2) If the product is provided with either internally or externally connected speakers, an audio load of equal impedance is to be substituted for each speaker or assembly of speakers provided.

3) If the product is not provided with speakers but the speaker impedance rating is marked on the product, an audio load of impedance equal to that marked on the product is to be connected to the product output terminals according to the manufacturer's instructions, or

4) If the product is not provided with speakers and there is no speaker impedance rating marked on the product, an audio load that results in the highest audio output power per channel of amplification is to be connected to the product output terminals in accordance with the manufacturer's instructions.

The audio load connected to each product is to be essentially resistive with not more than a 10-percent reactive component at any frequency up to 5 kHz. The audio load is to be capable of continuously dissipating the full output of the product while maintaining the resistance within 1 percent of its rated value.

g) Signal Input Not Affecting Power Input – A product provided with signal-input circuits need not be connected to an input signal if:

1) The signal-input circuits do not amplify the signal in the product, and

2) The supply-circuit input power or current is not noticeably affected by a signal input.

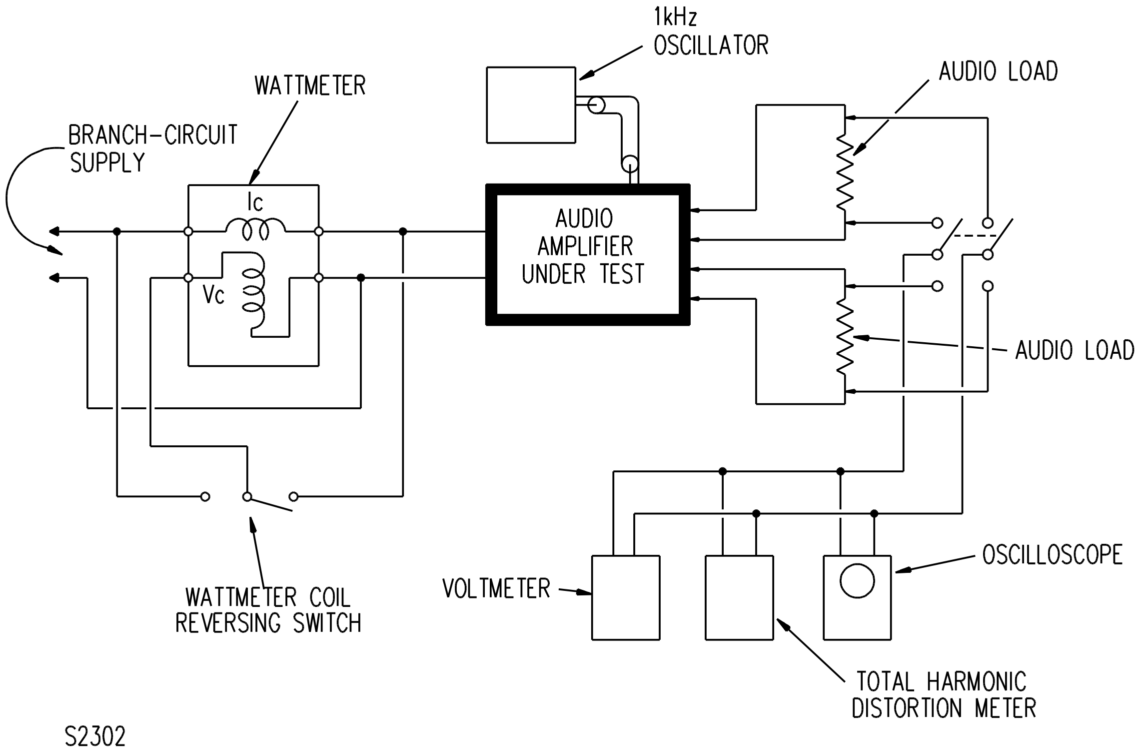
h) Signal Input Affecting Power Input– A product provided with signal-input circuits where the supply-circuit input power or current is noticeably affected by an audio signal input is to be connected as illustrated in Figure 38.1 and tested as follows:

1) A 1000-Hz sinusoidal signal is to be applied to the first audio stage of each preamplifier or amplifier circuit.

Exception: A sinusoidal signal of the geometric mean frequency of the upper and lower frequency limits of the circuit under test may be used if the amplifier has a limited bandwidth (for example, less than nominal 20 Hz – 20 kHz). The geometric mean frequency is equal to the square root of the product of the low frequency limit and the high frequency limit. The frequency limits may be specified by the manufacturer.

2) After a 15-minute warmup period, the signal input level and the product operating controls are to be adjusted to produce 1/10 of the maximum available undistorted sine wave output power or 0.5 W, whichever is greater. The maximum available undistorted sine wave output power is considered to be the maximum attainable with no evidence of clipping or flattening of the sine wave as determined by viewing the waveform on an oscilloscope. If there is a question about clipping or flattening of the output sine wave, a distortion analyzer may be used to measure the total harmonic distortion (THD) present in the waveform. The THD is not to be greater than 1 percent.

Figure 38.1
Typical input-power and input-current test circuit for an audio amplifier



38.3 When measuring the power input, increases in power having a duration of 5 seconds or less are to be discounted if the power increase does not occur more often than once a minute. Such increases may result from momentary operation of a motor, mechanical cycling of parts, or the like.

38.4 If an overload protective device opens during the power input test, the protective device is to be short-circuited when making the measurement.

39 Peak Inrush-Current Test

39.1 The peak value of inrush current controlled by the contacts of each supply-circuit control switch is to be determined according to the procedure described in this section.

Exception: This test is not required to be conducted when all of the supply-circuit control switches are marked Type TV. See 23.12 and 23.12.

39.2 The product is to be connected to a 120 V, 60 Hz supply source calibrated to represent a 20 A household branch circuit having a momentary 1000 A short-circuit current capability. For the purpose of these requirements, a circuit having a momentary 1000 A short-circuit current capability is defined as one meeting the requirements of the qualification tests described in 39.9 – 39.13.

39.3 The following devices are to be part of the supply source defined in 39.2, as shown in the test circuit illustrated in Figure 39.1:

a) A single-pole, single-throw, bounce-free type switch; for example, a wiping-blade knife switch.

b) A 0.02-ohm, high-frequency, current-viewing, resistive shunt complying with the specifications in Table 39.1. The construction details of the 0.02-ohm shunt may be found in Appendix C.

Figure 39.1
Peak inrush-current measurement test circuit

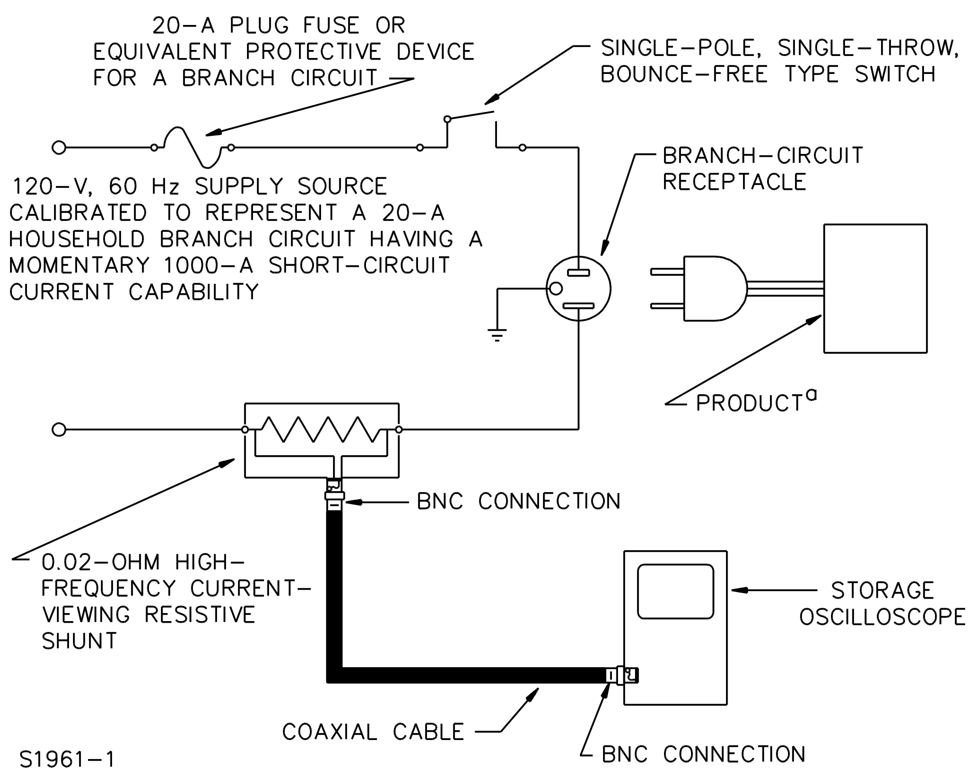


Table 39.1
Specifications for the high-frequency, current-viewing, resistive shunt used for measuring product peak inrush current

Parameter	Specification	Tolerance
Resistance	0.02 ohms	±2.5 percent
Rise time	30 nanoseconds[a]	plus 0; minus not specified

[a] If a peak-to-peak pulse of any convenient value having a rise time of 30 nanoseconds or less is applied, there shall not be discernible rise-time degradation of the applied waveform when viewed from the current-viewing connector.

39.4 The product controls and switches are to be adjusted and set with accessories connected, or not connected, so as to represent the condition of use that results in the highest value of peak inrush current. The thermal state of the product is to maximize the magnitude of the inrush current. If there is any doubt about the condition of use that will result in the highest value of peak inrush current, each mode of operation of the product is to be checked.

39.5 The 120 V, 60 Hz test circuit to which the product has been connected is to be momentarily energized by operating the test-circuit control switch asynchronously for 60 – 100 cycles of closure and opening. The waveforms of these events are to be displayed on a storage oscilloscope connected across the 0.02 ohm high-frequency, current-viewing, resistive shunt.

39.6 The peak inrush current is to be calculated according to the equation:

$$I_p = \frac{E_p}{R_s}$$

in which:

> I_p *is the calculated peak inrush current of the product being tested;*
>
> E_p *is the maximum value of voltage measured across the 0.02-ohm, high-frequency, current-viewing, resistive shunt as displayed by the storage oscilloscope; and*
>
> R_s *is the exact resistance of the high-frequency, current-viewing, resistive shunt.*

39.7 The inrush current contributed by any product circuitry that is not controlled by the contacts of the supply-circuit control switch is to be deducted from the calculation described in 39.6 so as to determine the actual peak inrush current controlled by the switch contacts.

39.8 When observing the waveforms on the oscilloscope, narrow, low-energy-content spikes may be visible due to charging of stray wiring capacitance of the load wiring or to circuit inductance due to a component, such as a phonograph motor. These spikes, which may precede, follow, or both precede and follow the main transient after switch closing and opening, are to be disregarded when the duration of each spike is 100 microseconds or less.

39.9 To be considered acceptable for use in the peak inrush-current measurements described in 39.1 – 39.7, the supply capability at the branch-circuit receptacle shown in Figure 39.1 (the supply source in combination with all of the circuit elements depicted in that figure) shall be such that the following qualification tests are satisfied:

> a) Static Load Regulation – The voltage measured at the receptacle shall not fall more than 2.4 V from the open-circuit value when loaded with a steady-state, 20.0 A, rms resistive load. The test method and conditions are to comply with 39.10 and 39.11.
>
> b) Dynamic Loading – The inrush current to the specified tungsten lamp test load shall achieve a value of 80 ±5 percent of the theoretical maximum inrush current which that tungsten lamp load could produce if it were to be placed across a source of zero impedance. The actual inrush current being produced is to be determined using the test methods and conditions described in 39.12 and 39.13.

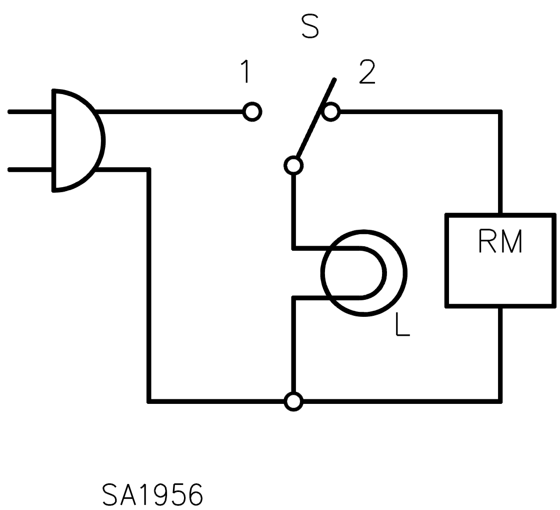
39.10 The static load regulation test evaluates the 60 Hz impedance of the supply source, including the inrush-current test equipment, by a measurement of the voltage drop under steady-state load conditions. Automatic voltage-regulation equipment in the supply source, which adjusts the supply voltage under load conditions, is to be connected to the supply circuit during these evaluation tests. However, the automatic voltage-control feature is to be disabled during the test in 39.11.

39.11 The open-circuit voltage at the supply receptacle of Figure 39.1 is to be adjusted to 120 V as measured with a voltmeter that has an accuracy of ±1 percent or better. For example, 120 V indicated on a 150 V full-scale voltmeter requires an instrument accuracy of 3/4 percent full scale, or better. A resistive load is to be applied to the receptacle, and adjusted to 20.0 A, rms as measured with an ammeter having an accuracy of ±1 percent, or better, at 20 A. The voltage across the receptacle is to be measured with the 20.0 A load applied, using the same instrument as for the open-circuit voltage measurement. The open-circuit voltage is to be rechecked. The difference between the open-circuit and load voltages is to be calculated. Refer to 39.9(a).

39.12 Prior to its use in the dynamic loading test, it is to be determined that the transient-current measurement instrumentation, which consists of an oscilloscope and high-frequency shunt, is reading the peak value of the 20.0 A rms steady-state current used in the test described in 39.11 within ±5 percent.

39.13 The test load in Figure 39.2 is to be prepared using the shortest possible direct-wiring of minimum 3.2 mm^2 (12 AWG) copper wire. This test circuit is to be connected to the supply receptacle of Figure 39.1, and the receptacle voltage adjusted to 120 V using the voltmeter described in 39.11. The open-circuit voltage, Voc, is to be recorded. The maximum theoretical peak inrush current is to be calculated as Voc X 1.414/1.00 ohm. Lamp L is to be preheated by throwing switch S to position 1 briefly, then back to position 2. The cooling resistance of lamp L is to be followed to 1.0 ohm with resistance-measuring equipment. Immediately upon reaching 1.0 ohm (typically reached within 20– 35 seconds after the last heat), switch S is to be rapidly transferred to position 1 briefly again, and then returned to position 2. The peak value of voltage measured for lamp L, except for the first cold start preheat cycle, is to be recorded by the use of the oscilloscope and high-frequency shunt. Closure of the 1.0 ohm tungsten load across the receptacle is to be repeated for a minimum of 60 – 100 cycles of operation of S. The value of the highest peak voltage measured during this sequence is to be noted. The highest peak inrush current is to be calculated using the equation in 39.6 and then its percentage of the maximum theoretical inrush current (determined by the equation above) calculated. Refer to 39.9(b).

Figure 39.2
Load for dynamic loading test



S – Single-pole, double-throw, bounce-free type switch (for example, wiping-blade knife switch) capable of rapid transfer between contacts.

L – No. 4 photoflood lamp, 1000 W at 120 V.

RM – Resistance-measurement equipment capable of accurately measuring 1.0 ohm (Wheatstone bridge, digital ohmmeter, or the like).

40 Grounding Impedance Test

40.1 The impedance of the grounding path at 60 Hz shall not exceed 0.1 ohm when measured from the grounding means of the product to the conductive part that is required to be grounded. The impedance can be determined by any impedance-measuring equipment.

Exception: If a grounding-path impedance of more than 0.1 ohm is measured, the impedance is to be determined by measuring the voltage when a current of 20 A derived from a 60 Hz source with a no-load *voltage not exceeding 12 V is passed between the product grounding means (point on the product where the cord grounding conductor is attached) and the grounded conductive part. The impedance in ohms is to be calculated by dividing the drop in potential in volts by the current in amperes passing between the two points. The power-supply cord is to be excluded when this measurement is made.*

41 Product Leakage and Shock Current Test

41.1 General

41.1.1 All accessible parts are to be tested for leakage current. All parts accessible during user servicing are to be tested for shock current. The currents from these parts are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible.

41.1.2 Parts are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is considered to be able to simultaneously contact parts that are within a 10 by 20 cm rectangle. Parts that can be contacted simultaneously by a person having a reach of 2 m are considered to be touchable by both hands.

41.1.3 Leakage or shock current refers to all currents, including capacitively coupled currents.

41.1.4 Insulation is to be short-circuited or open-circuited during leakage- and shock-current measurements as follows:

a) Between the voice coil and the frame of a speaker;

b) Between the plates of an adjustable or variable air-dielectric capacitor;

c) Between the heater and cathode elements of a vacuum tube;

d) Between any two adjacent elements of a vacuum tube;

e) Between any two adjacent elements of an electrolytic capacitor; or

f) Between the elements of a solid-state component (diode, transistor, integrated circuit, and the like).

41.1.5 Shock-current measurements are to be made under the conditions of:

a) Any operating control, adjustable control, door, cover, or any other part that is considered subject to user operation, in all possible positions and

b) Separable connectors, and similar devices subject to user-servicing, installed or removed.

41.2 Leakage-current

41.2.1 The leakage current shall not be more than that specified in 15.1.1(b)(1).

41.2.2 The measurement circuit for the product leakage-current test is to be as shown in Figure 41.1. The measurement instrument is defined in (a) – (d). The meter that is to be used for a measurement is required to indicate the same numerical value for the particular measurement as would the ideal instrument. The meter used is not required to have all of the attributes of the specified instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 μF;

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor;

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15 μF capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent of 60 Hz; and

d) Unless the meter is being used to measure current from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

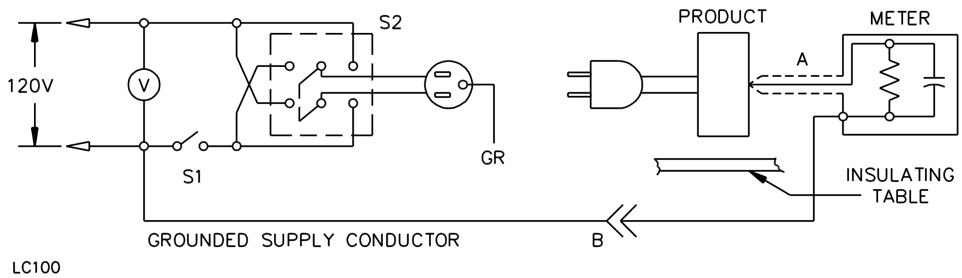
41.2.3 A sample of the product is to be tested starting with the as-received condition with all of its switches closed, but with its grounding conductor, if any, open. The as-received condition is defined as the product not being energized for a minimum of 48 hours prior to the test, and with the product at room temperature. The supply voltage is to be the maximum voltage marked on the product, but not less than 120 (or 240) V. See Table 37.1. The test sequence, with reference to the measuring circuit in Figure 41.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Immediately after connection, the current is to be measured using both positions of switch S2 and with the switching devices in the product in all of their operating positions.

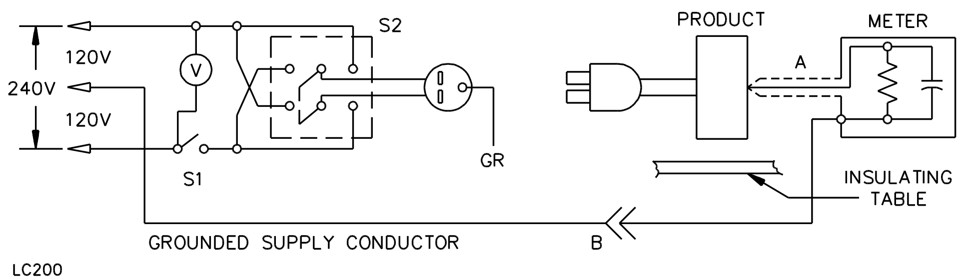
b) Switch S1 is then to be closed, energizing the product, and immediately after closing the switch, the current is to be measured using both positions of switch S2, and with the switching devices in the product in all of their operating positions.

c) The current measurements of (a) and (b) are to be repeated after thermal stabilization of the product.

Figure 41.1
Leakage-current measurement circuit



Product intended for connection to 120-V supply.



Product intended for connection to a 3-wire, grounded neutral power-supply as illustrated above.

NOTES –

1) – Probe with shielded lead.

2) – Separated and used as clip when measuring currents from one part of product to another.

41.3 Leakage current after humidity conditioning

41.3.1 A product shall comply with the requirements for leakage current in 41.2.1 – 41.2.3 and operate as intended following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C.

41.3.2 To determine whether a product complies with the requirement in 41.3.1, a sample of the product is to be heated to a temperature just above 34°C to reduce the risk of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and is to remain for 48 hours under the conditions specified in 41.3.1. Following the conditioning, the sample is tested unenergized as described in 41.2.3(a). The sample is then to be energized and tested as described in 41.2.3 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

41.4 Shock-current

41.4.1 The shock current between parts accessible only during user servicing (see 41.1.5) and between such parts and earth ground shall not be more than that specified in 15.1.1(b)(2) for a continuous current; or more than that specified in 15.1.1(b)(3) for a transient current.

41.5 Stored-energy electric shock

41.5.1 If the short-circuiting of accessible parts results in the discharge of a capacitor, thereby causing an instantaneous flow of current, the transient condition is to be considered with regard to 15.1.1(b)(4).

41.6 Component electric shock

41.6.1 To determine if the connectors, components, and leads of a product comply with the requirements in 32.1 and 32.2(e), disconnection is to take place while the product is operated under maximum-voltage conditions (see Maximum-Voltage Measurement, Section 43). Current and voltage readings are to be taken during the initial 5 minutes of the test.

42 Temperature Test

42.1 A product, when tested according to the applicable conditions and procedures described in this section, shall not attain a temperature that results in one or more of the following conditions:

a) The risk of ignition of materials or components;

b) An adverse effect upon materials or components;

c) The temperature limits of materials or components being exceeded; or

d) Temperatures at specific points greater than the limits specified in Table 42.1.

Table 42.1
Maximum temperatures

Parts of product	Temperature, °C
1. Accessible parts[a]	
a) Surfaces of an enclosure	90
b) Small areas and easily discernible heat sinks	90

Table 42.1 Continued on Next Page

Table 42.1 Continued

	Parts of product	Temperature, °C
2.	Handles or knobs that are grasped for lifting, carrying, or holding[a]	
	a) Metallic	50
	b) Nonmetallic	60
3.	Accessible front panel, all accessible control panels, handles or knobs that are contacted but do not involve lifting, carrying, or holding[a]	
	a) Metallic	60
	b) Nonmetallic	85
4.	Enclosure interior surfaces	
	a) Wood	90
	b) Insulating material	b
5.	Insulating materials	
	a) Polymeric[b]	b
	b) Varnished cloth	85
	c) Fiber	90
	d) Wood and similar material	90
	e) Laminated phenolic composition[c]	125
	f) Phenolic composition	150
6.	Softening point of any sealing compound[d]	d
7.	Coil winding surfaces employing impregnated organic insulation or film-coated wire[e]	90
8.	Capacitors[f]	
	a) Electrolytic	65
	b) Other types	90
9.	Fuses[c]	90
1-0.	Semiconductor devices[c]	100
11.	Selenium rectifiers[c,f]	75
1-2.	Conductors with rubber or thermoplastic insulation[c]	60

[a] Item 1 is concerned with risk of ignition of materials that may contact the enclosure. Items 2 and 3 are concerned with risk of skin-burn if contacted by the user. The lowest temperature limit on a given surface is the maximum acceptable temperature for that surface or part.

[b] Polymeric material shall be acceptable for the application when evaluated with regard to temperature.

[c] Does not apply if investigated and found acceptable for a higher temperature.

[d] The maximum sealing compound temperature, when corrected to 25°C ambient temperature, is 15°C less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring and Ball Apparatus, ASTM E28-67 (1982).

[e] A hot-spot temperature not higher than 105°C on the surface of a coil winding is acceptable, provided the temperature of the winding does not exceed 100°C.

[f] A capacitor operating at a temperature higher than 65°C is to be evaluated on the basis of its marked temperature rating, or if not marked with a temperature rating, can be investigated to determine the acceptability at the higher temperature.

[g] A rectifier, transistor, silicon controlled rectifier, or the like operating with a case temperature higher than 100°C is acceptable if it operates within its rated junction temperatures as specified by its manufacturer.

42.2 Thermal equilibrium is considered to be attained when three successive readings taken at 15-minute intervals indicate that there is no temperature change of the part.

42.3 The product is to be tested with the maximum projection on the back in contact with a flat vertical wall of wood or comparable heat-insulating material.

Exception: The spacing between the wall and the main surface of the back of the product is not to be less than 25 mm.

42.4 Covers and doors likely to be closed during operation are to be closed for the duration of the test.

42.5 Consideration is to be given to the normal conditions of intended operation.

42.6 Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in service.

42.7 Horizontal ventilating screens subject to the accumulation of dust and having holes less than 1.0 mm in diameter are to be covered with loose cheesecloth.

42.8 The product is to be operated:

a) At the power input as described in the Power Input Test, Section 38, with the product connected as described in 37.10 – 37.13 for supply circuit and frequency;

b) With all unused receptacles at their maximum rating; and

c) As described in 42.3 and 42.7 to represent expected conditions of use of the product.

42.9 When thermocouples are used in the determination of temperatures, the thermocouples are to consist of 0.051 mm^2 (30 AWG) iron and constantan wires and are to be used with a potentiometer-type instrument. If it is not practical to use iron and constantan thermocouples some other type as described in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M, can be used.

42.10 The temperature on a winding is to be measured by applying a thermocouple to the hottest part of the surface of the coil winding. If the winding is enclosed, a hole is to be made in the case. If the winding is potted, a heated wire may be used to provide a hole in the compound before the thermocouple is placed in contact with the coil surface.

42.11 The temperature of a copper or aluminum winding is to be calculated by the following equation. Windings are to be at room temperature at the start of the test.

$$t_2 = \frac{R}{r}(K + t_1) - K$$

in which:

t_2 is the temperature of the coil in degrees °C at the end of the test;

R is the resistance of the coil at the end of the test;

r is the resistance of the coil at the beginning of the test;

K is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum (values of the constant for other grades must be determined); and

t_1 is the room ambient temperature in degrees °C at the beginning of the test.