**Table 34.1**
**Accelerated aging tests**

| Temperature on component during normal-temperature test | Accelerated-aging procedure | Minimum percent of original | |
|---|---|---|---|
| | | Tensile strength | Elongation |
| 60°C (140°F) or less | Immersion for 168 hours at 70 ±1°C (158.0 ±1.8°F) in the liquid to which the component is exposed | 50 | 50 |
| | Air-oven for 70 hours at 100 ±2°C (212.0 ±3.6°F) and 300 ±10 pounds per square inch (2070 ±70 kPa) gauge | 60 | 60 |
| More than 60°C (140°F) | Immersion for 168 hours in a boiling solution of commercial dishwashing detergent (25 grams per liter of water)[a] | 50 | 50 |
| 61 – 75°C (142 – 167°F) | Air-oven for 168 hours at 100 ±2°C (212.0 ±3.6°F) and 300 ±10 pounds per square inch (2070 ±70 kPa) gauge | 50 | 50 |
| 76 – 90°C (169 – 194°F) | Air oven for 168 hours at 121 ±1°C (249.8 ±1.8°F) | 60 | 60 |
| 91 – 105°C (196 – 221°F) | Air oven for 168 hours at 136 ±1°C (276.8 ±1.8°F) | 60 | 60 |

[a] If the part is not subjected to a detergent solution, the appropriate agent should be substituted for this test.

## PROTECTION AGAINST INJURY TO PERSONS

### 35 General

35.1 If the operation and maintenance of an appliance involves a risk of injury to persons, or there can be a risk of injury resulting from the presence of toxic or flammable chemicals, and the like, means shall be provided to reduce the risk. Persons shall be protected during user servicing.

35.2 If an appliance involves the generation and confining under pressure of steam or other gas, or employs a component that involves gas under pressure, consideration shall be given to the possibility of explosion. The appliance is not acceptable unless its strength is acceptable with regard to any risk of explosion that may be involved.

35.3 Whether a guard, release, or similar part is required, and whether such a device is acceptable, shall be determined from an investigation of the complete appliance, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of malfunction or breakdown of any one component, but not more than one component at a time unless one event contributes to another. If the investigation shows that malfunction or breakdown of a particular component can result in a risk of injury to persons, that component shall be investigated for reliability. The investigation of a switch or other component in a safety circuit is to include at least 100,000 cycles of operation, unless the safety circuit is known to be reliable. An interlock shall comply with the requirements in Interlocks, Section 41.

35.4 A lamp emitting light in the ultraviolet frequency range shall be housed in an enclosure that will not permit a person to view the lamp directly if such viewing could result in an injury. An appliance employing an ultraviolet lamp shall be marked in accordance with 67.2.1. A photoflash lamp may normally be viewed without involving a risk of injury.

35.5 If an automatically-reset protective device is employed in an appliance, the automatic restarting shall not result in a risk of injury to persons.

35.6 The requirement in 35.5 requires the use of an interlock in the appliance if moving parts can present a risk of injury upon the automatic restarting of a motor.

35.7 A condenser lens shall be enclosed to prevent the direct expulsion of glass resulting from shattering of the lens.

## 36 Sharp Edges

36.1 An edge, a projection, a corner of an enclosure, an opening, a frame, a guard, a knob, a handle, or the like, of an appliance shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

36.2 Whenever referee measurements are required to determine that a part as mentioned in 36.1 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the Standard for Tests for Sharpness of Edges on Equipment, UL 1439, is to be employed.

## 37 Enclosure of Moving Parts

37.1 The rotor of a motor, a pulley, a belt, a gear, a fan, a folding mechanism, or other moving part that could cause injury to persons, shall be enclosed, guarded, or an interlock provided so as to reduce the risk of unintentional contact. An interlock shall comply with the requirements in Interlocks, Section 41.

37.2 Other than as provided in 37.4(b), a moving part that may involve a risk of injury to persons shall comply with the requirements specified in 7.1.2 and shall be considered with regard to:

a) The degree of exposure necessary to perform its intended function;

b) The sharpness of the moving part;

c) The risk of unintentional contact with the moving part;

d) The speed of the moving part; and

e) The risk that a part of the body could be endangered or that clothing could be entangled, resulting in a risk of injury to persons.

The above factors are to be considered with regard to both intended operation of the product and reasonably foreseeable misuse.

37.3 A manual or automatic feeding or cutting mechanism shall be constructed or guarded to reduce the risk or necessity for fingers of the operator to be in an area in which they could be injured.

37.4 With reference to 37.3, the cutting mechanism is acceptably recessed if:

a) The probe described in Figure 7.1 cannot be made to touch the cutter or

b) The average inside diameter (one-half the sum of the maximum and minimum dimensions) of the throat of a hopper or tubular feeding opening for manual feeding is not more than 2-1/2 inches (63.5 mm), and the cutters are recessed at least 4 inches (102 mm) below the plane of the opening.

## 38 Stability

38.1 An appliance, under all conditions of user servicing and during its intended use, shall not become mechanically unstable to the degree that it creates a risk of injury to the operator.

38.2 Other than the tests described in 38.3 and 38.4, the details of tests to determine lack of mechanical stability are not specified because of the differences in appliances. Among the factors that shall be considered are:

a) The number of gates or doors that can be extended or opened at any one time on one side of an appliance before the appliance starts to tip;

b) The risk that the appliance is capable of being installed without being fastened securely to a supporting surface; and

c) The necessity for application of an additional weight or moment to the appliance – for example, climbing or leaning on or over the appliance – during normal use or user servicing.

38.3 An appliance not intended to be secured in place – not bolted to other appliances or secured to the floor or other part of the building – shall not tip over when tilted 10 degrees from its normal, upright, freestanding operating position while all doors, covers, gates, drawers, and similar parts, are in place and closed and casters, if any, are in their most disadvantageous position.

38.4 A freestanding unit more than 39-3/8 inches (1.00 m) high and weighing more than 55.1 pound (25.0 kg) shall not tip over when a force equal to one-fifth the weight of the unit, but not more than 56.2 pound (250 N), is applied in any direction, except upward, at a height not exceeding 78-3/4 inches (2.00 m) from the floor. For this test, all doors, drawers, frames, and similar parts, that can be opened for operator or service personnel are to be opened and in the most unfavorable position. Separate tests may be performed when operator and service extensions are different or when stabilizers are employed in accordance with 38.5.

38.5 A stabilizing means may be used to improved stability when doors, drawers, and similar parts, are opened. The stabilizing means shall be automatic in operation or interlocked when associated with operator use. For service personnel, if it is not automatic in operation, conspicuous marking shall be provided to caution the personnel on its use. See 67.12.1.

## 39 Strength of Handles

39.1 A handle, strap, grip, or recess provided on an appliance shall withstand a force of four times the weight of the appliance without damage to the handle, its securing means, or that portion of the enclosure to which the handle is attached.

39.2 To determine whether an appliance complies with the requirement in 39.1, the handle and the means of securing the handle to the appliance are to be subjected to one application of a force of four times the weight of the appliance. The load is to be uniformly applied over a 3 inch (76 mm) width at the center of the handle without clamping. The load is to be started at zero and gradually increased so that the test value is attained in 5 – 10 seconds; the test value is to be maintained for 1 minute. If an appliance has more than one handle and cannot be carried by one handle the force is to be distributed between the handles. The distribution of forces is to be determined by measuring the percentage of the appliance weight sustained by each handle with the appliance in its intended carrying position. If an appliance is furnished with more than one handle and can be carried by only one handle, each handle is to withstand the total force.

## 40 Glass Parts

40.1 A glass part that is not of the required enclosure and has:

a) An area greater than 1 square foot (0.093 $m^2$) or

b) A major dimension greater than 18 inches (457.2 mm)

shall not be displaced, broken, or shattered (either totally or in part) from its mounting in a manner that may result in skin-lacerating injuries when tested as described in 40.2.

40.2 A glass part, as described in 40.1, shall withstand a single impact of 2.5 foot-pounds (3.39 J). The impact shall be applied by means of a smooth, solid, steel sphere 2 inches (51 mm) in diameter and weighing approximately 1.18 pounds (535 g). The sphere is to fall freely from rest so as to impact any area of the glass accessible to the ball.

## 41 Interlocks

41.1 A moving part that is capable of causing injury to a person is considered to be guarded if protected by a cover with an interlock that complies with one of the following conditions:

a) The part stops moving within 3 seconds after the cover is opened or

b) The interlock prevents the cover from being opened until the part stops moving.

41.2 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

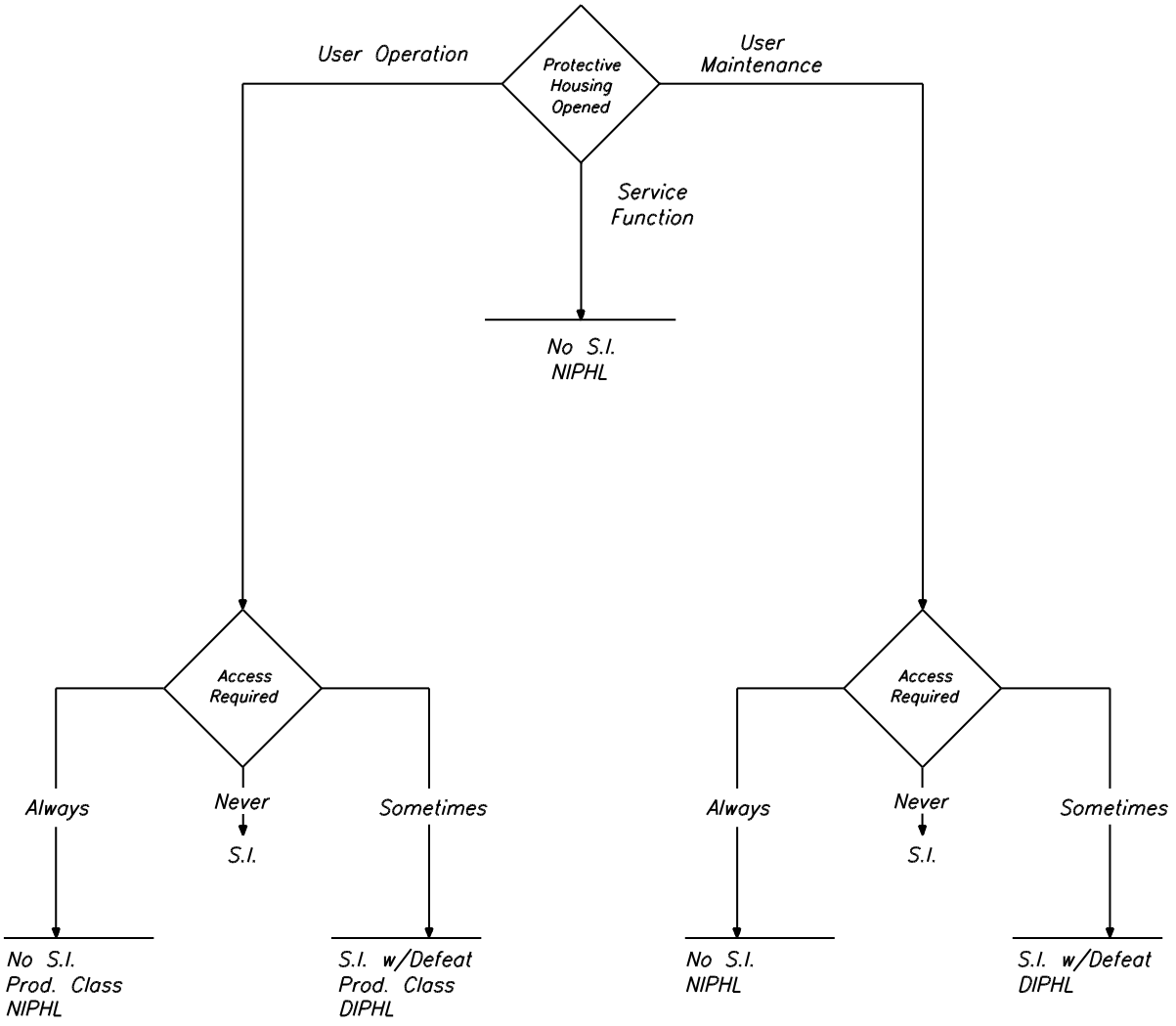
41.3 An interlock shall be located so that unintentional operation is unlikely. The interlock shall be located so that it cannot be actuated by the probe illustrated in Figure 7.1. The interlock shall not be readily deflectable without damaging the appliance, or making wiring connections or alterations.

41.4 An interlock switch that is required to reduce a risk of electric shock or injury to persons shall withstand 100,000 cycles of operation controlling a load not less than that controlled in the appliance, and shall function normally upon completion of the test.

41.5 An interlock that is required to reduce the risk of electric shock of a cord-connected product shall open all supply conductors.

41.6 The requirements for interlocks, for access to lasers, are illustrated in Figure 41.1. Reference to the Code of Federal Regulations, 21 CFR 1040, shall be made for Product Classifications and Label Wording requirements. References to labels shall be considered permanent markings and comply with the requirements of Marking, General, Section 65.

**Figure 41.1**
**Laser product safety interlock requirements**




Abbreviations:

| | |
|---|---|
| S.I. | –Safety Interlock |
| Prod. Class | –Interior level determines product classification (if higher than exterior level). |
| NIPHL | –Label for Non–interlocked protective housing |
| DIPHL | –Label for Defeatably–interlocked protective housing |

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41.7 With reference to 41.6, compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of laser (as defined by the CFR) from the manufacturers required documentation, such as the Center for Devices and Radiological Health (CDRH) report, markings and labels, or similar documentation;

b) Verifying that the manufacturer's markings and labels, having the information specified in the CFR, are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR; and

d) Determining that the resulting construction complies with the construction requirements of this standard.

## 42 Surface Temperatures

42.1 During the temperature test, the temperature of a surface that may be contacted by the user shall not be more than the value specified in Table 42.1. The test is to be conducted as described in the Temperature Test, Section 52.

**Table 42.1**
**Maximum surface temperatures**

| Location | Composition of surface[a] | | | |
|---|---|---|---|---|
| | Metal, | | Nonmetallic, | |
| | °C | (°F) | °C | (°F) |
| 1. An enclosure surface, including a handle and a knob, that is grasped for lifting, carrying, or holding the appliance | 50 | 122 | 60 | 140 |
| 2. An enclosure surface that is not known to be hot due to proximity to a source of heat[b] | 60 | 140 | 85 | 185 |
| 3. An enclosure surface, other than a heating function surface and an air exhaust grille[c], known to be hot due to proximity to a source of heat. | 70 | 158 | 95 | 203 |

[a] See 42.2.
[b] See 42.3.
[c] See 42.4.

42.2 A nonmetallic material that is plated or clad with metal having a thickness not more than 0.005 inch (0.13 mm) is to be evaluated as a nonmetallic part.

42.3 An enclosure surface that is not known to be hot due to proximity to a source of heat may exceed the temperature limits specified in Table 42.1(2) but shall not exceed the limits specified in Table 42.1(3), if it is permanently marked in accordance with 67.6.1.

42.4 An air-exhaust grille may exceed the temperature limits specified in Table 42.1(3) if a marking in accordance with 67.6.1 is permanently affixed near the grille.

## 43 Cord Flexing

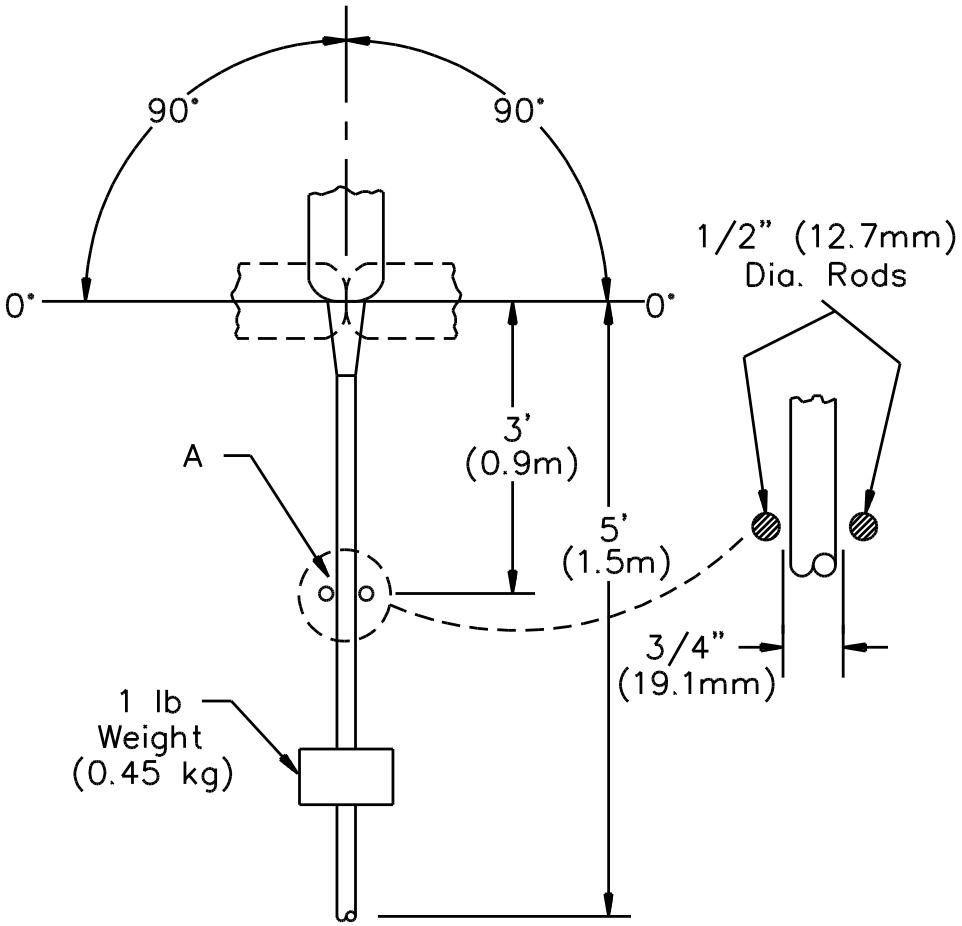
43.1 To determine whether the cord and cord guard (if provided) are acceptable, the tests described in 43.2 – 43.6 are to be conducted. During the test, the cord shall not develop an open circuit and there shall be no exposure of an uninsulated conductor strand.

43.2 The cord and cord guard (if provided) are to be conditioned for 96 hours in an oven maintained at a temperature of 70°C (158°F), or 10°C (18°F) more than the maximum temperature observed during the normal temperature test, whichever is greater.

43.3 A power-supply cord shall withstand 5,000 cycles of flexing at the cord entrance to the tool. Flexing shall be performed at a rate not exceeding 10 cycles per minute, unless agreeable to those concerned.

43.4 Three samples are to be tested. Each sample is to be mounted so that the cord entrance point of the product is at the center of rotation. A 1-pound (0.45-kg) weight is to be attached to the cord between 3 feet (0.91 m) and 5 feet (1.52 m) from the cord entry point. Any additional cord beyond 5 feet is to be removed. Guides are to be provided 3 feet from the cord entry point to minimize bouncing or side-to-side motion of the cord. The weight is to be located so as not to interfere with the guides. When a short cord is employed, the additional length is to be obtained by using an attached extension cord that the manufacturer makes available. See Figure 43.1.

**Figure 43.1**
**Cord flexing**




A – Portions of the cord damaged by contact with the guides or attachment of the weight may be removed prior to the electrical tests.

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43.5 Starting with the cord in a vertical position and the cord entrance pointing downward, each cycle is to consist of rotating the entrance point 90 degrees to the horizontal position, rotating back 180 degrees to the opposite horizontal position, and then back to the vertical position, for a total rotation of 360 degrees. Rotation is to be smooth with no sudden starts or stops.

43.6 After flexing:

a) Each current-carrying conductor shall be capable of carrying its rated ampacity (for the size conductor) as specified in the National Electrical Code, ANSI/NFPA 70, for 2 minutes without interruption. A grounding conductor, if provided, shall be capable of carrying twice its rated ampacity for 2 minutes without interruption;

b) Following the test in 43.6(a), there shall be no dielectric breakdown when a potential of 1000 V plus twice the rated voltage of the tool is applied for 1 minute between the individual conductors of the cord with the internal connections to the tool severed and insulated, and between live parts and accessible metal parts; and

c) There shall be no breakage of a cord jacket or individual conductor insulation. No strands shall be exposed through conductor insulation.

## 44 Marking

44.1 A projector using carbon arc, xenon, or other light source equipment that develops gases, dust, or radiation that may cause injury to persons shall be marked as specified in 66.9.1.

## PERFORMANCE

## 45 General

45.1 Unless otherwise specified, the voltage for tests shall be as indicted in Table 45.1.

45.2 Equipment with one frequency rating is to be tested at that frequency. Equipment with a dual frequency rating is to be tested at 60 Hz if 60 Hz is in the rating and may also be tested at the second frequency.

**Table 45.1**
**Voltage for tests**

| Marked voltage rating | Test voltage |
|---|---|
| 105 – 130 | Maximum marked voltage but not less than 120 volts |
| 210 – 260 | Maximum marked voltage but not less than 240 volts |
| 420 – 520 | Maximum marked voltage but not less than 480 volts |
| 520 – 600 | 600 volts |
| Other than as specified above | Maximum marked voltage |
| Battery-operated appliance | Maximum battery voltage |

## 46 Resistance of Grounding Circuit

46.1 The resistance between the point of connection of the equipment grounding means, at or within an appliance, and any other point in the grounding circuit shall not exceed 0.1 ohm.

46.2 An impedance-measuring instrument may be used to determine whether an appliance complies with the requirement in 46.1; or, in place of this instrument, an alternating current of at least 25 A from a power supply of not more than 12 V is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit, and the resulting drop in potential is to be measured between the two points. For a cord-connected product with a grounding-type attachment plug and grounding conductor, the connection of the equipment grounding means is considered to be the point on the appliance where the grounding conductor of the cord is attached. 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.

46.3 A conductor smaller than that specified in 13.1.9 or 13.2.4 may be used if the bonding or grounding connection does not open when carrying twice the current equal to the rating of the branch-circuit overcurrent device for the interval specified in Table 46.1.

**Table 46.1**
**Duration of current for bonding-conductor test**

| Overcurrent device rating, amperes | Minimum current flow duration, minutes |
|---|---|
| 30 or less | 2 |
| 31 – 60 | 4 |
| 61 – 100 | 6 |

## 47 Leakage Current and Shock Current Tests

### 47.1 General

47.1.1 All parts of a single-phase, cord-connected appliance rated for a nominal 240 V or less that are accessible during normal use are to be tested for leakage current and 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 and from one part, or group of parts, to another part, or group of parts where simultaneously accessible. 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 this measurement, one hand is considered to be able to simultaneously contact parts that are within a 4 by 8 inch (102 by 203 mm) rectangle. Parts that can be contacted simultaneously by a person having a reach of 6 feet (1.83 m) are considered to be touchable by both hands.

47.1.2 If the appliance has a direct-current rating, measurements are to be made with the appliance connected in turn to each side of a 3-wire, direct-current supply circuit.

47.1.3 Insulation, such as that usually used in a location as specified in (a) – (f), is to be short- or open-circuited during the test:

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

b) Between live parts and the metal frame of a phonograph pick-up cartridge.

c) Between the two channels of a stereophonic phonograph pick-up cartridge.

d) Between the heater and cathode elements of a vacuum tube.

e) Between any two adjacent elements of a vacuum tube, between the elements of an electrolytic capacitor.

f) Between the elements of a solid-state component – for example, a diode, a transistor, an integrated circuit, and a similar device.

*Exception: A solid-state component, the breakdown of which can be relied upon not to result in a risk of electric shock is not required to be short- or open-circuited during the test.*

47.1.4 Current measurements are to be made:

a) With any operating control or adjustable control that is considered subject to user operation in all possible positions of contact and

b) Either with or without tubes, separable connectors, and similar devices in place.

47.1.5 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the appliance.

## 47.2 Leakage current

47.2.1 A cord– connected product rated for a nominal 250-volt or less supply shall be tested in accordance with 47.2.2 – 47.2.5. Leakage current shall not be more than:

a) 0.5 MIU for a two-wire cord- and plug-connected appliance,

b) 0.5 MIU for a three-wire (including grounding conductor) cord- and plug-connected portable appliance, and

c) 0.75 MIU for a three-wire (including grounding conductor) cord- and plug-connected stationary or fixed appliance.

*Exception No. 1: The leakage current of an appliance incorporating a sheath type heating element is to be monitored during heat-up and cool-down and shall not exceed 2.5 MIU during the first 5 minutes of energizing the appliance. At the end of this time, the leakage current shall be not more than the 0.5 MIU or 0.75 MIU limit, as applicable.*

*Exception No. 2: Conductive parts of an appliance that complies with the following conditions and that have a leakage current greater than specified in (a), (b), or (c) shall have a leakage current from simultaneously accessible parts to the grounded supply conductor no greater than 3.5 MIU. The leakage current between simultaneously accessible parts shall not exceed 0.5 MIU.*

*a) The product is equipped with a grounding type supply cord and plug;*

*b) There is a low probability that a path for available current through the body will exist in the expected environment. If the available current flows to ground, this will involve consideration of the probability that the user will be grounded during the use of the product;*

*c) There is a low probability that high-leakage, conductive parts are capable of being contacted during normal use of the product;*

*d) The probability of injury resulting from an involuntary reaction is small.*

*Exception No. 3: For an appliance that upon loss-of-grounding, dependably disconnects all sources that can produce leakage current, the leakage current to ground shall not exceed 5 MIU with the grounding conductor open and with the loss-of-grounding circuit disabled. The leakage current between simultaneously accessible parts on the appliance shall not be more than 5 MIU.*

*a) The product requires electromagnetic interference (EMI) suppression filtering for compliance with other requirements, such as Federal Communications Commission (FCC) Regulations.*

47.2.2 All accessible conductive parts are to be tested for leakage currents. Leakage currents from these parts are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one part to another if simultaneously accessible. A part is considered to be accessible unless it is guarded by an enclosure that is acceptable for protection against the risk of electric shock. Conductive parts are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to involve a risk of electric shock. If all accessible conductive parts are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current can be measured between the grounding conductor of the product and the grounded supply conductor. If accessible dead-metal parts of a product are connected to the neutral supply conductor, this connection is to be opened during the test.

47.2.3 When a conductive part other than metal is used for an enclosure or part of an enclosure, leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters in contact with the surface. If the conductive surface has an area less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is to conform to the shape of the surface but is not to remain in place long enough to affect the temperature of the product.

47.2.4 Typical measurement circuits for leakage current with the ground connection open are illustrated in Figure 47.1. The measurement instrument is defined in Figure 47.2. The meter that is actually used for a measurement is only required to indicate the same numerical value for a particular measurement as would the defined instrument; it is not required to have all the attributes of the defined instrument. Over the frequency range 20 Hz – 1 MHz with sinusoidal current, the performance of the instrument is to be as follows:

a) The measured ratio of $V_1/I_1$ with sinusoidal voltages is to be as close as feasible to the ratio $V_1/I_1$ calculated with the resistance and capacitance values of the measurement instrument shown in Figure 47.2 and

b) The measured ratio of $V_3/I_1$ with sinusoidal voltages is to be as close as feasible to the ratio $V_3/I_1$ calculated with the resistance and capacitance values of the measurement instrument shown in Figure 47.2. $V_3$ is to be measured by the meter M in the measuring instrument. The reading of meter M in RMS volts can be converted to MIU by dividing the reading by 500 ohms and then multiplying the quotient by 1,000. The mathematic equivalent is to multiply the RMS voltage reading by 2.