other types of PTC thermistors are to be conditioned for 1000 hours in a full draft air-circulating oven at a temperature 30°C (54°F) above the temperature specified in items (a) and (b) for each type of PTC thermistor. In any case, the oven temperature shall not be less than 70°C (158°F) and is to be maintained within ±5°C (±9°F) of the temperature specified for the test. The oven temperature is to be monitored within the area of the oven in which the samples are being tested.

a) For a heater or control thermistor, the surface temperature (T_s) as determined in accordance with Surface Temperature Test, Section 11.6; or

b) For a sensing thermistor, the maximum rated temperature.

12.2.1 When tripping is an infrequent end-use occurrence, such as for a current limiter, three samples of a thermistor are to be energized and conditioned for 1000 hours while in the tripped state at maximum voltage (V_{max}) and carrying steady-state current (I_{ss}).

12.3 Revised and combined with 11.6.1.

12.4 Revised and relocated as 11.6.2.

12.5 Revised and relocated as 11.6.3.

13 Heat-Cold-Humidity Cycling Test

13.1 Following the conditioning specified in 13.2, a thermistor shall comply with 11.1.2.

13.2 Three unenergized samples of a thermistor are to be subjected to three complete cycles in the sequence specified in (a) or (b):

a) Indoor temperature use:

1) 24 hours at the surface temperature (T_s) determined in accordance with Surface Temperature Test, Section 11.6. In any case, the temperature shall not be less than 70°C (158°F). The oven temperature is to be maintained within ±5°C (±9°F) of the temperature specified for the test. The temperature is to be monitored within the area of the oven in which the samples are being tested;

2) 168 hours in a noncondensing atmosphere having a relative humidity of 90 – 95 percent at 40°C (104°F); and

3) 8 hours at 0°C (32°F) or at the manufacturer's specified ambient, whichever is lower.

b) Outdoor temperature use:

1) 24 hours immersed in water at 25°C (77°F);

2) 8 hours at minus 35° C (minus 31° F) or at the manufacturer's specified ambient, whichever is lower;

3) 24 hours at the surface temperature (T_s) determined in accordance with Surface Temperature Test, Section 11.6. In any case, the temperature shall not be less than 70°C (158°F). The oven temperature is to be maintained within ±5°C (±9°F) of the temperature specified for the test. The oven temperature is to be monitored within the area of the oven in which the samples are being tested; and

4) 168 hours in a noncondensing atmosphere having a relative humidity of 90 – 95 percent at 40°C (104°F).

14 Overload Test

14.1 Following the tests specified in 14.2, 14.3, or 14.4 and 15.1, a thermistor shall comply with 11.1.2.

14.2 For a heater, three samples are to be mounted and operated as intended for 50 cycles while connected to 120 percent of maximum voltage (V_{max}). Each cycle is to cover that portion of the R/T curve from the lower knee to the high resistance state.

14.3 For a control thermistor, three samples are to be mounted and operated as intended for 50 cycles while connected to maximum voltage (V_{max}) and the lesser value of:

a) 120 percent of rated maximum current (I_{max}), or

b) 120 percent of rated short-circuit current (I_{sc}).

Each cycle is to start with the sample thermally stabilized at 25 ±5°C (77 ±9°F). Each cycle is to cover that portion of the R/T curve from the lower knee to the high resistance state.

14.4 For a sensing thermistor, three samples are to be mounted and operated as intended for 50 cycles of operation consisting of starting with the sample thermally stabilized at 25 ±5°C (77±9°F) and increasing the temperature to 120 percent of the maximum rated temperature of the thermistor.

15 Endurance Test

15.1 The three thermistor samples that have been subjected to Overload Test, Section 14, are to be operated at the conditions specified in (a), (b), or (c) for the number of cycles specified in Table 15.1. Each cycle is to cover a significant portion of the R/T curve.

a) Heater – A heater thermistor or heater assembly is to be mounted and tested at maximum voltage (V_{max}) maximum rated wattage or maximum current (I_{max}). A thermistor, whose power consumption varies with the amount of heat sinking, air flow, or similar variables provided in the end-use equipment, is to be tested at the maximum rated wattage or maximum current (I_{max}) using the heat sinking, air flow, or other conditions of the end-use equipment.

b) Control – A control thermistor is to be tested at maximum voltage (V_{max}) and the following currents:

1) Current limiting – The test current shall not be less than the minimum tripping current (I_t) or the minimum functioning current (I_{fun}).

2) Degaussing – The test current shall be maximum current (I_{max}).

3) Motor Starting – The test current shall be maximum current (I_{max}).

c) Sensing – A sensing thermistor is to be cycled between 25 ±5°C (77 ±9°F) and the maximum rated temperature.

Table 15.1
Number of cycles for endurance test

Type of thermistor	Number of cycles of operation
Heater	100,000
Control (current-limiting: intended for use in a safety circuit)	100,000[a]
Control (current-limiting: not intended for use in a safety circuit)	30,000[a]
Control (degaussing or motor starting)	30,000
Sensing (not intended for use in a safety circuit)	6,000
Sensing (intended for use in a safety circuit)	100,000

[a] The minimum number of cycles is reduced to 6000 under the following conditions:
a) The trip state of the thermistor is apparent in the end-use application; and
b) Manual intervention is required in order to reset the thermistor.

16 Cold Operational Cycling Test

16.1 Following the test specified in 16.2, a thermistor shall comply with 11.1.2.

Exception: A sensing thermistor is not required to be subjected to this test.

16.2 Three samples of a thermistor are to be subjected to 1000 cycles of operation at an ambient temperature of 0° C (32° F) or at the manufacturer's specified ambient, whichever is lower. The test conditions are to be as specified in 15.1(a) for a heater or 15.1(b) for a control thermistor. The thermistor temperature is to be returned to the starting temperature before each cycle.

17 Cold Thermal Cycling Test

17.1 Following the cycling specified in 17.2, a thermistor shall comply with 11.1.2.

17.2 Three samples of a sensing thermistor are to be subjected to 1000 cycles of cold thermal cycling operation. Each cycle is to start at 0° C (32° F) or at the manufacturer's specified ambient, whichever is lower, and cover that portion of the R/T curve from the starting temperature to the maximum rated temperature.

18 Limited Short-Circuit Test

18.1 General

18.1.1 Following the test specified in 18.2.1 or 18.3.1, a thermistor shall:

a) Comply with the requirements in 11.1.2 or be in a permanently high resistance state; and

b) Complete the test without igniting the cotton indicator or opening the ground fuse described in 18.1.4 and 18.1.5.

18.1.2 When the results of the Limited Short-Circuit Test on the thermistor itself comply with 18.1.1, the test is not required to be repeated during the investigation of the end product.

18.1.3 Three samples of a control thermistor are to be subjected to this test. The test is to be conducted at rated voltage (V_r).

18.1.4 A ground fuse is to be connected between the metal enclosure, metal mounting surface, or metal screen described in 18.1.5 and the unswitched line to indicate an arc-over to the enclosure or mounting surface. Where each line is switched, the fuse is to be connected between the enclosure, mounting surface, or screen and the live pole least likely to arc to ground. The fuse is to be a 3.0 A nontime-delay fuse having a voltage rating not less than the rated voltage (V_r) of the thermistor.

18.1.5 Cotton not less than 12.7 mm (1/2 in) thick is to surround a metal screen enclosing the thermistor at a distance not more than 12.7 mm from all parts of the thermistor.

18.1.6 The cotton is to be surgical cotton, such as commonly used for medical purposes.

18.2 Primary circuit applications

18.2.1 For a control thermistor intended for use in a primary circuit application – such as current limiting, and motor starting – three samples are to be tested as described in 18.1.2 – 18.1.6 at rated maximum short-circuit current (I_{sc}) as shown in Figure 18.1 and operated as intended for one cycle. The current for the test is to be as specified in Table 18.1 with a power factor of 0.9 – 1.0. The cycle is to have a duration of two seconds "ON" time. Each sample is to be connected in series with a nontime-delay fuse with a rating equivalent to the rating of the branch circuit to which the end-use equipment is intended to be connected. In any case, the fuse shall not be less than 20A. The short-circuit load resistance (R_{sc}) is to be calculated using the following equation:

$$R_{sc} = \frac{V_r}{I_{sc}}$$

in which:

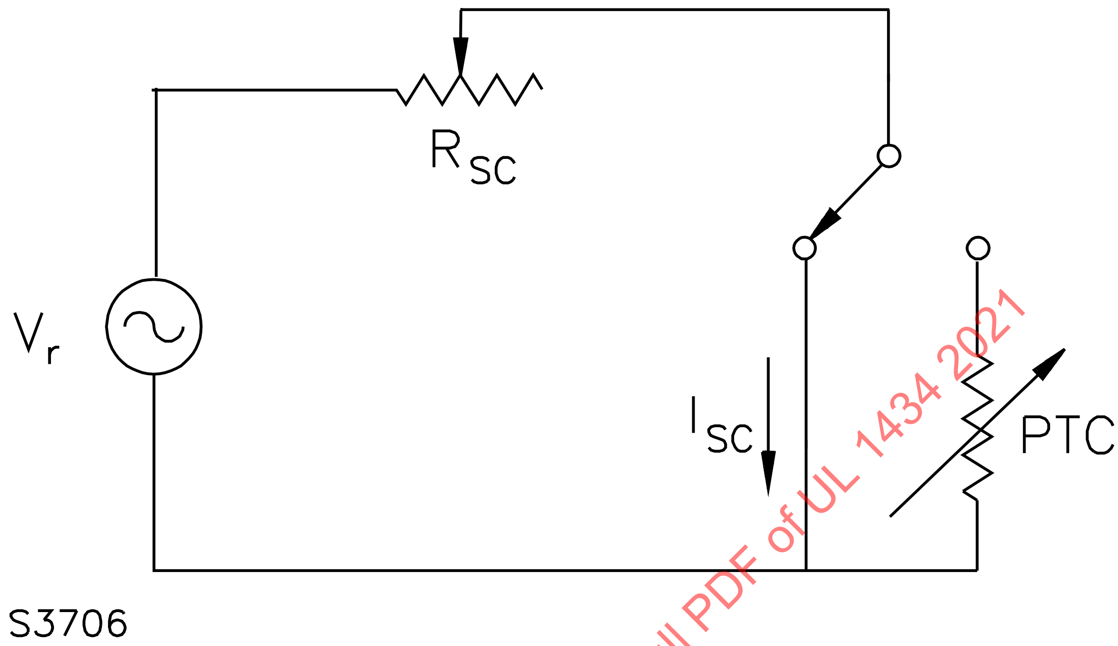
R_{sc} *is the load resistance for the short-circuit test,*

V_r *is the rated voltage, and*

I_{sc} *is the maximum short-circuit current.*

Figure 18.1

Test circuit for limited short-circuit test



Note: For the test for primary circuit applications, a branch-circuit fuse is to be connected in the test circuit on the line side of the thermistor. See 18.2.1.

Table 18.1
Current for limited short-circuit test

Rating of controlled equipment			Short-circuit current (Isc), A
Volt-amperes		Volts	
Alternating current	Direct current		
0 – 1176	0 – 624	0 – 250	200
0 – 1176	0 – 624	251 – 600	1000
1177 – 1920	625 – 1128	0 – 600	1000
1921 – 4080	1129 – 3000	0 – 250	2000
4081 – 9600	3001 – 6960	0 – 250	3500
9601 or more	6961 or more	0 – 250	5000
1921 or more	1129 or more	251 – 600	5000

18.3 Other than primary circuit applications

18.3.1 For a control thermistor intended for use in an impedance limited circuit or direct-current (DC) circuit application– such as current-limiting – three samples are to be tested as described in 18.1.2 – 18.1.6 at rated maximum short-circuit current (I_{sc}) as shown in Figure 18.1 and operated as intended for ten cycles. The power factor of the circuit is to be 0.9 – 1.0. Each cycle is to have a duration of two seconds "ON" time. The short-circuit load resistance (R_{sc}) is to be calculated using the equation in 18.2.1.

19 Thermal Runaway Test

19.1 There shall not be electrical or mechanical breakdown, expulsion of particles, or evidence of a risk of fire or electric shock as a result of the test specified in 19.2.

19.2 Each of the three samples is to be connected to a variable power source. The voltage is to be gradually increased from rated voltage to 200 percent of the maximum voltage (V_{max}). The voltage is to be increased in increments of 10 percent of rated voltage (V_r) at intervals of 2 minutes maximum. The test voltage is to be maintained for 2 minutes. During the test, maximum current (I_{max}) is not to be exceeded.

20 Dielectric Voltage-Withstand Test (For Insulated Thermistors Only)

20.1 An insulated thermistor intended for use in a line-voltage circuit or an isolated-limited-energy secondary circuit shall withstand for 1 minute, without breakdown, the application of an alternating potential of 1000 volts plus twice maximum rated voltage (V_r) between line-voltage parts and grounded or exposed metal parts or the enclosure.

20.2 An insulated thermistor intended for use in a low-voltage circuit shall withstand for 1 minute, without breakdown, the application of an alternating potential of 500 volts applied between low-voltage parts and grounded or exposed metal parts or the enclosure.

20.3 For a sensing thermistor (typically used in a low-voltage circuit) with an insulation voltage rating, the test is to be performed at a potential of 1000 volts plus twice the insulation voltage rating between the terminals and grounded or exposed metal parts or the enclosure.

20.4 A thermistor employing a barrier or liner to insulate an exposed dead metal part shall comply with 20.1, 20.2, or 20.3 between live parts and the exposed dead metal part.

20.5 To determine compliance with 20.1 – 20.4, the thermistor is to be tested using a 500 volt-ampere or larger capacity transformer, the output voltage of which is sinusoidal and variable. The applied potential is to be increased from zero until the specified test level is reached, and is to be held at that level for 1 minute. The increase in the potential is to be at a substantially uniform rate and as rapidly as is consistent with its value being correctly indicated by a voltmeter.

Exception: The use of a 500 volt-ampere or larger capacity transformer is not required when a voltmeter is provided to directly measure the applied potential.

PERFORMANCE – NTC THERMISTORS

21 General

21.1 Unless otherwise specified, representative samples as indicated in Table 21.1 shall be subjected to the tests specified in Sections 22 – 29. New samples are to be used for all tests other than the Overload and Endurance Tests.

Table 21.1
Test sample distribution and test program

		Test (section reference)					
		Aging (23)	Heat-cold-humidity cycling (24)	Overload (25)	Endurance (26)	Cold operational cycling (27)	Cold thermal cycling (28)
Number of samples per test		3	3	3[a]	3[a]	3	3
Thermistor application	Inrush-current limiting	X	X	X	X	X	–
	Sensing	X	X	X	X	–	X
Test samples	Pellet	X	-	-	–	–	–
		OR					
	Package	X	X[b]	X[b]	X[b]	X[b]	X[b]

NOTE – The resistance/temperature (R/T) measurement is to be conducted before and after each test in Sections 23 – 28.

[a] The same three samples are used for both the overload and endurance tests.

[b] Tests on pellet samples, when package samples are not provided or when package samples are provided with soldered leads, meet the intent of these requirements.

21.2 Unless otherwise specified, all test temperatures shall be within ± 2°C (± 3.6°F).

21.3 Tests shall be conducted for each temperature and electrical rating unless one temperature or electrical rating is representative of others.

21.4 Unless otherwise specified, the tests on inrush-current limiting thermistors are to be conducted at rated frequency and at the voltage specified in Table 21.2. In the event that the thermistor operation changes when the input voltage within the rated voltage (V_r) range is varied, tests are to be conducted at both the high and low values of the rated voltage (V_r) range. For a thermistor with a single voltage rating, that has changes in operation as a result of testing at the test potential specified in Table 21.2, a test is also to be conducted at the voltage rating of the thermistor.

Table 21.2
Test voltages

Voltage rating (V_r) of thermistor[a]	Test voltage
110 – 120	120
220 – 240	240
254 – 277	277
440 – 480	480
555 – 600	600

NOTE: See 21.3 and 21.4.

[a] For a thermistor with a single voltage rating that does not fall within any of the indicated voltage ranges, the thermistor is to be tested at its rated voltage. For a thermistor rated with a range of voltages with one or more of the values falling within one of the indicated voltage ranges, the thermistor is to be tested at the test potential specified for the indicated range or at the highest value of the rated range, whichever is greater. For a thermistor rated with a range of voltages with none of the values falling within any of the indicated voltage ranges, the thermistor is to be tested at the highest value in the specified range. For a thermistor with a dual rating, the thermistor is to be tested for both ratings unless testing for one rating is representative of testing for the other rating.

21.6 A temperature is stable when three successive readings measured by at intervals of 10 percent of the previously elapsed duration of the test indicate no change greater than ±1.0 °C (±1.8°F). In any case, the duration of the intervals shall not to be less than 5-minutes.

22 Calibration Tests

22.1 General

22.1.1 In the "as-received" condition, each thermistor sample is to be subjected to an R/T test as described in 22.2 and the applicable calibration tests described in 22.3 and 22.4. Test results shall be within the manufacturer's specified limits.

22.1.2 Following the tests described in Sections 23, 24, and 26 - 28 all previously conducted calibration tests are to be repeated. Test results shall be within one of the Classes as indicated in Table 22.1 or Table 22.2, and within the limits specified in the end-product standard and:

a) An inrush-current limiter shall not vary from the "as-received" R/T curve by more than indicated in Table 22.1, and an insulated thermistor shall comply with Dielectric Voltage-Withstand Test, Section 29.

b) For a sensing thermistor – After the tests, the resistance at three temperatures is to be determined. One of the temperatures is to be 25°C (77°F). The other two temperatures are to span the operating range of the thermistor. From the "as received" R/T curve, the corresponding temperatures for these resistances are to be determined. For each resistance, the temperature drift from the "as-received" condition is to be determined. The percent temperature drift shall not vary from the "as-received" R/T curve by more than indicated in Table 22.2, and an insulated thermistor shall comply with Dielectric Voltage-Withstand Test, Section 29.

Exception: A dielectric voltage-withstand test is not required for a thermistor identified as uninsulated. See also 29.4

Table 22.1
Classes for NTC inrush-current limiter thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature in °C for a given resistance, percent drift	±5	±10	±15	±20

Table 22.2
Classes for NTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature drift, K for a given resistance	±0.5	±1.0	±2.0	±5.0
Temperature values should be “normalized“ to the Kelvin scale when determining the temperature drift.				

22.2 R/T measurement for NTC thermistors

22.2.1 Thermistor samples are to be placed in a full draft circulating-air oven or fluid medium, such as silicon oil or flourinert, with the temperature maintained within ±1°C (±1.8°F) of the temperature specified for the test. The test is to be conducted at various temperatures, starting at room ambient and not exceeding the surface temperature (T_s) determined in accordance with 22.3.1. The resistance is to be measured at as many temperatures as required to create a complete R/T curve Measuring the resistance using an ohmmeter complies with the requirement.