36.2.2 Stored voltage

36.2.2.1 The maximum capacitance between capacitor terminals that are accessible during user servicing shall satisfy the following equations:

$$C = \frac{88,400}{E^{1.43}(L_n E^{-1.26})} \quad for \quad 21.2 \leq E \leq 400$$

$$C = 35,288 E^{-1.5364} \quad for \quad 400 \leq E \leq 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads,

E is the potential in volts across the capacitor prior to discharge, and

In is the natural logarithm (base e).

36.2.2.2 To determine whether a capacitor complies with the requirement in 36.2.2.1, the potential E is to be measured 5 seconds after the capacitor terminals are accessible by the removal or opening of an interlocked cover, or the like. Typical calculated values are given in Table 36.3.

Table 36.3
Stored voltage

Potential across capacitance prior to discharge, volts	Maximum acceptable capacitance, microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56

Table 36.3 Continued on Next Page

Table 36.3 Continued

Potential across capacitance prior to discharge, volts	Maximum acceptable capacitance, microfarads
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00
40	186.00[a]
30	319.00[a]
25	452.00[a]
21.2	625.00[a]

[a] Where wet contact is likely to occur only.

36.2.3 Transient current

36.2.3.1 The duration of a transient current – direct or alternating – through a 500-ohm resistor connected between any part exposed only during servicing and earth ground or any other accessible part shall satisfy the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I}\right)^{1.43}$$

in which:

T is the duration, measured in seconds, from the time that the instantaneous value of the current first exceeds 7.1 milliamperes until the time that the current falls below 7.1 milliamperes for the last time, and

I is the peak current in milliamperes.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. The peak current shall not exceed 809 milliamperes regardless of duration. Typical calculated values are given in Table 36.4.

Table 36.4
Transient current

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum acceptable duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
7.1	7.26
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.012
700.0	0.010
809.0	0.0083

37 Resistance of Grounding Circuit Test

37.1 The resistance between the point of connection of the equipment-grounding means, at or within the product, and any other point in the grounding circuit shall not be more than 0.1 ohm.

37.2 Any appropriate instrument may be used to determine whether a product complies with the requirement in 37.1, but if unacceptable results are obtained, an alternating current of at least 25 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment-grounding means to any point in the grounding circuit. The current and the resulting drop in potential are to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points. The grounding conductor of a power-supply cord is not to be tested by the latter method.

38 Power-Input Test

38.1 The current or wattage consumption of a product shall not exceed the marked input rating by more than 5 percent when the product is operated under normal conditions as specified in 38.2 – 38.10 while connected to a supply circuit of rated frequency and voltage as specified for normal operation in Table 33.1.

38.2 An organ or similar musical instrument having a tone generator shall be operated with any ten keys and two foot-pedals, if provided, depressed. Those stops and tabs causing the organ to operate under conditions of maximum load are to be activated. A matched resistive load is to be connected across the output of the product, and speakers, if provided, are to be disconnected and replaced by matched resistive loads. Input power (or current) is then to be determined according to the following equation:

$$P_{in} = P_o + \frac{1}{3}(P_{max} - P_o)$$

in which:

P_{in} *is the calculated normal input power,*

P_o *is the measured input power under no signal conditions, and*

P_{max} *is the measured input power with the volume control adjusted to deliver maximum output and with ten keys and two foot-pedals depressed.*

Exception: At the manufacturer's request, a 1-kHz or geometric mean frequency sine wave may be used as the input signal for a product employing a power amplifier. The input signal is to be applied to the first stage of the amplifier circuit. Input power or current is to be determined with the amplifier delivering one-eighth of the maximum undistorted output power into internal speakers or matched resistive loads when operated as specified in 38.5 – 38.9.

38.3 The input power or current of a product incorporating an amplifier and provided with auxiliary input jacks, with or without tone generators, is to be determined with the amplifier delivering one-eighth of the measured maximum undistorted output power or one-eighth of the manufacturer's marked output power, whichever is greater, into matched resistive loads when operated as specified in 38.5 – 38.9. The test is to be repeated for each audio-load-impedance tap provided, and in each test the resistive load is to closely match the rated-output load of the amplifier taps.

38.4 Each input and corresponding output of a biamplifier, multichannel amplifier, or other product that has an effect on the total power consumption of the product is to be operated simultaneously under the conditions specified in 38.3.

38.5 The audio-input connections of the product to be tested are to be connected to a sinewave oscillator. The frequency of the oscillator is to be adjusted to 1000 hertz.

Exception: The geometric-mean-frequency of each channel is to be applied as the input signal for each channel of a product intended to cover only a limited portion of the audio-frequency range, such as a bass amplifier, biamplifier, and the like.

38.6 The geometric-mean-frequency is equal to the square root of the product of the low-frequency limit and the high-frequency limit. The low-frequency limit is to be 20 hertz or the manufacturer's rated value, whichever is higher; the upper frequency limit is to be 20 kilohertz or the manufacturer's rated value, whichever is lower.

38.7 Tone controls, filters, and wave-shaping controls are to be set in the flat-response positions. The volume control is to be initially set in the middle of its range. The output connectors are to be connected to a resistive load matched to the manufacturer's output-load rating. Speakers provided with the product are to be electrically replaced with an equivalent resistive load unless the manufacturer requests that the speakers provided or sold with the product be used.

38.8 The sine wave oscillator output and amplifier volume control are to be adjusted to deliver maximum undistorted output power. The amplifier input used for the sine wave oscillator output is to be selected such that the sine wave is not distorted at a stage (for example, preamp) prior to amplification. Maximum undistorted output power is to be determined by visually examining the wave shape for clipping using 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 to be no greater than 1 percent. This is to be repeated for the range of audio load impedance taps and corresponding wattage ratings for the amplifier.

38.9 Each unused receptacle or connector, other than a conventional parallel-slot receptacle that is used to supply power to another product or accessory, is to be loaded to its maximum rating.

38.10 Other types of products not covered by 38.2 – 38.4 are to be tested under conditions closely approximating normal operating conditions.

39 Temperature Test

39.1 When a product is tested as specified in this section:

a) The temperature at any part shall not be sufficiently high to constitute a risk of fire or to adversely affect any materials employed and

b) A thermal- or overcurrent-protective device shall not function.

39.2 The temperatures specified in Table 39.1 are based on an assumed ambient temperature of 25°C (77°F). A test may be conducted at an ambient temperature within the range of 10 – 40°C (50 – 104°F).

Table 39.1
Maximum acceptable temperatures

Materials and components	°C	(°F)
A. MOTORS		
1. Class A insulation system on coil windings of an AC motor having a frame diameter not more than 7 inches (178 mm) and of a universal motor[a,b]		
a) In an open motor:		
Thermocouple or resistance method	100	212
b) In a totally enclosed motor:		
Thermocouple or resistance method	105	221
2. Class A insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm), and of a DC motor[a,b]		
a) In an open motor:		
Thermocouple method	90	194
Resistance method	100	212
b) In a totally enclosed motor:		
Thermocouple method	95	203
Resistance method	105	221
B. COMPONENTS		
1. Capacitor[c]:		
a) Electrolytic	65	149
b) Other type	85	185
2. Conductor, rubber- or thermoplastic-insulated[c]:	60	140
3. Fuse:		
Class G, J, L, T, or CC:		
Tube	125	257
Terminals	90	194
Other[d]	90	194
4. Rectifier		
a) Selenium[d]	75	167
b) Silicon[d,e]	100	212
5. Windings of a relay, solenoid, magnet, transformer, and the like (except motor coil windings) with Class 105 insulation systems[a]		
Thermocouple method	90	194
Resistance method	100	212
6. Wood and other combustible material	90	194
C. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	90	194

Table 39.1 Continued on Next Page

Table 39.1 Continued

Materials and components	°C	(°F)
2. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire of electric shock[d]		
a) Laminated	125	257
b) Molded	250	302
3. Varnished-cloth insulation	85	185
D. SURFACES		
1. Exterior surface of an overall enclosure	90	194
2. Enclosure of polymeric material[d]		
a) Portable product	65	149
b) Stationary product	50	122
3. Handle or knob	See Table 39.2	

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, a hot-spot temperature not higher than 105°C (221°F) on the surface of a coil winding is acceptable if the temperature, as measured by the resistance method, is not more than that specified in the table.

[b] The motor diameter is to be measured in the plane of the laminations as the diameter of the circle circumscribing the stator frame. All lugs, fins, boxes, and the like used solely for motor mounting, cooling, assembly, and connection are to be excluded.

[c] A capacitor operating at a temperature higher than that specified in the table may be judged on the basis of its marked temperature rating. If not marked with a temperature rating, it may be investigated to determine its acceptability at the higher temperature.

[d] This limitation does not apply to an insulated conductor, a rectifier, a material, or component that has been investigated and determined to be acceptable for a higher temperature.

[e] A rectifier operating at a temperature higher than 100°C (212°F) may be judged on the basis of its case temperature at the actual current compared with the case temperature at rated current – derating curves.

Table 39.2
Maximum surface temperature

Location	Composition of surface[a]	
	Metal	Nonmetallic
Handles or knobs that are grasped for lifting, carrying, or holding	50°C (122°F)	60°C (140°F)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding, and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)

[a] A handle, knob, or the like made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is considered to be, and is judged as, a nonmetallic part.

39.3 During a test conducted at an ambient temperature of 25°C (77°F), an observed temperature shall not exceed the values specified in Table 39.1.

39.4 If a test is conducted at an ambient temperature other than 25°C (77°F), an observed temperature shall be corrected as described in 39.5. A corrected temperature shall not exceed the values specified in Table 39.1.

39.5 An observed temperature is to be corrected by addition [if the ambient temperature is lower than 25°C (77°F)], or subtraction (if the ambient temperature is higher than 25°C) of the difference between 25°C and the ambient temperature.

39.6 If a corrected temperature exceeds the values specified in Table 39.1, at the request of the manufacturer, the test may be repeated at an ambient temperature closer to 25°C (77°F).

39.7 The product is to be operated until thermal equilibrium is reached:

a) At the input measured in the Power-Input Test, Section 38;

b) With all unused receptacles loaded to their maximum rating; and

c) With the product mounted, positioned, closed, or enclosed to represent intended use when use conditions are not specified in this section.

Exception: A product incorporating an amplifier and provided with auxiliary input jacks with or without tone generators is to be tested as described in 39.8.

39.8 The equipment is to be operated with a pink noise audio input signal (band-limited at 12 decibels per octave, 20 hertz to 20 kilohertz, equal energy per octave) connected to each input affecting the power consumption of the unit, coupled through a filter circuit with a frequency roll-off of minimum 12 decibels per octave as follows. The amplitude-probability distribution shall be three standard deviations. The low and high frequency figures of the amplifier mentioned as follows are those given by the manufacturer:

a) Low Frequency – Corner frequency (point where audio signal is down 3 decibels) of high pass filter set at 50 hertz or as close as practicable to twice the low frequency response figure, whichever is greater.

b) High Frequency – Corner frequency of low pass filter set at 20 kilohertz or as close as practicable to one half the high frequency response limit figure, whichever is lower.

The signal amplitude is to be adjusted to cause the unit to deliver power equal to one-eighth of the measured maximum undistorted output power as described in the Power-Input Test, Section 38, or one-eighth of the manufacturer's rated output power, whichever is greater, into the matching load impedance that produced the maximum input power consumption. The output power is to be calculated using the relation:

$$P = \frac{E^2}{R}$$

in which:

E is the voltage measured by a true rms indicating voltmeter across the noninductive resistive output load R.

Exception: At the manufacturer's request, the temperature test may be conducted using a 1 kilohertz or geometric mean frequency sine wave input signal instead of the pink noise audio input signal. Pink noise shall be used where the construction of the amplifier is such that using a sine wave does not represent loading of the amplifier.

39.9 Thermal equilibrium is considered attained when three successive readings taken at 15-minute intervals indicate that the temperature of the part has not changed by more than ±1/2°C over the 30-minute period.

39.10 Ordinarily, the temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples– for instance, a coil immersed in sealing compound, or if the coil wrap includes thermal insulation or more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar insulation – the resistance method is to be used. For the thermocouple-measured temperature of a coil of an alternating-current motor other than a universal motor having a frame diameter of 7 inches (178 mm) or less, as specified in item A of Table 39.1, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

39.11 It is common practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument, and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

39.11 revised March 18, 2010

39.12 When determining the temperature by the change in resistance method, the windings are to be at room temperature at the start of the test. The temperature of a winding is to be calculated by using the following equation:

$$T = \frac{R}{r}(k + t_1) - k$$

in which:

T is the temperature in degrees C;

R is the resistance of the coil at the end of the tests in ohms;

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

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant (k) for other grades must be determined; and

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

39.13 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. Horizontal ventilating screens that are subject to the accumulation of dust and lint and that have holes less than 3/64 inch (1.2 mm) in diameter are to be covered with loose cotton.

39.14 The product is to be set up or mounted as in actual service and connected to a supply circuit of the voltage specified for normal operation in Table 33.1.

39.15 The product is to be placed on a horizontal supporting surface and spaced 1 inch (25.4 mm) from a vertical wall surface of wood or comparable material.

Exception No. 1: The product may be operated in the open if ventilation or other cooling factors are arranged so that operation against a wall will not increase operating temperatures.

Exception No. 2: If the construction of the product is such that a spacing greater than 1 inch is maintained, the product is to be operated at that spacing.

39.16 Doors and covers that may be closed during operation of the product are to be closed during the test.

Exception: Consideration may be given to the actual conditions of normal operation of the product, including the changing of tape reels, cassettes, and the like.

39.17 During the temperature test, the temperature on surfaces that may be contacted by the user shall not be more than the values specified in Table 39.2. If the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

40 Audio-Output Test

40.1 The audio-output potential of exposed or accessible output terminals shall not exceed 100 volts when tested as specified in 40.2.

40.2 A variable-frequency signal generator is to be connected to the input terminals, and an adjustable load resistor is to be connected across the output terminals. If the output terminals are marked to indicate the load impedance that should be connected, the test impedance is to be adjusted to have a value equal to the rated output-load impedance of the amplifier, and the input-signal voltage is to be adjusted to such a value that the device delivers maximum available undistorted-sine-wave power to the load. If the output terminals are marked with a voltage rating, the value of the test-load impedance is to be adjusted to the value calculated on the basis of the rated power output of the amplifier ($R = E^2/W$), and the input-signal voltage is to be adjusted to give the maximum available undistorted-sine-wave power to the load. After the adjustments specified above are made in accordance with the marking on the output terminals, the output circuit is to be opened and the potential across the output terminals measured. The test is to be conducted over the range from 60 to 100 hertz – in steps of 10 – by adjusting the signal generator. Throughout these tests, the product is to be connected to a supply circuit of the voltage as specified in normal operation in Table 33.1.

41 Dielectric Voltage-Withstand Tests

41.1 General

41.1.1 The insulation and spacings of a product shall withstand without breakdown for 1 minute the application of the test potentials specified in Table 41.1.

Exception: This requirement does not apply if an investigation shows that such breakdown will not result in a risk of fire or electric shock.

Table 41.1
Dielectric voltage-withstand test potentials

Component being tested	Applied potential	Applicable paragraphs
Primary circuit	1000 V, 60 Hz	41.2.1 and 41.2.2
Isolating transformer	1000 V, 60 Hz	41.3.1
Primary insulation	1000 V, 60 Hz	41.4.1
Output circuit	4E[a] DC, (1270 V minimum)	41.5.1
Power transformer	3E[a] DC, (500 V minimum)	41.6.1 – 41.6.4
Direct-connected power supply	3E[a] DC, (1270 V minimum)	41.7.1 – 41.7.3
Printed-wiring assembly	2E[a] + 1000 V, DC	41.8.1
Basic insulation	1000 V, 60 Hz	13.1.9
Supplementary insulation	2500 V, 60 Hz	13.1.10
Reinforced insulation	3500 V, 60 Hz	13.1.11

[a] E is the maximum peak potential between the parts when measured with the product operated under the conditions described in 41.9.2 – 41.9.5.

41.1.2 The dielectric voltage-withstand tests are to be conducted with the product at its normal operating temperature.

41.1.3 In conducting the dielectric voltage-withstand test, the applied 60-hertz voltage is to be monitored with a voltmeter having a minimum resistance of 2000 ohms per volt. Breakdown, not leakage, is to be the criterion of nonacceptability. Breakdown is caused by insufficient insulation or spacing and is indicated by an abrupt decrease or retarded advance of the voltmeter reading. Leakage is the normal flow of current due to imperfect insulating materials and can vary with the applied voltage.

41.1.4 The 60-hertz test potentials specified in Table 41.1 are to be obtained from a testing transformer, the output voltage of which can be varied. The direct-current test potential is to be obtained from any convenient direct-current supply having an output of sufficient potential and that can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.