

UL 45

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Portable Electric Tools



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The revisions dated January 5, 2000 include a reprinted title page (page1) for this Standard.

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## **UL 45**

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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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## FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

## INTRODUCTION

### 1 Scope

1.1 These requirements cover portable electric tools rated not more than 600 V (at not more than 250 V if the tool employs a universal motor), for use in accordance with the National Electrical Code.

1.2 In addition these requirements cover accessories and attachments for use with portable electric tools. Specific requirements are outlined in Sections 62 – 66.

1.3 These requirements do not cover fixed or stationary electric tools, flexible-shaft tools, gardening appliances, garage equipment, soldering irons or guns, painting equipment, floor-finishing machines, or other equipment covered by individual requirements.

1.4 The requirements cover double-insulated tools. Specific requirements are given in Sections 59 – 61.

1.5 For the purpose of these requirements, tools are classified into two groups:

a) A general-use tool is considered to be a tool (usually employing a universal motor) that ordinarily is subject to a wide fluctuation of load, such as a drill, a hand circular saw, an aerial grinder, and a disc sander.

b) A special-use tool is considered to be a tool intended for a particular operation not involving a wide variation of load, such as an orbital sander and a nibbler.

1.6 These requirements cover an accessory and an attachment:

a) Recommended by the manufacturer;

b) Referred to in the instruction manual for a tool; or

c) Packed with a tool.

1.7 These requirements do not cover accessories or attachments that:

a) Are not provided with the tool; and

b) Are not identified by catalog number or equivalent product designation in the instruction manual for the tool.

These requirements do not cover accessories or attachments mentioned in minicatalogs or flyers even if the catalog or flyer is provided with the tool.

1.8 Multifunction tools that have clearly separate modes of operation, such as hammer-drills and rotary hammers, are required to separately comply with the requirements applicable to each separate mode of operation. See 29.1.

## 2 Terminology

2.1 In the following text, a requirement that applies only to a specific type or types of tools is so identified by a specific reference in the requirement to the type or types of equipment involved. Absence of such specific reference or use of the term tool indicates that the requirement applies to all of the types of equipment covered by this standard unless the context indicates otherwise.

2.2 For the purpose of these requirements:

- a) An attachment is a device attached to the housing or other component of the tool and may or may not attach to the spindle. Attachments include tables to convert hand held tools to bench mounted types; for example, a router table.
- b) An accessory is a device that is attached only to the spindle of the tool.

2.3 For the purpose of these requirements the following definitions apply:

- a) Portable Tool – A tool that is moved to the workpiece in order to perform the function for which it is intended and then removed. Generally, a portable tool is hand held or hand supported.
- b) Fixed or Stationary Tool – A tool for which the workpiece is moved to the tool in order to perform an operation.

## 3 Components

3.1 Except as indicated in 3.2, 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 generally used in the products covered by this standard.

3.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

3.4 Specific components are recognized as being 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 for which they have been recognized.

## 4 General

4.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.



## CONSTRUCTION

### 5 General

5.1 A tool shall employ materials throughout that are acceptable for the particular use.

### 6 Frame and Enclosure

6.1 A tool shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.2 The minimum thickness of cast metal shall be in accordance with Table 6.1.

**Table 6.1**  
**Minimum thicknesses of cast metal**

Metal	At surfaces that are reinforced by curving, ribbing, or the like (or are otherwise of a shape and/or size to provide acceptable physical strength),		At unreinforced flat surfaces,	
	inch	(mm)	inch	(mm)
Die-cast metal	3/64	(1.2)	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	3/32	(2.4)
Other cast metal	3/32	(2.4)	1/8	(3.2)

6.3 An enclosure of sheet metal is to be considered with respect to its size, shape, thickness of metal, and its acceptability for the particular application, including the intended use of the complete tool.

6.4 Among the factors taken into consideration when determining the acceptability of a nonmetallic enclosure or an enclosure of magnesium is each of the following items:

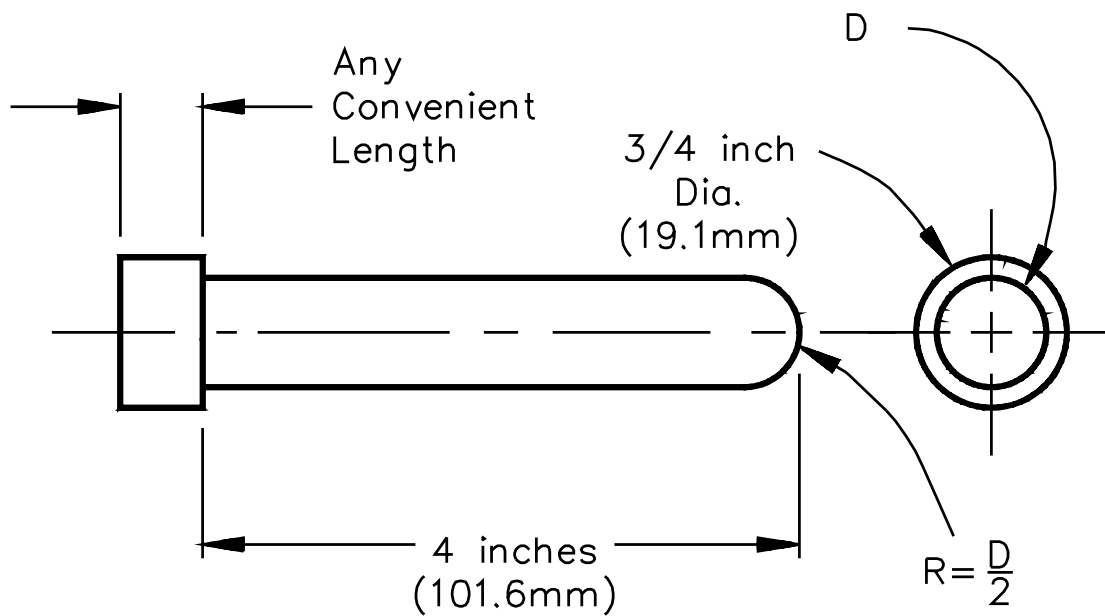
- a) Mechanical strength.
- b) Resistance to impact.
- c) Moisture-absorptive properties.
- d) Combustibility.
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of intended use and reasonably foreseeable abuse.
- f) Resistance to arcing.

6.5 Electrical parts of a tool shall be so located or enclosed that protection against unintentional contact with uninsulated live parts will be provided. Insulated brush caps do not require additional enclosure.

6.6 With reference to the requirement in 6.5, an opening in the enclosure of a tool that is hand-supported during intended use is acceptable if a probe, as illustrated in Figure 6.1, having a diameter of 3/8 inch (9.5 mm) cannot be made to touch any uninsulated live part or film-coated wire when inserted through the opening. An opening in the enclosure of any other tool is acceptable in accordance with the following:

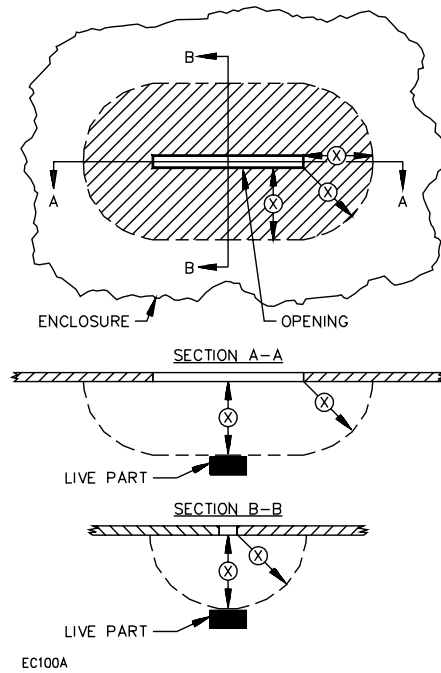
- a) An opening that will admit a 3/4 inch (19.1 mm) diameter rod is acceptable if there is no uninsulated live part or film-coated wires in the space indicated in the illustration in Figure 6.2.
- b) An opening that will not admit a 3/4 inch (19.1 mm) diameter rod is acceptable if:
  - 1) A probe as illustrated in Figure 6.1 having a diameter of 1/2 inch (12.7 mm) cannot be made to touch film-coated wire when inserted through the opening, and
  - 2) A probe as illustrated in Figure 6.3 cannot be made to touch any uninsulated live part when inserted through the opening.

**Figure 6.1**  
**Probe for film-coated wire**

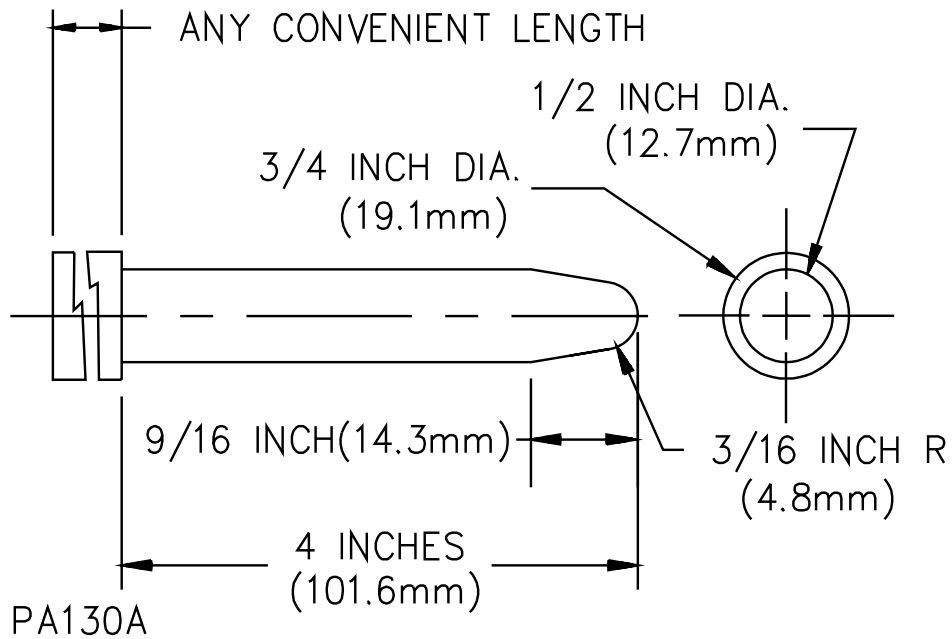


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**Figure 6.2**  
**Opening in enclosure**  
Proportions exaggerated for clarity



**Figure 6.3**  
**Probe for uninsulated live part**



6.7 An opening that has a minor dimension of 1 inch (25.4 mm) or more in an enclosure as illustrated in Figure 6.2 is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire less than:

- a) R distance from the inside edge of the perimeter of the opening; and
- b) X distance from the plane of the opening.

T equals the enclosure thickness, R equals X minus T, and X equals five times the diameter of the largest round rod that can be inserted through the opening but not less than 6-1/16 inches (154 mm). In evaluating an opening, any barrier located within the volume is to be ignored unless it intersects the boundaries of the volume in a continuous, closed line.

6.8 During examination of a tool in connection with 6.6, a part of the outer enclosure that is intended to be removed, without the use of tools, by the user of the tool (for the attachment of accessories, access to means for making operating adjustments, or other reasons) is to be disregarded – that is, such a part is not considered to reduce the risk of electric shock.

6.9 The enclosure of a tool or of a control unit or auxiliary component, such as a rheostat or a rectifier, that is not integral with the tool proper shall exclude foreign matter – abrasive or electrically conductive particles and the like – likely to be present during operation that might adversely affect electrical insulation or otherwise result in risk of fire, electric shock, or injury to persons.

## **7 Mechanical Assembly**

7.1 A tool shall be so assembled that it will not be affected adversely by the vibration of intended operation.

7.2 A brush cap shall be tightly threaded or otherwise constructed so that it does not loosen.

7.3 A switch, an attachment-plug receptacle, and a plug connector shall be mounted securely and shall be prevented, by means other than friction between surfaces, from turning or shifting to the extent of:

- a) Reducing spacings below the minimum acceptable values;
- b) Applying stress to connections; or
- c) Flexing leads.

7.4 A properly applied lock washer is acceptable as a means to prevent turning of a switch or other device having single-hole mounting means.

7.5 A tool shall be so constructed that user-maintenance can be accomplished without the likelihood of:

- a) Pinching leads;
- b) Reducing spacings to values less than those indicated in Table 18.1;
- c) Mislocating or damaging the means for accomplishing strain relief; and
- d) Mislocating or damaging a guard or other similar device.

7.6 User-maintenance is considered to consist of inspection of or replacement of motor brushes or fuses and other service that is recommended in the instruction manual to be performed by the user. It does not include maintenance that the instruction manual recommends be done by authorized service personnel.

7.7 Compliance with the requirement in 7.5 may be accomplished by routing of wires, provision of wire channels, provision of locating wells for components, use of barriers, use of restraints, securing of components, and other means.

7.8 Routing as mentioned in 7.7 is acceptable if the construction is such that after the wire has been put into the intended position preparatory to the reassembling of the tool, that the reassembly procedure will not result in the wire contacting a moving part or being pinched. This does not mean that the wire must be of such length or so clamped that it cannot reach the pinch point or the moving part.

7.9 A tool employing a soft rubber, neoprene, or polyvinyl chloride pressure pad to hold down or maintain permanent position of an electrical part, such as a motor, to provide for intended functioning of the tool shall be tested in accordance with 41.1. If the pressure pad is exposed to grease, it shall also be tested in accordance with 41.2.

*Exception: The test is not required if a risk of fire or electric shock does not result from deterioration of the pad as determined by an abnormal operation test in which the tool is operated without the pressure pad.*

## **8 Protection Against Corrosion**

8.1 Except as noted in 8.2, iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means if deterioration or breakage of such parts would be likely to result in a risk of fire, electric shock, or injury to persons.

8.2 If the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – the surfaces of sheet steel and cast-iron parts in an enclosure may not be required to be protected against corrosion. The requirement in 8.1 does not apply to bearings, laminations, and minor parts of iron or steel, such as washers, screws, and the like.

## **9 Power Supply Cords**

### **9.1 Cords and plugs**

9.1.1 A tool shall be provided with flexible cord, permanently attached to the tool, and with an attachment plug, which may be of the locking type, for connection to the power-supply circuit.

9.1.2 Except as noted in 9.1.4, the flexible cord on a hand circular saw shall be at least 6 feet (1.8 m) long.

9.1.3 Except as noted in 9.1.4, the flexible cord on all other tools shall be at least 5 feet (1.5 m) long.

9.1.4 A tool may be provided with less than 5 feet (1.5 m) of permanently attached flexible cord (see 9.1.6) or with a motor attachment plug:

a) If the manufacturer makes an acceptable extension cord available, and if a statement indicating the availability of such extension cord is marked on the tool or is included in the instruction book or the like regularly furnished with the tool; or

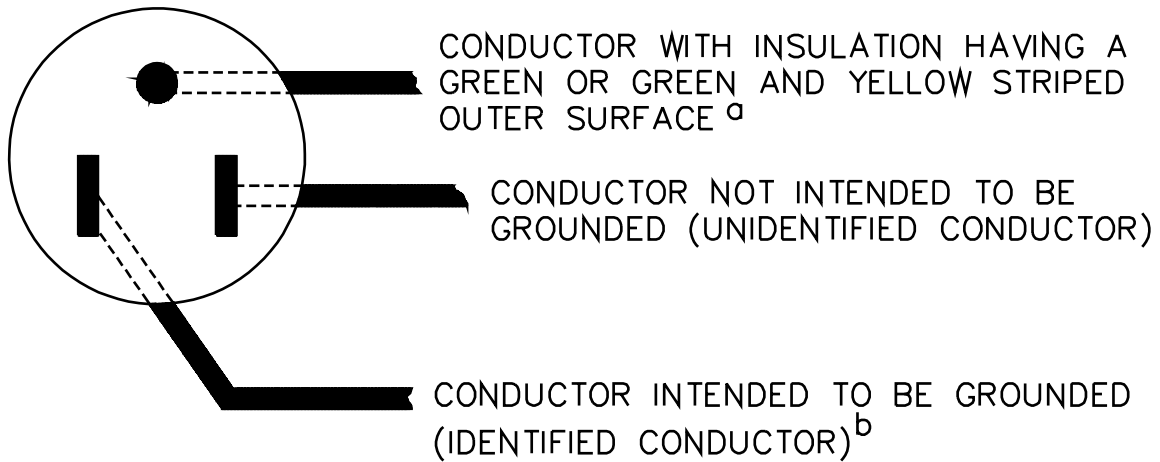
b) If the manufacturer furnishes an acceptable detachable cord set, 5 feet (1.5 m) or more in length, with the tool. If several tools are packaged and marked together, only one cord set need be furnished with the group of tools.

9.1.5 If a 3-wire grounding type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connections shall be as shown in Figure 9.1. See 9.1.1.

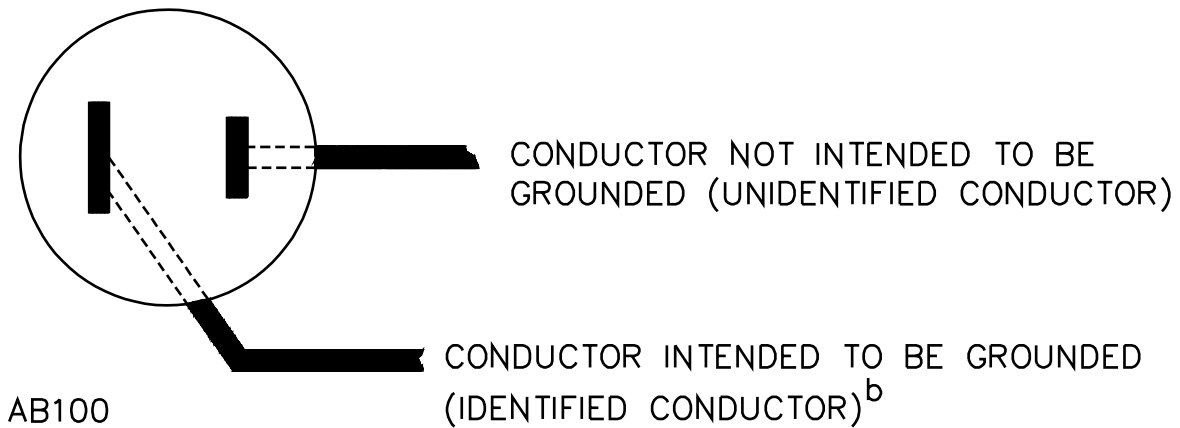
**Figure 9.1**  
**Connection to attachment plug**

Figure 9.1 revised August 7, 1998

CONNECTIONS OF CORD CONDUCTORS TO GROUNDING – TYPE ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



CONNECTIONS OF CORD CONDUCTORS TO POLARIZED ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



<sup>a</sup> The blade to which the green conductor is connected may have a U-shaped or circular cross section.

<sup>b</sup> Signifies a conductor identified in accordance with Table 9.1.

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**Table 9.1**  
**Polarity identification of flexible cords**

Method of identification	Acceptable combinations	
	Wire intended to be grounded <sup>a</sup>	All other wires
Color of braids on individual conductors	A Solid white or natural gray – without tracer	Solid color other than white or gray – without tracer
	B Color other than white or natural gray, with tracer in braid	Solid color other than white or natural gray – without tracer
Color of insulation on individual conductors	C Solid white or natural gray	Solid color other than white or natural gray
	C1 Light blue	Solid color other than light blue, white, or natural gray
<sup>a</sup> A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used as an equipment grounding conductor.		

9.1.6 The power supply cord mentioned in 9.1.4 shall be of such length that it cannot be damaged or impaired by any cutting edges, blades, belts, or rotating parts; and shall not be more than 18 inches (457 mm) in length in any case.

9.1.7 A three-to-two wire grounding-type adapter shall not be provided with a tool employing a short cord as described in 9.1.4 unless an acceptable 3-wire grounding-type extension cord set is also provided with the tools.

9.1.8 Except as noted in 9.1.9, 9.1.10, and 9.1.11, the flexible cord shall be hard-service cord, such as Type SJ, or extra-hard-service cord, such as Type S.

9.1.9 A portable tool intended principally for hobby use and having a chuck size not larger than 1/8 inch (3.2 mm) may employ Type SV or SP2 or equivalent cord having No. 36 AWG (0.0127 mm<sup>2</sup>) individual strands.

9.1.10 A concrete vibrator, or other tool of which the cord is likely to be subjected to extremely rough usage, shall employ an extra-hard service cord, such as Type S.

9.1.11 A light weight hand-held sharpening tool, such as a chain saw sharpener, may employ Type SVT or SV, or equivalent jacketed cord having No. 36 AWG (0.0127 mm<sup>2</sup>) individual strands.

9.1.12 If a lamp having a separate power supply cord is provided as a part of a tool, the cord for the lamp shall be the same type as that specified for the tool.

9.1.13 The flexible cord shall be rated for use at a voltage not less than the rated voltage of the tool, and shall have an ampacity, as given in the National Electrical Code, ANSI/NFPA No. 70-1996, not less than the current rating of the tool.

9.1.14 The attachment plug shall be acceptable for use with a current not less than the rated current, and at the rated voltage of the tool. If the tool is adaptable for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the tool shall be rated for the voltage for which the tool is connected when shipped from the factory. See 52.8.

9.1.15 A tool intended for use with a detachable power supply cord shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

9.1.16 If a tool incorporates a disconnecting means, such as a cord connector in the power supply cord, the arrangement shall be such that no live parts will be exposed under any normal conditions.

## **9.2 Strain relief**

9.2.1 Strain relief shall be provided to prevent a mechanical stress on a flexible cord from being transmitted to terminals, splices, or internal wiring.

9.2.2 A metal strain relief clamp or band is acceptable with a Type SP-2, SPE2, SPT2, SVT, SVTO, or SVTOO cord only if auxiliary nonconductive protection is provided over the cord. A metal strain relief clamp or band without auxiliary protection is acceptable for other cord types.

9.2.3 Means shall be provided to prevent the flexible cord from being pushed into the tool through the cord-entry hole if such displacement may expose the cord to mechanical damage or to a temperature higher than that for which the cord is rated, or is likely to reduce spacings, such as to a metal strain relief clamp, below the minimum acceptable values.

9.2.4 If a knot in a flexible cord serves as strain relief, the surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the cord jacket or the insulation on the conductors.

9.2.5 The strain relief provided on the power supply cord shall be independent of any rubber cord guard unless the guard is molded on the cord or has been determined to be acceptable for the particular application.

## **9.3 Bushings**

9.3.1 At a point at which a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be acceptably constructed and secured in place, and shall have a smooth, round surface on which the cord may bear. If Type SP-2 or SPT-2 cord is employed and if the wall or barrier is of metal, an insulating bushing shall be provided.

9.3.2 If the cord-entry hole is in porcelain, phenolic composition, or other equivalent insulating material, a smooth, round surface is considered to be equivalent to a bushing.

9.3.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings; but separate bushings of wood or of so-called hot-molded shellac and tar compositions are not acceptable.

9.3.4 Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick, and if it is so formed and secured in place that it will not be affected adversely by conditions of ordinary moisture.

9.3.5 An acceptable separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor (but not elsewhere in the tool, except as noted in 9.3.6), if:

- a) The bushing is not less than 1/16 inch (1.6 mm) thick; and
- b) The bushing is so located that it will not be exposed to oil, grease, oily vapor, or any other substance having a deleterious effect on the compound employed.

9.3.6 A bushing of any of the materials mentioned in 9.3.5 may be employed at any point in a tool if used with cord of a type for which an insulating bushing is not required. See 9.3.1.

9.3.7 If a bushing of one of the materials mentioned in 9.3.5 is used, the edges of the hole in which the bushing is mounted shall be smooth and free from fins, burrs, and the like, regardless of the type of cord involved.

9.3.8 At any point in a tool, a bushing of the same material as, and molded integrally with, the supply cord is acceptable on a Type SP-2 or heavier cord if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure. An insulating metal grommet may be accepted in place of an insulated bushing if the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

## 10 Live Parts

10.1 Metal employed for a current-carrying part shall be silver, copper, a copper alloy, or other metal that is acceptable for the particular application.

10.2 Iron or steel with a corrosion-resistant coating may be used for a current-carrying part:

- a) If permitted in accordance with Section 3; or
- b) Within a motor or associated governor.

The use of unprotected iron or steel for current-carrying parts elsewhere in a tool is not acceptable.

10.3 An uninsulated live part shall be so secured to the surface on which it is mounted, and supporting insulating materials shall be so secured in place, that it will be prevented from turning or shifting in position, if such motion may result in a reduction of spacing below the minimum acceptable values. A brushholder connector shall be acceptably captivated independently of the brush.

10.4 Friction between surfaces is not acceptable as a means to prevent turning or shifting of uninsulated live parts; but a lock washer, properly applied, is acceptable for this purpose.

## 11 Internal Wiring

11.1 The wiring and the connections between parts of a tool shall be protected or enclosed, except that a length of flexible cord may be employed for external interconnection between components if flexibility is essential.

11.2 With reference to exposure of internal wiring through an opening in the enclosure of a tool, the protection of the wiring required by 11.1 is considered to exist if, when considered as though it were film-coated wire, the wiring would be acceptable according to 6.6. Internal wiring not so protected may be acceptable if it is so secured within the enclosure that it is unlikely to be subjected to stress or mechanical damage.

11.3 Internal wiring of a tool shall consist of wires that are acceptable for the particular application when considered with respect to:

- a) The temperature and voltage to which the wire is likely to be subjected;
- b) Exposure to oil, grease, or other substances likely to have a deleterious effect; and
- c) Other conditions of service to which it is likely to be subjected.

11.4 Thermoplastic-insulated, or neoprene-insulated wire, used for internal wiring shall be standard building wire or appliance wiring material and shall comply with Table 11.1.

**Table 11.1**  
**Characteristics of internal wiring**

Insulation	Nominal wall thickness of insulation,		Braid or jacket required	Nominal thickness of braid or jacket,	
	Inch	(mm)		Inch	(mm)
Thermoplastic or neoprene	0.030 <sup>a</sup>	(0.76)	No <sup>a</sup>	—	—
Cross-linked synthetic polymer	0.015	(0.38)	No	—	—
<sup>a</sup> The wall thickness may not be less than 0.015 inch (0.38 mm) if the wire is provided with a braid or jacket not less than 0.015 inch (0.38 mm) thick.					

11.5 Insulating tubing employed instead of wire insulation shall be acceptable for the application and shall have a wall thickness of not less than 1/32 inch (0.8 mm).

11.6 Wiring shall be protected from sharp edges (including screw threads), burrs, moving parts, and other agencies that might cause abrasion of the insulation of conductors.

11.7 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of a tool shall be provided with a smooth, rounded bushing or shall have smooth, well-rounded surfaces upon which the wires may bear to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 11.1 shall be provided with a bushing and strain relief in accordance with 9.2.1 – 9.3.8 and Section 39 unless the construction is such that the cord will be protected from stress and motion.

11.8 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of a tool.

11.9 Film-coated wire employed as a jumper between a coil and a brush holder or switch shall be secured in place unless there is no likelihood of its contacting other live parts or dead metal parts if breakage occurs as a result of vibration.

11.10 All splices and connections shall be mechanically secure and shall provide acceptable electrical contact. A soldered connection shall be made mechanically secure before being soldered.

11.11 A tool shall be so constructed that if a wire breaks, loosens, or otherwise becomes free to move at a switch termination the enclosure will not be made live and no live part will project from the enclosure.

11.12 Compliance with the requirement in 11.11 may be accomplished by use of barriers, by relative placement of parts, by mechanical restraint of the conductor in addition to that resulting from its electrical connections, or by other equivalent means.

11.13 On a tool in which excessive vibration is likely to occur (such as an impact tool), the requirements in 11.10 necessitate the use of lock washers or other acceptable means to prevent wire-binding screws and nuts from becoming loosened.

11.14 An open-end spade lug is not acceptable unless additional means (such as upturned ends on the lug, bosses, shoulders, and the like) are provided to hold the lug in place should the wire-binding screw or nut become slightly loosened.

11.15 A wire-binding screw shall thread into metal.

11.16 A splice shall be provided with insulation if permanence of spacings between the splice and other metal parts may not be maintained.

11.17 The thickness of insulation on a splice shall be 1/32 inch (0.8 mm) or more. In determining if splice insulation consisting of coated fabric, thermoplastic, or other tubing is acceptable, consideration is given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

11.18 Stranded internal wiring shall be so connected to a wire-binding screw that loose strands of wire will be prevented from contacting other uninsulated live parts not always of the same polarity as the wire, and from contacting dead metal parts. This may be accomplished by use of pressure terminal connectors, crimped eyelets, soldering all strands of the wire together, or other equivalent means.

11.19 In a hammer, impact wrench, or other tool, the intended use of which causes severe vibration, a splicing device of the thread-on or setscrew type shall be additionally secured by wrapping the wires and the connector with friction tape or by other equivalent means.

*Exception: This requirement does not apply to double-insulated tools.*

## **12 Insulating Material**

12.1 Material for the mounting of uninsulated live parts shall be phenolic composition, cold molded composition, or other material that is acceptable for the particular application.

12.2 Vulcanized fiber may be used for insulating bushings, washers, separators, brushholder liners, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a condition likely to result in a risk of fire or electric shock. Thermoplastic materials may be employed for sole support of uninsulated live parts only if found to have mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric properties, resistance to arc tracking, and other properties that are acceptable for the application.

12.3 A molded part shall be so constructed that it will have mechanical strength and rigidity to withstand stresses likely to occur in service. A brush cap shall be protected from mechanical damage, by recessing or other means, that might occur unless the part has the strength necessary to withstand the abuses to which it is likely to be subjected.

### **13 Motors**

13.1 The motor of a tool shall drive the maximum intended load of the tool without introducing a risk of fire, electric shock, or injury to persons.

13.2 A motor winding shall resist the absorption of moisture and shall be formed and assembled in a workmanlike manner.

13.3 A brushholder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary so that:

- a) An accessible dead metal part does not become energized; and
- b) A live part does not become accessible.

### **14 Switches and Controls**

14.1 A switch or other control device shall be acceptable for the application, with a voltage rating and an ampacity not less than the corresponding values of the load that it controls.

14.2 A tool shall not employ a through-cord switch.

14.3 A single-pole switch employed in a tool having a nominal rating of 120 V shall be connected in the ungrounded conductor circuit.

### **15 Lampholders**

15.1 If a tool is intended to be connected to the grounded conductor of the power-supply circuit, a lampholder comprising part of the tool shall be so wired that the screw shell will be connected to that conductor.

### **16 Thermal Cutoffs**

16.1 If a thermal cutoff is used as noted in 59.7.1.2, it shall comply with the requirements applicable to such a device in addition to the applicable requirements in this standard. A thermal cutoff shall comply with the applicable requirements in this standard and those in the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020.

## 17 Capacitors

17.1 A capacitor provided as a part of a capacitor motor, and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or a container that will protect the plates against mechanical damage and will contain the emission of flame or molten material resulting from malfunction of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm). Sheet metal having a thickness less than 0.026 inch (0.66 mm) is not recommended.

17.2 The individual container of a capacitor may be of sheet metal thinner than that mentioned in 17.1 or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the tool and if such a box, case, or the like, is acceptable for the enclosure of live parts.

17.3 The total capacitance of capacitors connected from one side of the line to the frame or enclosure of a tool shall not be such as to permit the flow of more than 0.5 mA in the grounding conductor when the frame or enclosure is connected to ground. See also 30.1.

## 18 Spacings

18.1 Except as noted in 18.2, the spacing between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead metal part, shall not be less than the value indicated in Table 18.1. If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the spacing will not be reduced to less than the minimum acceptable value.

18.2 The spacing requirements given in Table 18.1 do not apply to the inherent spacings of a component of the tool, such as a snap switch; such spacings are considered on the basis of the requirements covering the component in question. For a repulsion motor, a repulsion-induction motor, or a repulsion-start induction motor the spacing requirements do not apply to the commutator, the brush assembly, and the jumpers that short-circuit the brushes. Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with respect to the stator circuit, and the appropriate spacing is required between uninsulated rotor and stator conductors.

**Table 18.1**  
**Minimum spacings in inches (mm)**

Potential involved, volts	Motor diameter 7 inches (178 mm) or less <sup>c</sup>		Motor diameter more than 7 inches (178 mm) <sup>c</sup>	
	Over surface	Through air	Over surface	Through air
0 – 125	3/32 (2.4)	3/32 (2.4)	1/4 <sup>a,b</sup> (6.4)	1/8 <sup>a,b</sup> (3.2)
126 – 250	3/32 (2.4)	3/32 (2.4)	1/4 <sup>a,b</sup> (6.4)	1/4 <sup>a,b</sup> (6.4)
251 – 600	1/2 (12.7)	3/8 <sup>b</sup> (9.5)	1/2 <sup>b</sup> (12.7)	3/8 <sup>b</sup> (9.5)

<sup>a</sup> Spacings of not less than 3/32 inch (2.4 mm) are acceptable throughout a universal motor.

<sup>b</sup> Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) – over surface and through air – between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

<sup>c</sup> This is the diameter, measured in the plane of a lamination, of the circle circumscribing the stator frame excluding lugs, boxes, and the like used solely for motor mounting, assembly, or connection.

18.3 In the application of Table 18.1 to the motor not rated in horsepower, use is to be made of the appropriate table in the National Electrical Code, ANSI/NFPA No. 70-1996, that gives the relationships between horsepower and full-load currents for motors. The table applying to single-phase alternating-current motors is to be used for a universal motor.

18.4 At terminal screws and studs to which connection may be made in the field by wire connectors, eyelets, and the like, and at garter springs of brushes, the spacings shall not be less than those shown in Table 18.1 when such connectors, eyelets, and similar parts are in such position that minimum spacings (opposite polarity and to dead metal) exist.

18.5 An insulating liner or barrier of vulcanized fiber or similar material employed where a spacing would otherwise be less than the minimum acceptable value shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it will not be affected adversely by arcing; except that vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

18.6 A printed wiring board with spacings between circuits of opposite polarity and potentials less than those required is acceptable provided that the spacings:

a) Are located on a portion of the printed wiring board provided with a conformal coating which complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and:

- 1) Applied at no less than the required thickness; and
- 2) Complies with the dielectric voltage withstand test in 34.7;

b) Are located on a portion of the printed wiring board provided with an epoxy coating not less than 1/32 inch thick and:

- 1) Having a minimum spacing of not less than 1/32 inch; and
- 2) Complying with the dielectric voltage withstand test in 34.7; or

c) Are connected to the load side of a resistor where a short circuit at that point does not result in the resistor wattage exceeding the resistor rating.

*Exception: Spacings on a printed wiring board may alternatively be evaluated to UL 840, the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, in accordance with 18.7.*

18.7 For the purpose of determining suitability of spacings in accordance with the exception to 18.6, a tool is considered to operate in a pollution degree 3 environment. For a tool employing a conformal coating to comply with pollution degree 1 criteria or a solder mask or unevaluated conformal coating used to achieve a Pollution Degree 2 level shall be used according to UL 840, the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, the conformal coatings shall be used in accordance with its ratings, and applied in accordance with the coating manufacturer's instructions.



## 19 Grounding

19.1 The power supply cord of a tool shall include an equipment-grounding conductor.

19.2 An equipment-grounding conductor in a flexible cord shall be:

- a) Finished to show a green color with or without one or more yellow stripes;
- b) Connected to the grounding member of an attachment plug of the grounding type; and
- c) Conductively connected to:
  - 1) All exposed dead metal parts that are likely to become energized; and
  - 2) All dead metal parts within the enclosure that are exposed to contact during user servicing and that are likely to become energized.

The grounding conductor shall be connected by means of a screw or equivalent means not likely to be removed during any servicing operation; solder alone shall not be used for securing this conductor.

19.3 The screw mentioned in 19.2(c) shall be of corrosion-resistant metal or shall be protected against corrosion. A lock washer or other equivalent means shall be employed to prevent the screw from being loosened by vibration.

19.4 The grounding member of the attachment plug mentioned in 19.2(b) shall be fixed in position with respect to the plug unless the tool is hand-supported.

## 20 Insulating Surfaces

20.1 A saw, drill, or hammer drill with 1/2 inch (12.7 mm) or less chuck size, and other tools likely to cut into live wiring in a wall or their own cords, shall have an insulating handle of a type that will make it convenient to use the tool grasping this handle, and shall be marked as described in 52.31. If the tool is not double insulated, the switch trigger shall be of insulating material or have double insulation between the trigger and live parts of the switch. The switch shall either be a double pole switch or a single pole switch that opens the ungrounded conductor, and used in combination with a polarized or grounding type attachment plug. The switch shall be located in the handle with an outer surface of non-conductive material.

*Exception: A low voltage battery-operated portable tool need not be provided with a double pole switch.*

20.2 A belt sander, disc sander, right angle grinder, or drain cleaner shall have insulated surfaces for the two surfaces most likely to be grasped during operation of the tool, unless it is convenient to use the tool using a single insulated grasping surface only, as specified in 20.1.

20.3 All auxiliary type handles on the tools mentioned in 20.1 and 20.2 shall have insulating material on the outer surfaces for at least the area that is intended to be grasped or touched during operation. Examples of auxiliary handles include: spade type handles, "D" shaped handles, pipe handles, or stick type handles. A pistol grip drill or hammer drill with an optional auxiliary handle whether provided or not provided with a tool, is considered to be a single grasping handle tool.

20.4 A stick type auxiliary handle, that is required to be insulated, and that is provided as a grasping area, shall be:

- a) Provided with a flange of insulating material located on the tool side of the grasping surface with a height not less than 3/4 inch (19 mm) above any point around the circumference of the handle at the flange base, unless the tool housing serves as an insulating flange; and
- b) Insulated along the full length of the grasping surface to the flanges or housing.

20.5 A bolt, screw, or other mounting hardware in an area likely to be grasped during operation that secures a covering of insulating material to a metal enclosure and threads into a metal enclosure containing electrical components or into a metal enclosure that contacts another metal enclosure containing electrical components shall be one of the following:

- a) Of insulating material;
- b) Provided with a layer of insulation between the hardware and the metal enclosure equivalent to supplementary (protecting) insulation;
- c) Inaccessible to the probe illustrated in Figure 6.1, having a diameter of 3/8 inch (9.5 mm), when inserted to a depth of 1 inch (25.4 mm); or
- d) Recessed not less than 1/8 inch (3.2 mm) below the outer surfaces of the insulating material if the opening will not admit a 3/8 inch (9.5 mm) diameter cylinder rod.

20.6 As described in 20.1 – 20.5, the outer surface of a handle or other area likely to be grasped may be of electrically conductive material provided it is:

- a) Separated from internal live parts by at least two separate insulating systems;
- b) Spaced not less than 3/32 inch (2.4 mm) from any dead metal part insulated from a live part by basic insulation only; and
- c) For a tool likely to cut into wiring in a wall or its own cord, isolated from the cutting tool.

20.7 As described in 20.1 – 20.6, the insulating material on the outer surface of a handle or in an area likely to be grasped shall be acceptable for its intended application.

20.8 If the insulating material mentioned in 20.1 – 20.7 overlies dead metal, the material shall be tested as described in 45.3.1.

20.8 revised June 2, 1997

20.9 Tools not likely to cut into wiring or its own cord as described in 20.1 need not have an outer surface of insulating material if it has:

- a) A switch with a trigger of insulating material; or
- b) A switch with double insulation or reinforced insulation between the trigger and the live parts of the switch.

## PROTECTION AGAINST INJURY TO PERSONS

### 21 Scope

21.1 This section gives the requirements for tools covered by this standard the operation of which may involve an injury to the operator or a bystander in the work area.

21.2 During examination of a tool with respect to risk of injury to persons, the general requirements for such features as materials, enclosures, guards, and the like will be applied, along with appropriate requirements for tests, construction, markings, guards, and the like, that apply to that tool. The requirements given in Sections 22 – 27 apply to tools of common constructions, and specific features of tools that are not contemplated herein will be given consideration. A specific requirement pertaining to a particular tool takes precedence over the requirement specified in the general section.

21.3 To determine the SFPM for peripheral surface, the following formula may be employed:

$$SFPM = \frac{3.1416 \times D \times RPM}{12}$$

*in which:*

*SFPM is surface feet per minute,*

*D is diameter in inches, and*

*RPM is revolutions per minute.*

### 22 Accessories and Attachments

22.1 Operation of a tool with an accessory or an attachment, see 1.6, 1.7 and 2.2, shall not increase the risk of injury to persons. See Sections 62 – 66 for specific requirements regarding accessories and attachments.

### 23 Materials

23.1 The material of a part such as an enclosure, a frame, or a guard, the breakdown of which might result in a risk of injury to persons shall have such properties as to meet the demand of expected loading conditions.

### 24 Rotating Members

24.1 A tool employing a user-removable rotating part secured by a threaded member, such as a blade or a grinding wheel, shall be so constructed that the direction of rotation tends to tighten the nut that secures the rotating part in place.

24.2 Unless secured as described in 24.1, a removable rotating part not intended to be removed by the user shall be secured by a keyed nut, a jam nut, a nut locked in place with a pin, or other positive means.

## 25 Enclosures and Guards

25.1 A moving part shall be so enclosed or guarded as to acceptably reduce the likelihood of injury to persons, except only as such part is necessarily exposed during intended operation of the tool.

25.2 Among the factors to be considered in determining the acceptability of an exposed moving part are:

- a) The degree of exposure;
- b) The sharpness of the moving part;
- c) The likelihood of unintentional contact therewith;
- d) The speed of the moving part; and
- e) The likelihood that fingers, arms, feet, or clothing would be endangered by the moving part.

These factors are to be considered with respect to the intended operation of the tool and also during setting of any adjustment or replacement of any tool.

25.3 Some guards provided over moving parts are required to be of the self-restoring type. Other features of guards that will be considered include each of the following:

- a) Removability of the guard without the use of tools.
- b) Removability for servicing and the need for replacement.
- c) Strength and rigidity.
- d) Completeness.
- e) Creation of additional risks, such as pinch points, and the necessity for additional handling because of increased need for servicing, such as cleaning and unjamming.

25.4 Except for an opening for the cutting edge of a tool, an opening in a guard or enclosure around a moving part capable of causing injury, such as a cutting tool, fan, pulley or gear, shall have a baffle to prevent contact with that part or the opening shall have a minor dimension less than 1 inch (25.4 mm).

25.5 The unobstructed distance from the opening to the moving part mentioned in 25.4 shall not be less than  $8D-1.5$  inches ( $8D-38.1$  mm), in which D is the minor dimension of the opening in inches (mm), except that a fan is considered to be acceptably guarded if it cannot be contacted with the probe described in Figure 6.3 having a diameter of 1/2 inch (12.7 mm).

25.6 The enclosure or guard around a rotating member shall be complete from the standpoint of number and size of the openings provided, and shall have such strength as to contain a member or part of a member, such as a grinding wheel, or a carbide-tipped saw blade, that, because of breakage or other reason, might become loose or separate from the rotating member and strike the guard.

## 26 Switches and Controls

26.1 A device that automatically starts a tool, such as a timer, an automatically reset overload protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

26.2 An on-off switch or control shall be provided on a tool.

26.3 If unintentional operation of a switch, including a reversing switch, can result in risk of injury to persons, the switch shall be so located or guarded that such operation is unlikely.

26.4 A switch, other than a momentary-contact switch, that controls the motor of a tool shall have a marked off position if the tool, when energized, has moving parts that are likely to cause injury to persons.

26.5 With reference to the requirement in 26.3, 26.4, and 26.6, the platens of orbital and reciprocating sanders and orbital and reciprocating polishers are not considered likely to cause injury to persons.

26.6 A maintained-contact on-off switch or a momentary-contact switch that can be locked in the on position shall not be provided on a tool if a risk of injury to persons is likely to result if the tool is energized while unattended. See 26.7 – 26.12.

26.7 The following tools shall be provided with a momentary-contact switch with no provision for being locked in the on position:

- a) A circular saw.
- b) A percussion tool without positive accessory holding means.
- c) A combination tool.

*Exception: A combination tool may be provided with a maintained contact on-off switch or with a momentary-contact switch having a means for locking the on-off switch in the on position, if all functions of the tools are functions for which the type of switch used would be acceptable.*

26.8 A drill, a tapper, a fastener-driver, a grinder intended for use with a grinding wheel 2 inches (50.8 mm) or more in diameter, a plate jointer, a reciprocating saw, a jigsaw intended for use with blade shanks wider than 1/4 inch (6.4 mm), a polisher, a sander other than an orbital or reciprocating type, and a polisher other than an orbital or reciprocating type shall be equipped with a momentary-contact on-off switch. The on-off switch may be provided with a means for locking the switch in the on position if the switch can be unlocked with a single motion of the same finger or fingers that turns it on.

26.9 For a drill or a hammer drill, the lock-on device mentioned in 26.8 shall be located outside the grasping area or designed such that it is not likely to be unintentionally locked on by the user's hand during intended left or right-handed operation.

26.10 Compliance with the requirement in 26.9 can be accomplished by recessing the lock-on button or by placement outside the grasping area of the lock-on device. If located within the grasping surface area, the lock-on device shall not be actuated by a straight-edge utensil when the utensil is made to pass back and forth across the device in any direction. The straight-edge utensil is to be of any convenient length sufficient to bridge the surface of the lock-on device and any surface adjacent to the lock-on device.

26.11 A router, an orbital or reciprocating sander, an orbital or reciprocating polisher, a laminate trimmer, a grinder intended for use with a grinding wheel 2 inches (50.8 mm) or less in diameter, a nibbler, shears, a sabre, a scroll, and a jigsaw with a blade shank not more than 1/4 inch (6.4 mm) wide may be provided with a maintained-contact on-off switch.

26.12 A portable band saw may be provided with a momentary contact switch that can be locked in the on position if the saw is limited to a maximum cutting speed of 350 feet per minute.

26.13 When the power-supply cord of a tool is plugged in, unexpected operation can result in a risk of injury to persons. Consideration is to be given to risks that may occur if an unattended tool is energized with the cutting tool or abrading surface in contact with the supporting surface.

## 27 Specific Tools

### 27.1 Circular saws

27.1.1 The switch on a hand circular saw shall comply with the requirements contained in 26.7 and shall meet at least one of the following:

- a) The travel from off to on of that part of the switch actuator that has the greatest travel shall not be less than 1/4 inch (6.4 mm).
- b) The switch shall be equipped with a device that automatically locks it in the off position when the actuator is released so that two motions are required to energize the tool.
- c) The equivalent.

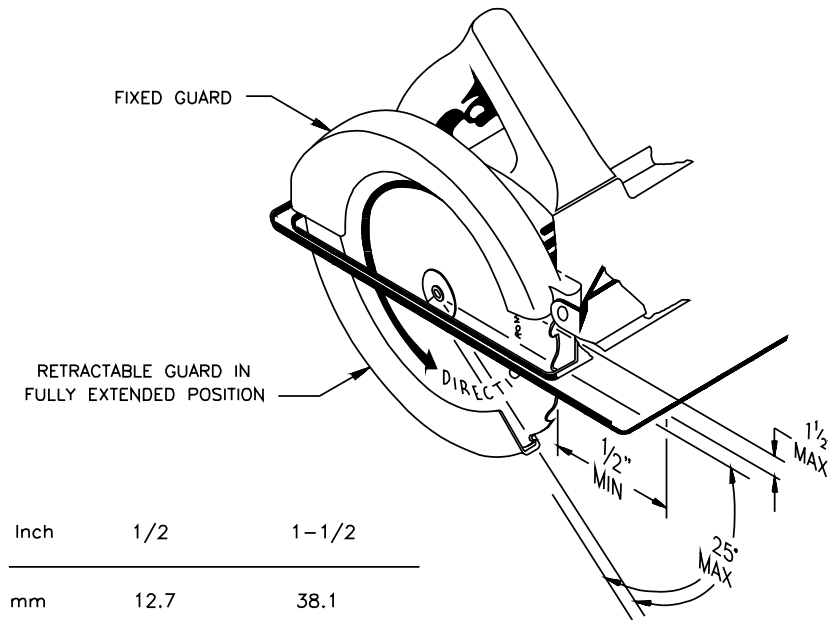
27.1.2 A circular saw shall be provided with a guard that:

- a) Conforms with the dimensions specified in Figure 27.1 with the blade set for a cut of maximum depth and with the plane of the blade 90 degrees from the plane of the table. The angle in Figure 27.1 is to be measured between the intersections of the blade tip circle with the underside of the table and each side of the lower guard;
- b) Provides protection when the saw is at any other setting – depth and angle of cut – that its adjusting means permits;

*Exception: When set for an angle cut, blade exposure of more than 25 degrees below the table may be accepted after consideration of the particular construction.*

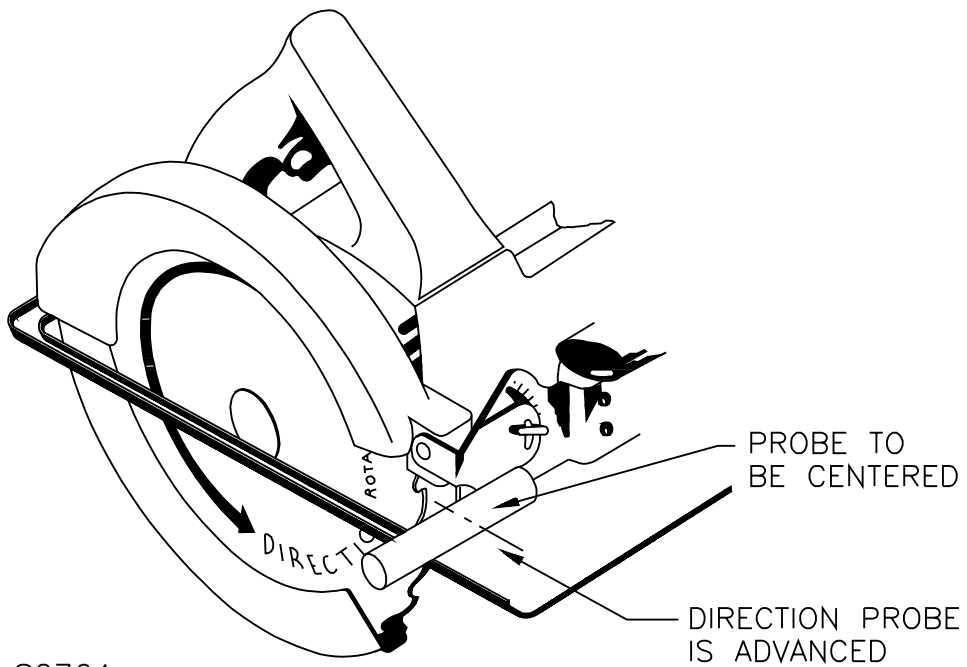
- c) Extends at least to the root of the teeth; and
- d) Provides protection such that a 1/2-inch (12.7-mm) diameter rod, 2 inches (50.8 mm) long, will not touch the blade teeth when advanced toward the blade from the front of the saw, perpendicular to the blade, parallel to the table and above the table. The saw is to be set for a 90-degree cut when the probe is applied. The probe is to be first centered on the blade and then offset 1/2 inch (12.7 mm) to the right and 1/2 inch (12.7 mm) to the left of the center of the blade. See Figures 27.2 and 27.3.

**Figure 27.1**  
**Circular saw guard**



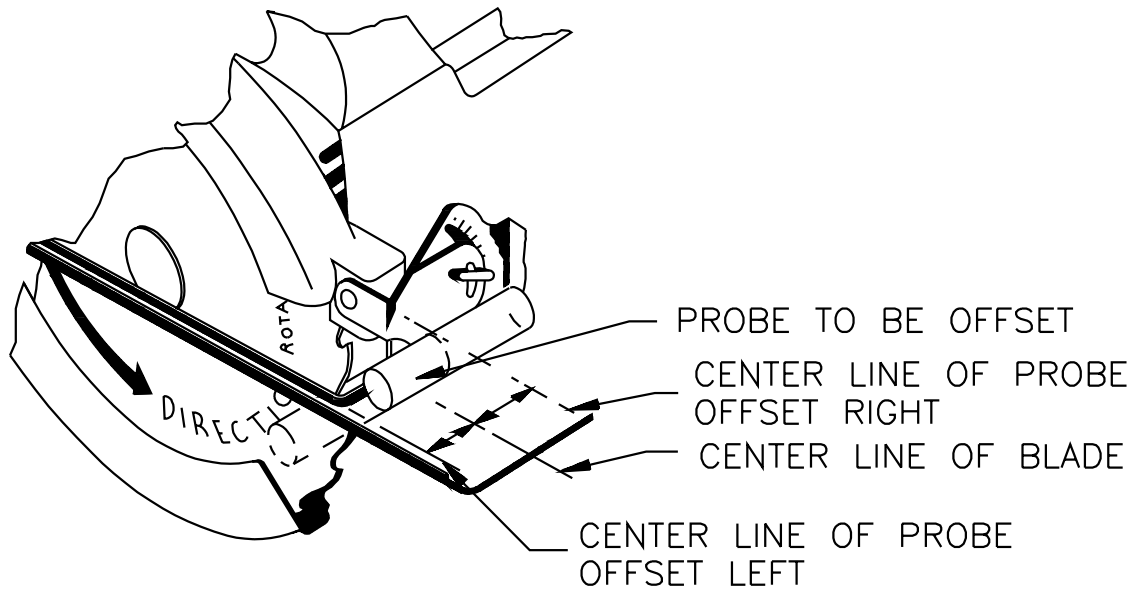
S2763

**Figure 27.2**  
**Guard illustrating test probe centered**



S2764

**Figure 27.3**  
**Guard illustrating probe offset**



S2765

27.1.3 If the blade exposure angle below the table (reference 27.1.2(a) and Figure 27.1) exceeds 10 degrees, the table of a circular saw shall have an outboard section. The outboard section shall enclose the full diameter of the saw blade and its outer edge shall not be less than 1 inch (25.4 mm) from the face of the blade.

27.1.4 An opening may be provided in a blade guard to facilitate viewing the blade, but this does not waive the requirement in 27.1.2.

27.1.5 The retractable lower guard mentioned in 27.1.2 shall:

- a) Automatically retract to the closed position when the saw is not in use, regardless of the position of the saw or the setting (depth and angle of cut).
- b) Have no provision for being locked in the open position.
- c) When released from its full open position, move to its full closed position in a time not more than 0.3 seconds when tested in accordance with 45.4.1.
- d) When released from its full open position, move to its full closed position in a time not more than 0.3 seconds when tested in accordance with 45.4.2.

27.1.6 A guard-retracting handle is acceptable on a circular saw if:

- a) To manipulate the handle, the operator's fingers need not be in an area at which teeth are exposed; that is, the portion of the handle intended to be grasped is remote from the teeth, or is separated from the teeth by an acceptable guard, baffle, or the like; and
- b) The guard is not likely to jam in any position during the intended operation.



27.1.7 A transparent window provided in an opening as mentioned in 27.1.4 shall be easy to remove and replace for cleaning but shall require a deliberate effort to remove. Nonshattering glass or thermoplastic material shall be used for the window.

27.1.8 An opening provided for the ejection of dust in the fixed blade guard of a circular saw shall conform to one of the following:

- a) The opening shall be located beyond the outer circumference of the blade, including the teeth; or
- b) A 1/2-inch (12.7-mm) diameter probe (see Figure 6.3) shall not contact the blade when inserted through the opening.

27.1.9 The enclosure or guard, or a separate pin or stop, shall prevent placing on the mandrel a saw blade larger than that recommended by the manufacturer.

27.1.10 If a circular saw is provided with an anti-kickback device as part of the assembly, instructions shall be provided as described in 52.3.3.

## 27.2 Reciprocating saws

27.2.1 A reciprocating saw shall have the blade-holding mechanism so constructed as to minimize the likelihood of pinch points during intended use of the tool.

27.2.2 The balance and the tendency for the blade to rotate toward the operator during intended use will be considered when evaluating the risk of injury to persons associated with a reciprocating saw.

## 27.3 Grinders

27.3.1 For the purposes of these requirements, a grinder is considered to be a tool employing an abrasive wheel consisting of abrasive grains held together by either organic or inorganic bonding materials. Organically bonded wheels may be reinforced by a webbing, fabric, or filament that provides resistance to total breakage at the rated operating speed should the wheel become cracked or damaged.

27.3.2 A grinder, other than as mentioned in 27.3.5, shall be furnished with a substantial guard to reduce the risk of injury to the operator if the grinding wheel or disc is broken unintentionally. The combined strength of the fastenings shall maintain the guard in the event of wheel breakage.

27.3.3 A guard for a grinder may expose the spindle, nut, and outer flange.

27.3.4 The guard and mounting hardware mentioned in 27.3.2 shall not be shipped unassembled from the tool.

*Exception No. 1: A guard as described in 27.3.15 may be shipped unassembled.*

*Exception No. 2: The guard and mounting hardware may be shipped partially disassembled, in one carton with the tool, to facilitate packaging provided;*

- a) Proper assembly can be readily accomplished without risk of injury;*
- b) Clear, detailed assembly instructions are included; and*
- c) The tool carton is marked in accordance with 52.35.*

*Exception No. 3: The guard and mounting hardware may be shipped in a separate carton(s) from the tool provided;*

- a) The carton containing the tool is marked in accordance with 52.35 and 52.36;*
- b) The carton or cartons containing the guard and mounting hardware are marked in accordance with 52.37; and*
- c) Proper assembly can be readily accomplished without risk of injury and clear, detailed assembly instructions are provided and packaged with the tool.*

27.3.5 No guard is required for the following:

- a) A grinder employing a mounted wheel 2 inches (50.8 mm) or less in diameter that is securely bonded on the end of a steel mandrel or quill, if the grinder is marked in accordance with 52.34(b);
- b) A valve-seat grinder;
- c) A portable drill recommended for use as a grinder, employing Type 1 wheels 2 inches (50.8 mm) or less in diameter, not more than 1/2 inch (12.7 mm) thick, where the peripheral speeds are less than 1800 SFPM (9.0 m/sec) and the drill is marked in accordance with 52.34(d);
- d) A grinder employing Type 1 reinforced wheels 3 inches (76.2 mm) or less in diameter, not more than 1/4 inch (6.4 mm) thick, where the peripheral speeds are less than 9500 SFPM (47.5 m/sec) if the grinder is marked in accordance with 52.34(e); or
- e) A grinder employing Type 16, 17, 18, 18R, and 19 cones and plugs and threaded hole pot balls where the work offers protection or where the size does not exceed 3 inches (76.2 mm) in diameter by 5 inches (127 mm) in length.

27.3.6 A grinding wheel, where grinding is done on the periphery of the wheel only, and a cut-off wheel shall be provided with a hood-type guard that does not expose the periphery or side of the wheel for more than 180 degrees. Top half of the wheel enclosed at all times.

27.3.7 A guard that does not comply with the requirements in 27.3.8 – 27.3.12 shall not be employed unless there is no breakage or penetration of the guard when tested as follows: a wheel of the maximum diameter and thickness recommended by the manufacturer is to be assembled to the spindle. The grinder is then to be operated at maximum no-load speed, and the grinding wheel is to be broken by a sharp impact or other means while running.

27.3.8 A guard for a grinding wheel where grinding is done on the periphery of the wheel shall be so constructed that removal of the peripheral protection is not necessary for replacement of a grinding wheel. The wheel shall be provided with a hood type guard that does not expose the periphery or side of the wheel for more than 180 degrees. The top half of the wheel shall be enclosed at all times.

27.3.9 A guard as mentioned in 27.3.6 shall be of a material and shall comply with the dimensions given in Table 27.1, 27.2, or 27.3. See Figures 27.4, 27.5, or 27.6, whichever is applicable.

**Table 27.1**  
**Thickness of peripheral and side members for guards**

Material of guard	Maximum peripheral speed, ft/min (m/sec)	Maximum thickness of grinding wheel inches (mm)	Grinding-wheel diameter, inches (mm)							
			3 (76.2) through 6 (152)		More than 6 (152) but not more than 12 (305)		More than 12 (305) but not more than 16 (406)		More than 16 (406) but not more than 20 (508)	
			A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>
Malleable iron (A47-68 minimum tensile strength 50,000 psi)	9,000 (45)	2 (50.8)	1/4 (6.4)	1/4 (6.4)	3/8 (9.5)	5/16 (7.9)	1/2 (12.7)	3/8 (9.5)	5/8 (15.9)	1/2 (12.7)
Steel castings (A27-71 minimum tensile strength 60,000 psi)	16,000 (80)	2 (50.8)	1/4 (6.4)	1/4 (6.4)	5/16 (7.9)	5/16 (7.9)	3/8 (9.5)	3/8 (9.5)	1/2 (12.7)	7/16 (11.1)
Structural steel (A238-70 <sup>a</sup> and A306-64 excluding specifications for rivet steel, minimum tensile strength 60,000 psi)	16,000 (80)	2 (50.8)	1/8 (3.2)	1/16 (1.6)	5/16 (7.9)	1/4 (6.4)	5/16 (7.9)	1/4 (6.4)	5/16 (7.9)	1/4 (6.4)

<sup>a</sup> A is minimum thickness of the peripheral protecting member; B is the minimum thickness of the side member of the guard. See Figure 27.4. Note: Minimum Tensile Strengths per ASTM.

**Table 27.2**  
**Drawn-steel guard**

Material of guard minimum tensile strength sheet steel 60,000 psi, maximum peripheral speed,	Minimum thickness of wheel,	Grinding-wheel diameter, inches (mm)							
		2 (50.8) through 5 (127)				More than 5 (127) but not more than 8 (203)		More than 8 (203) but not more than 10 (254)	
		A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>	A <sup>a</sup>	B <sup>a</sup>
ft/min (m/sec)	inches (mm)								
5,000 (25)	2 (50.8)	1/16 (1.6)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)
9,500 (47.5)	2 (50.8)	1/16 (1.6)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)	—	—
12,500 (62.5)	2 (50.8)	3/32 (2.4)	1/16 (1.6)	3/32 (2.4)	1/16 (1.6)	3/32 (2.4)	3/32 (2.4)	—	—
17,000 (85)	1 (25.4)	3/32 (2.4)	1/16 (1.6)	1/8 (3.2)	3/32 (2.4)	3/32 (2.4)	3/32 (2.4)	—	—

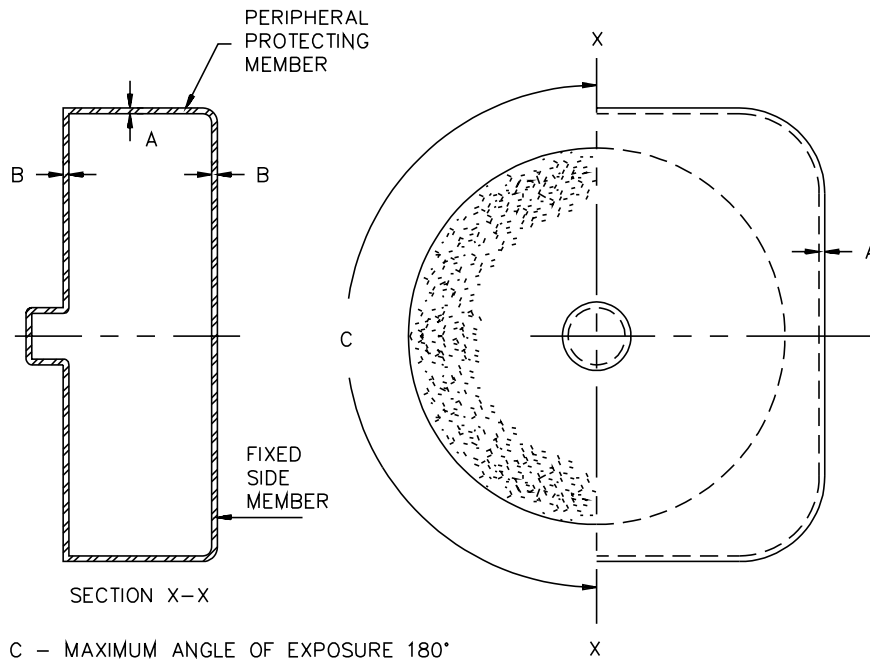
<sup>a</sup> A is the minimum thickness of the peripheral protecting member; B is the minimum thickness of the side member of the guard. See Figure 27.5.

**Table 27.3**  
**Minimum thickness for peripheral and side members for guards used with cutting-off wheels<sup>a</sup>**

Material used in construction of guards	Maximum thickness of cutting off	Speed not to exceed	Cutting-off wheel diameters, inches (mm)			
			6 (152) through 11 (279)		More than 11 (279) but not more than 20 (508)	
			A	B	A	B
Structural Steel (Minimum Tensile Strength 60,000 psi)	1/2 inch (12.7 mm)	14,200 SFPM (71 m/sec)	1/16 (1.6)	1/16 (1.6)	3/32 (2.4)	3/32 (2.4)
	1/2 (12.7 mm)	16,000 SFPM (80 m/sec)	3/32 (2.4)	1/8 (3.2)	1/8 (3.2)	1/8 (3.2)

<sup>a</sup> See Figure 27.6.

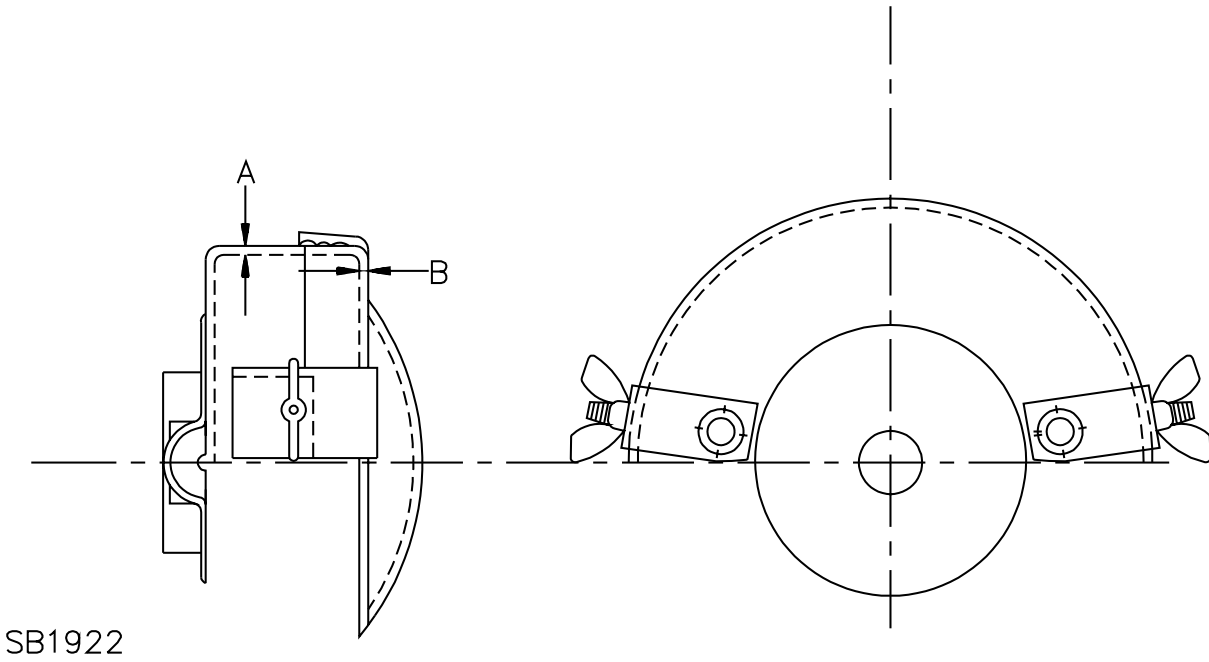
**Figure 27.4**  
**Typical guard for wheel not more than 20 inches in diameter**



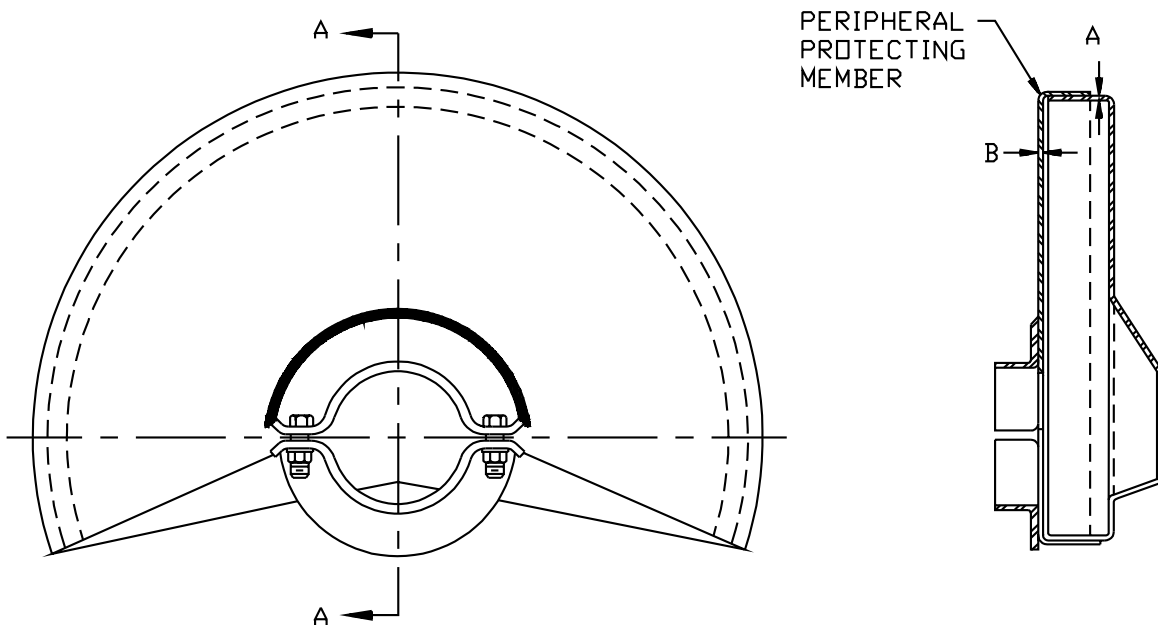
C – MAXIMUM ANGLE OF EXPOSURE 180°

SB1917

**Figure 27.5**  
Typical drawn-steel guard for type 1 straight wheels not more than 10 inches in diameter



**Figure 27.6**  
Typical guard for cutting-off wheels



27.3.10 A Type 27 and 28 grinding wheel shall be provided with a guard that does not expose the periphery or the operator's side of the wheel for more than 180 degrees. The guard shall include an inward formed lip on the side away from the operator that overlaps the wheel. The guard shall be located so as to be between the operator and the wheel during use and adjustable so that pieces of an accidentally broken wheel will be deflected away from the operator.

27.3.11 A drawn-steel guard for a Type 27 and 28 thin abrasive wheel for surface grinding shall comply with Table 27.4. See Figure 27.7.

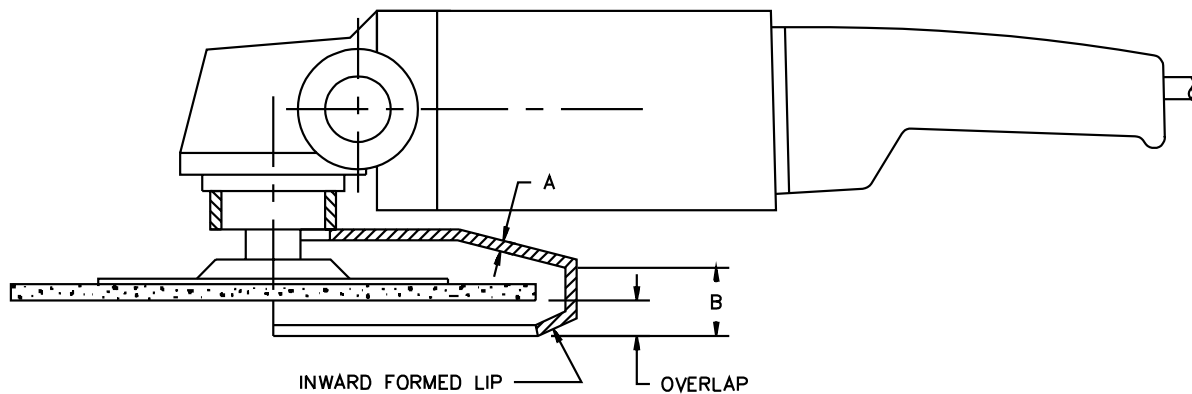
**Table 27.4**  
**Drawn-steel guard for types 27 and 28 thin abrasive wheel**

Maximum peripheral speed, Ft/Min (m/sec)	Material of guard	Thickness of wheel, inches (mm)	Wheel diameter, inches (mm)	Minimum wall thickness, inches (mm)	Minimum leg length, inches (mm)
				A <sup>a</sup>	B <sup>a</sup>
14,200 (71)	Sheet Steel minimum tensile strength 60,000 psi	3/8 (9.5) or less	3 (76.2) through 9 (229)	1/16 (1.6)	1/2 (12.7)
11,000 (55)		More than 3/8 (9.5) but not more than 1 (25.4)	Not more than 7 (178)	3/32 (2.4)	1-1/8 (28.6)

<sup>a</sup> See Figure 27.7.

**Figure 27.7**  
**Typical drawn-steel guard for type 27 and 28 wheels**

Figure 27.7 revised August 7, 1998



S2176

27.3.12 A grinder provided with a cup wheel shall be provided with a fixed guard complying with Table 27.5. See Figure 27.8.

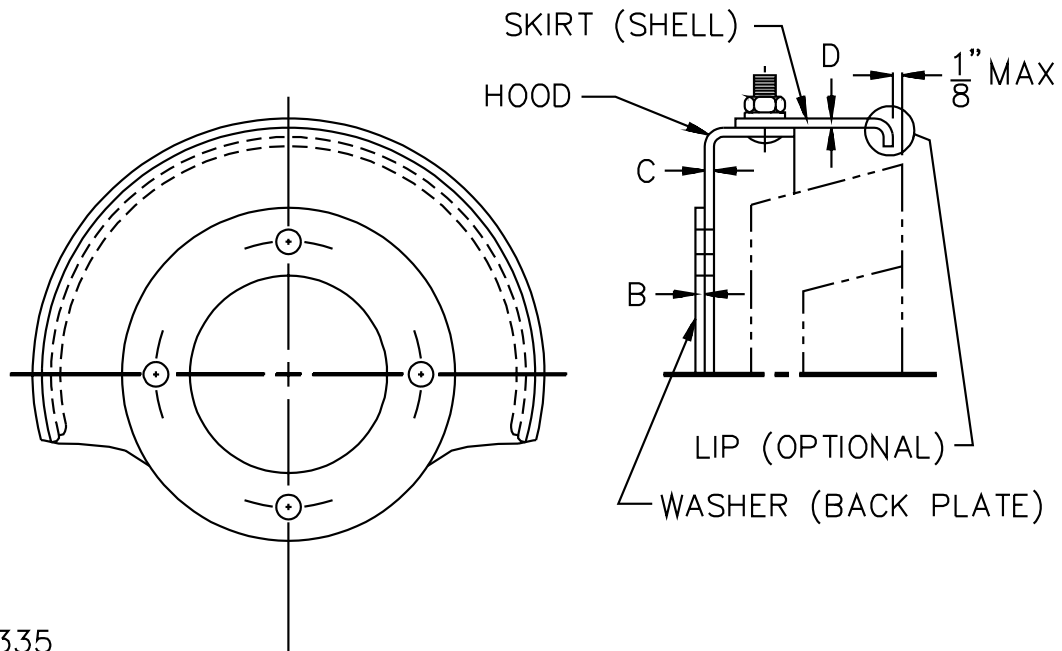
**Table 27.5**  
**Material thickness for drawn steel cup type wheel guards<sup>a</sup>**

Wheel Diameter,		B		C		D	
		Washer Back Plate Thickness,		Hood,		Skirt	
Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
4	(100)	3/32	(2.4)	1/16	(1.6)	1/8	(3.2)
5	(125)	3/32	(2.4)	3/32	(2.4)	1/8	(3.20)
6	(150)	3/32	(2.4)	3/32	(2.4)	1/8	(3.20)

<sup>a</sup> Thickness based 50,000 psi minimum tensile strength and operating speed not exceeding 9,500 SFPM. See Figure 27.8.

**Figure 27.8**  
**Typical drawn steel guard for cup-type wheels, types 6 and 11**

Figure 27.8 revised August 7, 1998



SM335

27.3.13 The guard for a cup type wheel shall have a skirt that is adjustable to cover the wheel for not less than the nominal wheel thickness minus 1/8 in (3.2 mm), see 27.3.14 and Figure 27.8. The guard shall cover the wheel for at least 180 degrees toward the operator.

27.3.14 If it is necessary to determine whether a cup-wheel guard complies with 27.3.13, an artificial Type 6 or 11 cup wheel fabricated from aluminum, wood, or other hard material is to be used. When fabricating the artificial wheel, the actual dimensions used are to be the nominal wheel dimensions, not the measured wheel dimensions, (for example, for a nominal 2 inch thick wheel, the thickness is to be 2.00 inches). The wheel is to be mounted on the tool in the intended manner.

27.3.15 If alternate types or sizes of grinding wheels are mentioned in the instruction manual with the grinder, the manufacturer shall make acceptable guards available and shall recommend their use in the manual.

27.3.16 A polymeric guard for a grinder shall additionally be classed V-2 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

27.3.16 revised January 5, 2000

27.3.17 A guard for a grinding wheel for which requirements are not specified in this standard shall have the strength and construction needed to provide protection for the operator.

27.3.18 An abrasive wheel, other than a mounted wheel and other than as indicated in 27.3.19– 27.3.22, that is intended for grinding on the peripheral surface shall be mounted between flanges having a diameter not less than one-third the wheel diameter. The flanges shall be of mild steel, cast iron, or other material of equivalent strength for the application. The flanges shall be of the same diameter.

27.3.19 A Type 27A cutting-off wheel shall be mounted between unrelieved flanges having matching bearing surfaces. Each flange shall have a diameter not less than one-fourth the wheel diameter.

27.3.20 A Type 27 or 28 wheel larger than 5 inches (127 mm) in diameter shall be provided with a back flange extending beyond the raised portion to counteract the side pressure. The front nut flange, that is less than one-third the wheel diameter, shall fit in the depressed side to prevent interference.

27.3.21 A Type 27 wheel 5 inches (127 mm) or smaller, shall be mounted as indicated in 27.3.18 or 27.3.20.

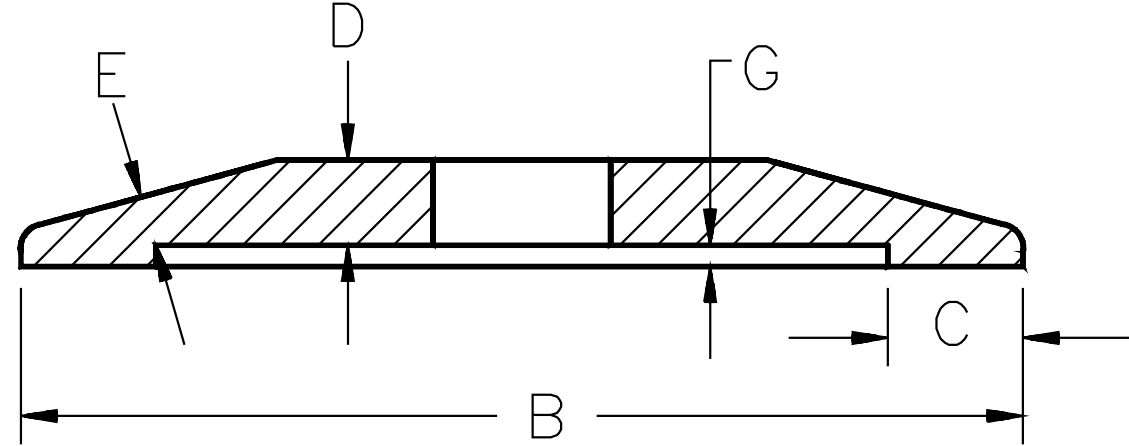
27.3.22 A Type 1 cutting-off wheel shall be mounted between properly relieved flanges having matching bearing surfaces. Each flange shall have a diameter not less than one-fourth the wheel diameter.

*Exception: On portable saws employing reinforced cutting-off wheels 8 inches (203 mm) or less in diameter, the diameter of the flanges may be less than one-fourth the wheel diameter provided the flanges are in conformance with Table 27.7 and Figure 27.9.*



**Figure 27.9**  
**Straight flange<sup>a</sup>**

Figure 27.9 revised August 7, 1998



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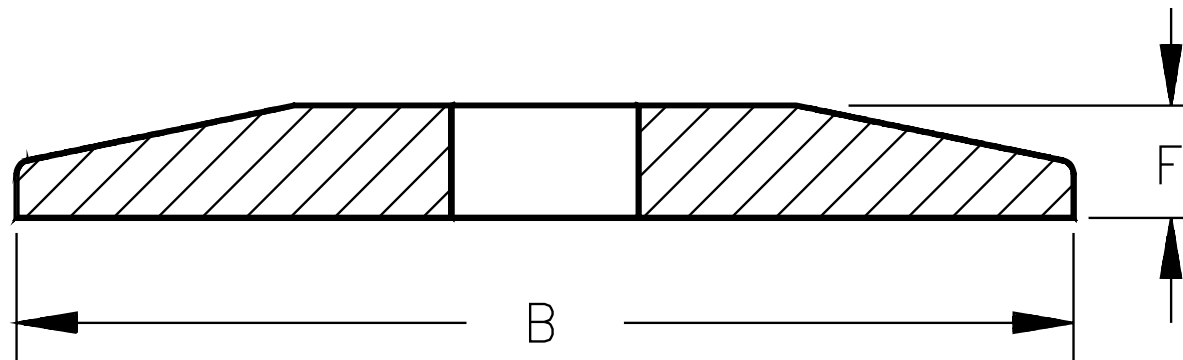
<sup>a</sup> See Table 27.6 for dimensions

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27.3.23 Flanges shall be constructed with respect to rigidity and flatness so that when tightened, the radial width of bearing surface of contact on the wheel is maintained. When assembled, the flanges shall transmit the driving torque from the spindle to the abrasive wheel.

27.3.24 A straight relieved and an unrelieved flange shall be formed as shown in Figures 27.9 and 27.10. Tables 27.6, 27.7, and 27.8 give the minimum dimensions for such flanges. The recess adjacent to the wheel surface shall not be less than 1/16 inch (1.6 mm) for a relieved flange 2 inches (50.8 mm) or more in diameter. Reference Table 27.6. Other constructions are acceptable if found to have equal or greater strength and rigidity when tested as described in 27.3.26 and 27.3.27.

**Figure 27.10**  
**Typical straight unrelieved flange<sup>a</sup>**



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<sup>a</sup>See Table 27.8 for dimensions.

**Table 27.6**  
**Dimensions for straight relieved machined flanges<sup>a</sup>**

Wheel diameter, inches <sup>b</sup> (mm)	Minimum outside diameter of flange, inches (mm),B	Radial width of bearing surface,C		Minimum thickness of					
		Minimum inches (mm)	Maximum inches (mm)	Flange at bore, inches (mm),D		Flange at edge of recess, inches (mm),E		Recess, inches (mm),G	
1 (25.4)	3/8 (9.5)	1/16 (1.6)	1/8 (3.2)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	—	
2 (50.8)	11/16 (17.5)	1/8 (3.2)	3/16 (4.8)	1/8 (3.2)	3/32 (2.4)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
3 (76.2)	1 (25.4)	1/8 (3.2)	3/16 (4.8)	3/16 (4.8)	3/32 (2.4)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
4 (102)	1-3/8 (34.9)	1/8 (3.2)	3/16 (4.8)	3/16 (4.8)	1/8 (3.2)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
5 (127)	1-11/16 (42.9)	3/16 (4.8)	1/4 (6.4)	1/4 (6.4)	1/8 (3.2)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
6 (152)	2 (50.8)	1/4 (6.4)	1/2 (12.7)	3/8 (9.5)	3/16 (4.8)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
7 (178)	2-3/8 (60.3)	1/4 (6.4)	1/2 (12.7)	3/8 (9.5)	3/16 (4.8)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
8 (203)	2-11/16 (68.3)	1/4 (6.4)	1/2 (12.7)	3/8 (9.5)	3/16 (4.8)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
10 (254)	3-3/8 (85.7)	5/16 (7.9)	5/8 (15.9)	3/8 (9.5)	1/4 (6.4)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
12 (305)	4 (102)	5/16 (7.9)	5/8 (15.9)	1/2 (12.7)	5/16 (7.9)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
14 (356)	4-11/16 (119)	3/8 (9.5)	3/4 (19.1)	1/2 (12.7)	5/16 (7.9)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
16 (406)	5-3/8 (137)	1/2 (12.7)	1 (25.4)	1/2 (12.7)	5/16 (7.9)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
18 (457)	6 (152)	1/2 (12.7)	1 (25.4)	5/8 (15.9)	3/8 (9.5)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	
20 (508)	6-11/16 (170)	5/8 (15.9)	1-1/4 (31.8)	5/8 (15.9)	3/8 (9.5)	1/16 (1.6)	1/16 (1.6)	1/16 (1.6)	

<sup>a</sup> See Figure 27.9 for significance of symbols.

<sup>b</sup> Flanges for wheels under 2 inches diameter may be unrelieved and shall be maintained flat and true.

**Table 27.7**  
**Minimum dimensions for straight relieved flanges for reinforced cutting-off wheels 8 inches (204 mm) in diameter or less used on portable saws**

Major diameter or major dimension of wheel arbor hole	Minimum outside diameter of flanges, B		Radial width of bearing surface, C				Minimum thickness of flange at bore, D		Minimum thickness of flange at recess edge, E	
			Minimum		Maximum					
Inches (mm)	Inches	(mm)	inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
5/8 (15.9) or smaller	1-1/8	(28.6)	1/4	(6.4)	1/2	(12.7)	1/8	(3.2)	1/16	(1.6)
Over 5/8 (15.9) through 3/4 (19.1)	1-1/4	(31.8)	1/4	(6.4)	1/2	(12.7)	1/8	(3.2)	3/32	(2.4)
Over 3/4 (19.1) through 1-1/4 (31.8)	1-3/4	(44.5)	1/4	(6.4)	1/2	(12.7)	5/32	(4.0)	1/8	(3.2)

<sup>a</sup> See Figure 27.9 for significance of symbols.

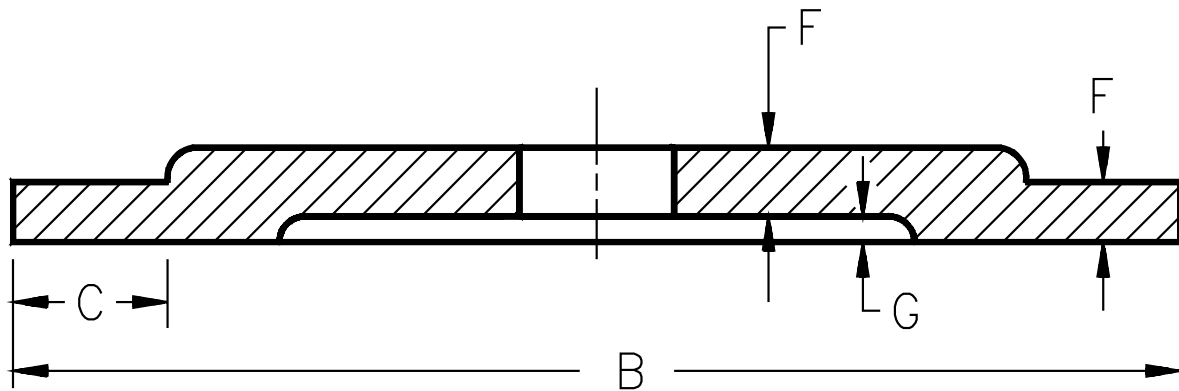
**Table 27.8**  
**Dimensions for straight unrelieved flanges for wheels with threaded inserts<sup>a</sup>**

Diameter of wheel,		B Outside diameter flange, minimum		F Thickness of flange, minimum	
Inches	(mm)	Inches	(mm)	Inches	(mm)
1	(25.4)	5/8	(15.9)	1/8	(3.2)
2	(50.8)	1	(25.4)	1/8	(3.2)
3	(76.2)	1	(25.4)	3/16	(4.8)
4	(102)	1-3/8	(34.9)	3/16	(4.8)
5	(127)	1-3/4	(44.5)	1/4	(6.4)
6	(152)	2	(50.8)	3/8	(9.5)

<sup>a</sup> See Figure 27.10 for significance of symbols.

27.3.25 A straight relieved flange of steel may be stamped, formed, or sintered as shown in Figure 27.11 and used as an alternative to those mentioned in 27.3.24. The dimensions of the flanges shall conform to the dimensions specified in Table 27.9.

Figure 27.11<sup>a</sup>  
Typical stamped or formed straight relieved flange



SA1924

<sup>a</sup> See Table 27.9 for dimensions

Table 27.9  
Dimensions for stamped or formed straight relieved steel flanges<sup>a</sup>

Diameter of wheel, Inches (mm)	B		C				F		G	
	Outside diameter of flange, minimum		Radial width of bearing surface				Thickness of flange		Recess	
	Inches	(mm)	Minimum inches	(mm)	Maximum Inches	(mm)	Minimum Inches	(mm)	Minimum Inches	(mm)
4 (102)	1-3/8	(34.9)	1/8	(3.2)	3/16	(4.8)	0.067	(1.7)	1/32	(0.8)
4-1/2 (114)	1-1/2	(38.1)	3/16	(4.8)	1/4	(6.4)	0.067	(1.7)	1/32	(0.8)
5 (127)	1-11/16	(42.9)	3/16	(4.8)	1/4	(6.4)	0.067	(1.7)	1/32	(0.8)
6 (152)	2	(50.8)	1/4	(6.4)	1/2	(12.7)	0.093	(2.4)	1/16	(1.6)
7 (178)	2-3/8	(60.3)	1/4	(6.4)	1/2	(12.7)	0.123	(3.1)	1/16	(1.6)
8 (203)	2-11/16	(68.3)	1/4	(6.4)	1/2	(12.7)	0.123	(3.1)	1/16	(1.6)

<sup>a</sup> See Figure 27.11 for significance of symbols.

27.3.26 Flange constructions differing from those described in 27.3.24 and 27.3.25 are acceptable if, when investigated as described in 27.3.27, a 0.002 inch (0.04 mm) feeler gauge cannot be inserted between the bearing area of the flange and the steel wheel.

27.3.27 With reference to 27.3.26, a flat steel wheel having a diameter at least 2 inches (50.8 mm) more than that of the flanges being investigated is to be mounted on the spindle between the flanges. The mounting nut is to be tightened in accordance with Table 27.10. Blotters or other compressible materials are not to be employed between the steel wheel and the flanges. The feeler gauge is then to be applied between each flange and the steel wheel at all locations on the periphery of each flange. The flange is acceptable if the feeler gauge cannot be inserted.

**Table 27.10**  
**Tightening torque for spindle unit**

Diameter of grinding wheel		Torque in lb-ft	
In inches <sup>a</sup>	(mm)		(J)
4-1/2	(114)	4-1/2	(6.1)
5	(127)	4-1/2	(6.1)
6	(152)	8	(10.9)
7	(178)	10	(13.6)
8	(203)	10	(13.6)
10	(254)	12	(16.3)

<sup>a</sup> For a grinding wheel not covered by this table, the spindle nut is to be tightened in accordance with the recommendation of the manufacturer but not less than the next smaller size grinding wheel specified.

27.3.28 Except as indicated in 27.3.29, blotters (compressible washers) or flange facings of compressible material shall be fitted between the wheel and its flanges. A washer of highly compressible material such as blotting paper shall not be thicker than 0.025 inch (0.64 mm). If a greater thickness is used, the compressibility of the blotter material shall be less. The diameter of a washer shall not be smaller than the diameter of the flange.

27.3.29 Compressible washers are not required for Types 27 and 28 wheels, or Types 1 and 27A cutting-off wheels. Modified Types 6 and 11 (Terrazzo) wheels with a special inside flange require a compressible washer on the back flange only. See Specifications for Shapes and Sizes of Grinding Wheels and for Shapes, Sizes and Identification of Mounted Wheels, ANSI B74.2-1992, for description of wheel types.

27.3.30 A grinding wheel of unique construction or contour shall be properly mounted, as determined by an investigation.

27.3.31 Any grinding wheel shall not be used at a speed more than its rated speed.

27.3.32 An eye shield provided on a grinder shall employ nonshattering glass or nonshattering thermoplastic material.

27.3.33 An angle grinder intended to be grasped by the body of the tool directly behind the wheel shall have a wheel guard constructed so that in any position of adjustment associated with recommended use of the construction will not increase the risk of the operator's fingers coming in contact with the wheel.

## 27.4 Plate jointers

27.4.1 A plate jointer shall be provided with a guard that complies with the requirements in 27.4.2.

27.4.2 The guard mentioned in 27.4.1 shall:

- a) Automatically retract to the closed position to cover the blade teeth when the tool is not in use;
- b) Have no provision for being locked in the open position; and
- c) Be constructed such that the guard stays in contact with the workpiece as the tool is retracted, or when released from its full open position, retract to its fully closed position in a time not more than 0.3 seconds when tested in accordance with 45.5.1.

## 27.5 Torquing devices

27.5.1 A socket provided with an impact wrench by the manufacturer shall be capable of withstanding the impact to which it may be subjected.

## 27.6 Combination tools

27.6.1 A motor unit intended to be used with an attachment provided by the unit manufacturer shall be guarded against risk of injury to persons with and without the attachment applied to the motor unit.

27.6.2 A guard required on an individual tool shall be integral with the tool or shall be permanently attached. Each attachment shall be provided with its own guard, or a universal guard may be provided on the basic tool if it provides protection for each attachment to be used with the tool.

27.6.3 If a tool is converted by an attachment to a combination that falls within the scope of another standard, the combination shall comply with the appropriate guarding requirements therefore.

27.6.4 Examples of combinations referred to in 27.6.3 are a hedge trimmer, a reciprocating saw, or a knife sharpener resulting from conversion of a portable drill.

## PERFORMANCE

### 28 General

28.1 If the tool has a single frequency rating, the test is to be made at that frequency. A tool rated alternating current/direct current, or direct current - 60 hertz, is to be tested on direct current or on 60 hertz alternating current, whichever results in higher temperatures. A tool rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

28.2 Except as indicated in 28.3, a fuse or other protective device shall not operate during tests. See 29.1. For all other tests, unless otherwise indicated, a fuse or other protective device is to be shorted.

28.3 During the abnormal tests described in 47.4.2 and 48.7.1, and Sections 43 and 44, the tool is to be connected in series with a nontime-delay fuse of the maximum size branch circuit device that the equipment is likely to be connected, (but no less than 30A). Opening of the fuse before a risk of fire, electric shock, or injury to persons results is an acceptable conclusion of a test.



28.4 An alternate magnet wire coating used in a tool motor subject to tests in Section 44 or 59.7.1.1 – 59.7.3.3 and 59.8.1 – 59.8.8, shall:

- a) Be an investigated magnet wire of the same ANSI grade designation or generic material type and construction with the same temperature rating as the original magnet wire tested, or
- b) Be tested as indicated in Section 44 or 59.7.1.1 – 59.7.3.3 and 59.8.1 – 59.8.8 as appropriate.

## 29 Loads for Tests

29.1 For tools of the most common types, Table 29.1 gives the conditions of loading for the tests. These have been found to be close approximations of the most severe conditions of intended use. However, a tool, regardless of designation, having features not contemplated in these test procedures may be tested as considered necessary to meet the intent of these requirements. A tool intended to perform two or more different operations, such as sanding, polishing, or grinding, is to be tested with the load that results in maximum temperatures. The tool is to be subjected to an input test while operating with the attachment or accessory if any accessory or attachment is:

- a) Provided with a tool;
- b) Recommended for use with a tool; or
- c) Referred to in the instruction manual of a tool.

Unless indicated otherwise, the temperature test is to be continued until constant temperatures are attained.

**Table 29.1  
Loads for tests**

Tool	Test procedure	General or special use
1. Bandsaw	The test is to be conducted with the saw cutting 2/3 the maximum thickness of mild steel intended to be cut, using only the weight of the saw.	General
2. Drill	The test is to be conducted with the tool drilling holes, using a sharpened drill bit of the largest diameter that the chuck will accommodate, in a steel plate of RB 60 – 75 of thickness not less than the diameter of the drill. If the diameter of the drill is larger than 1/2 inch (12.7 mm), a pilot hole having a diameter equal to the length of the chisel edge of the drill used for the test is to be used to start the drilling. A test is to be conducted in accordance with the foregoing and each speed of a 2-speed drill except that, at the high speed, a drill of the size indicated in the marking mentioned in 52.10 is to be used. The drill point force shall be:	
Drill bit diameter, inches (mm)	Drills rated up to 2A and pistol grip drills, pounds (N)	Drills rated over 2A other than pistol grip, pounds (N)
Less than 0.37 (9.5)	45 (200)	65 (290)
0.37 – 0.5 (9.5 – 12.7)	60 (267)	86 (380)
Over 0.5 (12.7)	Determine the force by use in accordance with the instruction manual.	
3. Grinder, aerial	The input test is to be conducted in one of the following procedures: A. The input test for horizontal and vertical grinders having wheels less than 5 inches (127 mm) in diameter, and right-angle grinders having wheels 5 inches (127 mm) or less in diameter, is to be conducted with the tool grinding a commercial quality, cold rolled steel plate having a width of no less than that of the grinding surface of the wheel. B. The input test for types of grinders not specified in item A is to be conducted with the manufacturer's recommended accessory (usually an abrasive wheel) that produces the highest load. The tool is to be manually supported to produce a force of 13 pounds (58 N) at the grinding surface while grinding commercial quality, cold rolled steel plate. Grinders shall be held as follows: A. Horizontal grinders are to be held so that the full grinding face width of the wheel is in contact with the grinding surface. B. Right-angle grinders shall be held so that the grinding face of the wheel or disc is at an angle of between 5 and 15 degrees from the grinding surface. C. Vertical grinders shall be held so that the grinding wheel face is in contact with the surface.	General

Table 29.1 Continued on Next Page

Table 29.1 Continued

Tool	Test procedure	General or special use
4. Grinder, valve-seat	The test is to be conducted with the grinder operating without a load and with the grinding wheel of the largest size that the tool accommodates.	Special
5. Hammer	The tests are to be conducted with the tool using the attachment (chisel, star drill, and the like) and hammering into material (brick, stone, and the like) that results in the most severe duty. The temperature test is conducted in cycles of 1 minute on and 1 minute off.	Special
6. Hammer Drill	Drilling mode: The test is to be conducted with the tool using the rotating bit (core bit, steel drill bit, masonry drill, and the like) and drilling the material (brick, concrete, stone, steel, and the like) that results in the most severe duty. The temperature test is to be conducted with the unit loaded to drilling mode nameplate rating.	General
	Hammering and drilling mode: The test is to be conducted in the same manner as the masonry drilling modes except that the unit is to be hammering while rotating during the test. The temperature test is to be conducted with the tool loaded in the same manner as the input test except with cycles of 1 minute on and 1 minute off.	General
7. Hammer Rotary	Hammering mode: The test is to be conducted in the same manner as for a hammer.	Special
	Rotating and hammering mode: The input test is to be conducted with the tool using a rotating bit (core, masonry, and the like) and while hammering the material (brick, concrete, stone, and the like) that results in the most severe duty. The temperature test is to be conducted with the tool loaded in the same manner as the input test and under a duty cycle of 1 minute on and 1 minute off.	Special
8. Hand motor tool	The test is to be conducted with the tool operating in the intended manner, as in pattern making. Each of the cutting and abrasive attachments furnished with the tool is to be used.	General
9. Impact wrench	<p>The input is to be measured with the wrench impacting against a nut so restrained that it will not rotate more than 5 revolutions per minute. The temperature test is to consist of:</p> <p>A. Operation at no load until constant temperatures are attained.</p> <p>B. Ten cycles, each consisting of 5 seconds on and 5 seconds off impacting against the nut described above, with the direction of rotation reversed after each cycle.</p> <p>C. Operation at no load until temperatures again become constant.</p> <p>D. Uninterrupted impacting for one minute against the nut described above without reversal of rotation.</p> <p>Temperatures are to be measured near the conclusion of steps B and D.</p>	Special

Table 29.1 Continued on Next Page

Table 29.1 Continued

Tool	Test procedure	General or special use
10. Nibbler	The test is to be conducted with the tool cutting steel (or other material with which the tool is intended for use) of the maximum thickness recommended by the manufacturer.	Special
11. Nut setter	The test is to be conducted with the clutch set for maximum torque.	General
12. Planer	The test is to be conducted with the tool cutting soft pine board, the depth of cut being 75 percent of the maximum permitted by the construction of the tool.	General
13. Plate Jointer	The input test is to be conducted with the tool set at the maximum depth of cut while plunge cutting soft pine wood. The cut is to be made with the largest size bit the tool will hold. If the intended use of the tool is for slotting operations, the test shall also be conducted while slotting soft pine wood at the recommended rate of cut. The highest load measured shall be used for this test.	General
14. Polisher	The test is to be conducted with the tool polishing, without wax or abrasive, a smooth surface of asbestos cement composition board.	General
15. Router	The test is to be conducted in the same manner as that of a planer, using the cutter that results in maximum loading.	General
16. Sander, Belt	The test is to be conducted with the sander sanding soft pine wood. A 60 grit sand paper without weight additional to that of the sander is to be used. The sanding is to be done with the grain of the wood.	General
17. Sander, Detail	The test is to be conducted with the sander sanding soft pine wood. A 60 grit sand paper is to be used. The force used is to be the weight of the sander (i.e., no additional weight applied), or the force specified in the manufacturer's instructions (i.e., by adding a weight equal to the force specified by the manufacturer minus the actual weight of the tool), whichever is greater.	Special
18. Sander, Disc	The test is to be conducted the same as that of a belt sander, except that the disc is to be revolved across as well as with the grain.	General
19. Sander, (orbital motor, powered)	The input test is to be conducted with the sander sanding soft pinewood. A 60 or 80 grit sand paper with 8 pounds (3.6 kg) of mass added to the sander to result in a vertical force at the center of the platen is to be used. The temperature test is to consist of continuous sanding until temperatures become constant.	Special

Table 29.1 Continued

Tool	Test procedure	General or special use								
20. Sander (vibrator-powered)	<p>The input test is to be conducted with the sander sanding soft pine wood. A 60 or 80 grit sandpaper with 5 pounds (2.3 kg) of mass added to the sander to result in a vertical force at the center of the platen is to be used. The temperature test is to be conducted as follows:</p> <p>A. A sander rated 3 A or less at 125 V or less is to be operated for 8 cycles, with each cycle consisting of 5 minutes of sanding followed by 3 minutes off.</p> <p>B. Any other sander is to be operated sanding continuously until temperatures become constant.</p>	Special								
21. Saw, circular hand	<p>The test is to be conducted using a sharp combination blade. The test is to consist of ripping regular grade of fir plywood thickness obtained by using several sheets of plywood, equal to 75 percent of the maximum depth of cut permitted by the construction of the saw.</p> <p>A horizontal cutting force shall be applied to the tool as follows:</p> <table border="1" data-bbox="602 779 1089 961"> <thead> <tr> <th data-bbox="602 779 883 869">Blade diameter, inches (mm)</th> <th data-bbox="883 779 1089 869">Horizontal cutting force, pounds (N)</th> </tr> </thead> <tbody> <tr> <td data-bbox="602 869 883 900">Less than 6.5 (165)</td> <td data-bbox="883 869 1089 900">5 (22)</td> </tr> <tr> <td data-bbox="602 900 883 932">6.5 – 9.25 (165 – 235)</td> <td data-bbox="883 900 1089 932">8 (35)</td> </tr> <tr> <td data-bbox="602 932 883 961">Greater than 9.25 (235)</td> <td data-bbox="883 932 1089 961">15 (66)</td> </tr> </tbody> </table>	Blade diameter, inches (mm)	Horizontal cutting force, pounds (N)	Less than 6.5 (165)	5 (22)	6.5 – 9.25 (165 – 235)	8 (35)	Greater than 9.25 (235)	15 (66)	General
Blade diameter, inches (mm)	Horizontal cutting force, pounds (N)									
Less than 6.5 (165)	5 (22)									
6.5 – 9.25 (165 – 235)	8 (35)									
Greater than 9.25 (235)	15 (66)									
22. Saw, reciprocating	<p>The input test of a motorpowered saw having 6 tooth per inch (25.4 mm) blade is to be conducted with the saw cutting plywood 1/2 inch (12.7 mm) thick, except that wood of the maximum thickness recommended by the manufacturer is to be used if such thickness is more than 1/2 inch (12.7 mm). A force of 6 pounds (27 N) is to be applied in the cutting direction and the operator shall only apply such additional force as is necessary to eliminate excessive vibration and provide guidance along a straight line. A force of 6 pounds (27 N) or the weight of the saw, whichever is heavier, is to be applied when cutting in a vertical direction.</p> <p>The temperature test is to consist of operation until constant temperatures are reached, employing a duty cycle of:</p> <p>A. Five minutes of sawing the plywood described above, followed by</p> <p>B. One minute idling.</p> <p>The input test of a vibrator-powered saw having a blade not more than six inches (152.4 mm) long is to be conducted with the saw cutting plywood 1/2 inch (12.7 mm) thick. The temperature test is to be conducted as follows:</p> <p>1. A saw rated 3 A or less at 125 V or less is to be operated for 12 cycles with each cycle consisting of 2 minutes of sawing followed by 1 minute off.</p> <p>2. Any other saw is to be operated sawing continuously until temperatures be come constant.</p>	Special								

Table 29.1 Continued on Next Page

Table 29.1 Continued

Tool	Test procedure	General or special use
23. Abrasive wheel cutoff machine	The test is to be conducted cutting concrete of a thickness equal to 75 percent of the maximum depth of cut permitted by the construction of the saw.	General
24. Screwdriver	The test of a screwdriver not having an adjustable clutch is to be conducted while the tool is driving a wood screw of the largest size, and under the other conditions recommended by the manufacturer. The test of a screwdriver with an adjustable clutch is to be conducted with the clutch set for maximum torque.	General
25. Shears	The test is to be conducted in the same manner as those of a nibbler	Special
26. Stapler	The input test is to be conducted with the stapler driving staples into wood. If the tool accommodates staples of different sizes, staples of the largest of those sizes are to be used in this test. The temperature test is to be conducted with the tool being operated in cycles until temperatures become constant. Each cycle is to consist of 1 minute stapling at the rate of one staple per second, followed by 3 minutes off.	General
27. Tapper	The test is to be conducted with the tool tapping with the tap of largest size that the manufacturer recommends, using a pilot hole of proper size in a steel plate of such thickness that the depth of the hole will not be less than the length of the thread-cutting section of the tap.	General
28. Strapping Tool	The test is to be conducted with the tool operating in the intended manner, strapping packages. The test package is to consist of a corrugated container with wood or other interior bracing to prevent the package from collapsing. The package size is to be 18 inch (380 mm) wide x 24 inch (610 mm) long x 8 inch (203 mm) high. Three straps are to be placed around the width (18 inch) and height (8 inch) dimension and one strap around the length (24 inch) and height (8 inch) dimension. The test is to consist of clinching these 4 straps around the package with the tool followed by 1 minute with the tool off. The four straps are to be removed between package applications. The overall strap application rate is to be 120 straps per hour.	

### 30 Leakage Current Test

30.1 The leakage current of a tool rated for a nominal 240-V or 120-V supply when tested in accordance with 30.3 – 30.6, shall not be more than 0.5 mA.

30.2 Leakage current refers to all currents, including capacitively coupled currents that may be conveyed between exposed conductive surfaces of a tool and ground or other exposed conductive surfaces of the tool.

30.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible and from one surface to another if simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for protection against risk of electric shock as defined in 6.5 – 6.8. Surfaces 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 considered to be acceptable.

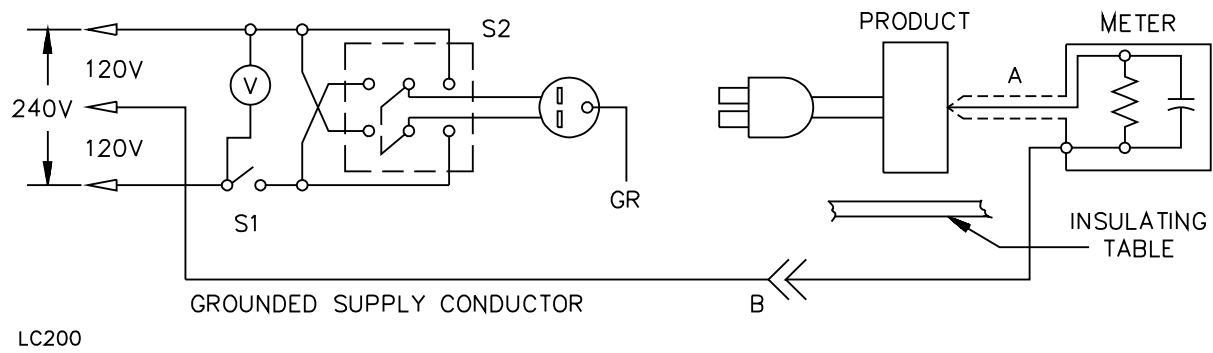
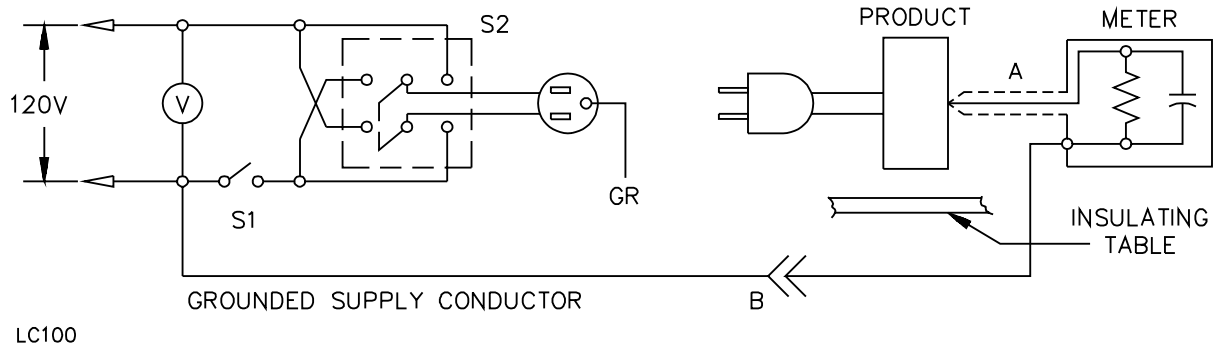
30.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 cm in contact with the surface. When the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface.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

30.5 The measurement circuit for leakage current is to be as shown in Figure 30.1. The measurement instrument is defined in (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

- a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15  $\mu$ F.
- b) The meter is to indicate 1.11 times the average of the full-wave rectified composite wave-form 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 1500-ohm resistor shunted by a 15- $\mu$ F capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent.
- d) Unless the meter is being used to measure leakage from one part of a tool to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

**Figure 30.1**  
**Leakage-current measurement circuits**

Figure 30.1 revised August 7, 1998



A: Probe with shielded lead.

B: Separated and used as clip when measuring currents from one part of device to another



30.6 A sample of the tool is to be tested for leakage current starting with the as received condition (as received being without prior energization, except as may occur as part of the production line testing), but with its grounding conductor, if any, open at the attachment plug. The supply voltage is to be adjusted to 120 V or 240 V, depending upon the rating of the tool. The test sequence, with reference to the measuring circuit (Figure 30.1) is to be as follows:

- a) With switch S1 open, the tool is to be connected to the measuring circuit. Leakage current is to be measured using both positions of S2, and with the tool switching devices in all their normal operating positions.
- b) Switch S1 is then to be closed, energizing the tool, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all their normal operating positions.
- c) Leakage current is then to be monitored under the no load condition until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement.

No Text on This Page

### 31 Starting Current Test

31.1 A tool shall start and operate normally on a circuit protected by an ordinary (not time-delay) fuse having a current rating corresponding to that of the branch circuit of minimum rating to which, in accordance with the National Electrical Code, ANSI/NFPA No. 70-1996, the tool may be connected.

31.2 In a test to determine whether a tool complies with the requirement in 31.1, it is to be started three times with the tool at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation and the tool is to be given time to come to rest between successive starts. Opening of the fuse or tripping of an overload protector provided as part of the tool is considered to be unacceptable.

### 32 Current Input Test

32.1 The current input to a tool that is connected to a circuit of rated frequency and maximum rated voltage and loaded in accordance with Table 29.1 shall be:

a) Not more than 150 percent of the rated value for a general-use tool; such as a planer, a hand circular saw, a screwdriver, a nut setter, a band saw, a plate jointer, an abrasive wheel cutoff machine, or a router, in which, during intended operation, the no-load or off periods are relatively long; except that, for a hand circular saw employing a universal motor, the current input may be not more than 175 percent of the rated value if, during the temperature test, the temperature rise of the windings is not more than 75°C (135°F) as measured by the resistance method, as well as not more than 65°C (117°F) as measured by thermocouples.

b) Not more than 120 percent of the rated value for a general-use tool such as an aerial grinder, a tapper, a drill, a hammer-drill, a sander, a hand motor tool, or a polisher, in which, during intended operation, the no-load or off periods are relatively short.

*Exception: Not more than 150 percent of the rated value for a tool when using any accessory or attachment that is:*

- 1) *Provided with the tool;*
- 2) *Recommended for use with the tool; or*
- 3) *Referred to in the instruction manual of the tool.*

c) The maximum normal load as indicated in 29.1 shall be 90 – 110 percent of the rated value for a special-use tool.

*Exception No. 1: Not more than 100 percent of the rated value for a valve-seat grinder.*

*Exception No. 2: The lower limit does not apply to operation or loading other than the maximum normal load or if the temperature test is conducted with the tool so loaded that it draws rated input current. See 33.8.*

*Exception No. 3: Not more than 90 – 120 percent for rotary hammers in the mode of operation that results in the highest input current, except that the lower limit does not apply if the temperature test is conducted with the tool loaded so that it draws the maximum normal load or the rated input current, whichever is greater.*

*Exception No. 4: The input at all settings of any adjustment control provided for a vibrator-power tool rated at 3 A or less may be 50 – 110 percent of the rated value.*

32.2 On a tool provided with means for controlling the speed, the input test is to be performed at the maximum-speed setting. It is then to be repeated with the tool operated in accordance with the manufacturer's recommendations as to speeds, drill bits, saw blade, or other accessory to be acceptable for use with the tool, and work stock, such as steel, wood, concrete, and the like.

32.3 For a concrete vibrator, the input test is to be conducted with the vibrator head positioned vertically in a test mixture of 55 percent by weight gravel, 35 percent by weight sand, and 10 percent by weight water.

32.4 The means for controlling the speed mentioned in 32.2 and 33.2 – 33.6 includes a controller having a number of discrete settings, as well as a controller having an infinite number of settings.

32.5 During the current-input test, the no-load speed of a drill, grinder, hammer-drill, hand motor tool, impact wrench, planer, polisher, router, disc sander-grinder, circular saw, tapper, or any other tool having a rotating output means, shall not exceed the marked value by more than 20 percent when measured at the maximum speed setting.

*Exception No. 1: Grinders shall not exceed their marked value unless additionally marked to indicate the minimum recommended accessory speed in rpm, in which case the 20 percent tolerance applies to the grinder-speed marking. In any case, the grinder speed shall not exceed the minimum accessory speed indicated.*

*Exception No. 2: The above does not apply to:*

- 1) Nut setters, screw drivers, and drain cleaners.*
- 2) Belt sanders, band saws, chain saws, and other tools with predominantly linear work function motion.*

32.6 If a tool has more than one frequency rating, the requirements given in 32.1 for current input apply when the tool is tested at each of the frequencies indicated in 28.1.

### **33 Temperature Test**

33.1 When tested under the conditions described in 33.2 – 33.7, a tool shall not attain a temperature at any point sufficiently high to constitute a risk of fire or to damage any materials employed in the tool, nor show temperature rises at specific points more than those indicated in Table 33.1. See also 33.8 and 33.12 – 33.19.

33.2 When loaded as described in 33.3, a general-use tool is to be operated continuously until constant temperatures are obtained.

33.3 For the temperature test, a general-use tool is to be loaded by an eddy-current brake, dynamometer, or the like as follows:

- a) A single-speed tool with a universal motor is to be operated loaded to rated current.
- b) A tool with an induction motor is to be operated at rated voltage and loaded to obtain rated current. The input wattage is to be measured. If the tool is intended for use on a nominal 120-V or a 240-V supply, the load is to be increased until the initial wattage is obtained at 120 or 240 V.

c) A variable-speed tool with a universal motor, and discrete speed setting is to be operated when loaded to rated current at highest and lowest speed settings and may be operated at intermediate speed settings.

d) An infinitely variable-speed tool with a universal motor, without feedback, is to be operated as follows:

1) At the maximum-speed setting, while loaded to rated current,

2) At the no-load speed setting equal to 25 percent of the no-load maximum speed and then loaded to obtain 25 percent of the maximum speed obtained with rated current.

*Exception: For an infinitely variable speed tool having a pre-determined low speed, the low speed test shall be performed at the speed ( $N_L$ ) determined by the following equation:*

$$N_L = \frac{N_F \times N_{\min}}{N_{\max}}$$

*in which:*

$N_L$  is the low speed,

$N_F$  is speed at full load current,

$N_{\max}$  is maximum speed at no load current, and

$N_{\min}$  is minimum speed at no load current.

e) An infinitely variable-speed tool with feedback is to be operated as follows:

1) At the maximum-speed setting while loaded to obtain rated current.

2) At a no load speed setting equal to 25 percent of the maximum no load speed and then loaded to obtain rated current.

*Exception: If a tool with feedback employs circuits to limit the current at low speed, so that rated current cannot be obtained at 25 percent of no load speed, then the load is to be adjusted to result in the maximum current obtainable at 25 percent of the maximum no load speed.*

33.4 With reference to feedback as mentioned in 33.3 (d) and (e), a tool is considered to have feedback if the rated current is exceeded when making the adjustment described in 33.3(e)(2).

33.5 The temperature test on a special-use tool not provided with means for controlling the speed is to be conducted in accordance with 29.1 and Table 29.1 except as indicated in 33.8.

**Table 33.1**  
**Maximum temperature rises**

Materials and Components		°C	°F
1.	Varnished-cloth insulation	60	108
2.	Fuses	65	117
3.	Fiber employed as electrical insulation	65	117
4.	Wood and other similar material	65	117
5.	Class E insulation systems on coil windings and core laminations		
	Thermocouple method	75	135
	Resistance method	85	153
6.	Class A insulation systems on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor <sup>a,f</sup> :		
	A. In an open motor:		
	Thermocouple method	65	117
	Resistance method	75	135
	B. In a totally enclosed motor:		
	Thermocouple method	70	126
	Resistance method	80	144
7.	Class A insulation systems on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less (not including a universal motor) and on a vibrator coil <sup>a,f</sup> :		
	A. In an open motor and on a vibrator coil:		
	Thermocouple or resistance method	75	135
	B. In a totally enclosed motor:		
	Thermocouple or resistance method	80	144
8.	Class 105 insulation on windings of a relay, a solenoid, and the like:		
	Thermocouple method	65	117
	Resistance method	85	153
9.	Phenolic composition employed as electrical insulation or relied upon to prevent a risk of electric shock or fire	125 <sup>c</sup>	225 <sup>c</sup>
10.	Rubber or thermoplastic-insulated wire and cord	35 <sup>b,c</sup>	63 <sup>b,c</sup>
11.	Capacitor:		
	Electrolytic	40 <sup>e</sup>	72 <sup>e</sup>
	Other types	65 <sup>d</sup>	117 <sup>d</sup>

Table 33.1 Continued on Next Page

Table 33.1 Continued

Materials and Components		°C	°F
12.	Sealing compound (This is a maximum temperature, not temperature rise)	40°C (140°F) less than melting point	
13.	Class B insulation systems on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm), of a d-c motor, and a universal motor <sup>a,f</sup> :		
	A. In an open motor:		
	Thermocouple method	85	153
	Resistance method	95	171
	B. In a totally enclosed motor:		
	Thermocouple method	90	162
	Resistance method	100	180
14.	Class B insulation systems on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less (not including a universal motor) and on a vibrator coil <sup>a,f</sup> :		
	A. In an open motor and on a vibrator coil:		
	Thermocouple or resistance method	95	171
	B. In a totally enclosed motor:		
	Thermocouple or resistance method	100	180
15.	Class 130 insulation on windings of a relay, a solenoid, and the like:		
	Thermocouple method	85	153
	Resistance method	105	189
16.	Handle or knob grasped for lifting, carrying, or holding:		
	A. Metallic	25 <sup>g</sup>	45 <sup>g</sup>
	B. Nonmetallic	35 <sup>g</sup>	63 <sup>g</sup>
17.	Handle, knob, or surface of the enclosure intended to be contacted during intended use but not requiring continuous holding:		
	A. Metallic	35 <sup>g</sup>	63 <sup>g</sup>
	B. Nonmetallic	60 <sup>g</sup>	108 <sup>g</sup>
18.	Surface subjected to casual contact:		
	A. Metallic	45 <sup>g,h</sup>	81 <sup>g,h</sup>
	B. Nonmetallic	70 <sup>g,h</sup>	126 <sup>g,h</sup>

Table 33.1 Continued

Materials and Components	°C	°F
<p><sup>a</sup> See 33.13.</p> <p><sup>b</sup> Rubber-insulated conductors within a motor having Class A insulation systems, rubber-insulated leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), if an acceptable braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords. See 33.17.</p> <p><sup>c</sup> The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been found to have heat-resistant properties.</p> <p><sup>d</sup> A capacitor that operates at a temperature rise of more than 65°C (117°F) may be considered on the basis of its marked temperature limit.</p> <p><sup>e</sup> For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may not be more than 65°C (117°F).</p> <p><sup>f</sup> See note c to Table 18.1.</p> <p><sup>g</sup> These temperatures do not apply to the cutting tool.</p> <p><sup>h</sup> These temperatures do not apply to a hammer, including the rotary type.</p>		

33.6 The temperature test on a special-use tool provided with means of controlling the speed is to consist of operation in accordance with 29.1 and Table 29.1 at the maximum-speed setting, except as indicated in 33.8. The test is then to be repeated at lower speeds, and the requirements in 33.1 and Table 33.1 apply at these lower speeds. During these tests at lower speeds, the duty cycle described in Table 29.1 is to be followed, and the test is to be conducted in accordance with the manufacturer's recommendations as to the blade, chisel, or other accessory acceptable for use with the tool, and the work stock, such as steel, wood, concrete, and the like.

33.7 For temperature tests during which the unit is cycled on and off, the temperatures shall be recorded until constant or for specified duty cycles. Only temperatures measured during the on portion of the test cycle are to be used to determine compliance with 33.1.

33.8 With reference to 33.5 and the maximum-speed test mentioned in 33.6, the test procedure described in Table 29.1 may be waived if, at the request of the manufacturer, the test is conducted with the tool so loaded (by a loading device if necessary) that the current input equals the rated value.

33.9 A tool when operated as described in 33.11 shall not attain a temperature of more than 125°C (257°F) on any exterior surface of the tool that may be laid on combustible material or against which combustible material may be laid. There shall not be emission of smoke, flame, or molten material from the tool. See 33.10.

*Exception: The requirement in 33.9 does not apply to a tool equipped with a momentary-contact switch if the switch is:*

- a) Not provided with means for being locked in the on position; and*
- b) So located that the tool will not become and remain energized, regardless of the position in which it is laid down.*



33.10 A tool is considered to comply with the requirement in 33.9 if, during the temperature test, it was operated until constant temperatures were attained.

33.11 To determine whether a tool complies with the requirements of 33.9, it is to be operated at the voltage and frequency indicated in 28.1 and 33.12 until constant temperatures are attained. The tool may be stationary in a rest position during the test and simulation of conditions of actual use need not be attempted.

33.12 For the temperature test, the tool is to be connected to a power-supply circuit of the voltage indicated below. If the voltage rating of the tool is nominally 115 V, it is to be tested on a circuit of 115 V if direct current, and 120 V if alternating current. If the nominal rating is 230 V, the tool is to be tested on a circuit of 230 V if direct current, and 240 V if alternating current. For a tool having rating other than those indicated above, the voltage of the power supply circuit for the test is to equal the maximum rated voltage of the tool.

33.13 The coil or winding temperature is to be measured by thermocouples mounted on the coil surface unless the coil is inaccessible for mounting of the thermocouples (for example, a coil immersed in sealing compound) or unless the coil wrap includes thermal insulation, such as asbestos, or more than two layers of cotton, paper, rayon, or the like. The change in resistance method is then to be employed, see 33.15, or the thermocouples are to be applied to the coil magnet wire coating under the wrap if feasible.

33.14 For a coil of an alternating current motor, other than a universal motor, having a diameter of 7 inch (178 mm) or less (items 7 and 14 in Table 33.1) the thermocouple is to be applied to the coil magnet wire coating.

33.15 The temperature of a winding may be determined by the resistance method by comparing the resistance of the winding at the temperature determined with the resistance at a known temperature according to the equation:

$$T = R/r (k + t_1) - (k + t_2)$$

*in which:*

*T is the temperature rise,*

*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,*

*t<sub>1</sub> is the room temperature in degrees C at the beginning of the test,*

*t<sub>2</sub> is the room temperature in degrees C at the end of the test, and*

*k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum.*

*Values of the constant for other grades must be determined.*

33.16 All values for temperature rises in Table 33.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

33.17 A short length of rubber or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of acceptable dielectric strength is employed on the individual conductors of the cord to safeguard the tool against deterioration of the conductor insulation and if the strain relief means is not dependent on that portion of the insulation subjected to the excessive temperature.

33.18 In a test in which constant temperatures are to be obtained, thermal equilibrium is considered to exist when three successive readings, taken at intervals of 10 percent of the previous duration of the test, but not less than 5-minute intervals, indicate no change. Temperatures are not to be measured after final shutdown; however, they are to be observed during the off or idling intervals if the loading during the test is of a cyclic nature. Thermocouples are to consist of wires no larger than No. 24 AWG (0.21 mm<sup>2</sup>).

33.19 When thermocouples are used in the determination of temperatures in connection with the heating of electrical equipment, it is common practice to employ thermocouples consisting of No. 30 AWG (0.05 mm<sup>2</sup>) iron and constantan wires and a temperature indicating instrument. No 30 AWG iron and constantan wire is to be used whenever referee temperature measurements by thermocouples are necessary.

### **34 Dielectric Voltage Withstand Test**

34.1 A tool shall withstand for 1 minute, without an indication of unacceptable performance, the application of a potential of 1000 V plus twice the rated voltage applied, except as indicated in 34.2, between live parts and dead metal parts, with the tool at the temperature reached during the temperature test.

34.2 For a tool employing an induction motor rated 1/2 horsepower (373 W output) or less and 250 V or less, the potential for the motor (but not for the remainder of the tool) is to be 1000 V.

34.3 A line bypass capacitor, or a capacitor connected across the line or provided for power-factor correction shall withstand for 1 minute, without an indication of unacceptable performance, the application of a sinusoidal potential of 1000 V plus twice the rated voltage of the tool between terminals of the capacitor.

*Exception: To distinguish between capacitor leakage and unacceptable performance, the test instrument may use a dc potential of 1414 V plus 2.828 times the rated voltage of the tool. This dc potential is to be maintained for 1 minute without an indication of unacceptable performance. The capacitor is to be disconnected from the circuit for this test.*

34.4 To determine whether a tool complies with the requirements in 34.1 – 34.3, the test potential is to be applied as described in 34.6 by means of test equipment having the characteristics outlined in 34.5.

34.5 The test equipment for conducting the dielectric voltage withstand test is to have the following features and characteristics:

- a) A means for indicating the test voltage that is being applied to the tool under test. This may be accomplished by sensing the voltage at the test leads or by an equivalent means.
- b) An output voltage that:
  - 1) Has a sinusoidal waveform;
  - 2) Has a frequency that is within the range of 40 – 70 Hz; and
  - 3) Has a peak value of the waveform that is not less than 1.3 and not more than 1.5 times the root-mean-square value.
- c) A sensitivity of the test equipment that is such that when a resistor of 120,000 ohms is connected across the output, the test equipment does not indicate unacceptable performance for any output voltage less than the specified test voltage, and the test equipment does indicate unacceptable performance for any output voltage equal to or greater than the specified test value. The resistance of the calibrating resistor is to be adjusted as close to 120,000 as instrumentation accuracy can provide, but never more than 120,000 ohms.

*Exception: The sensitivity of the test equipment may be increased and a higher value of calibrating resistance may be used, if agreeable to those concerned.*

34.6 The method of applying the test voltage to the tool is to be such that there are not any transient voltages that result in the instantaneous voltage applied to the appliance exceeding 105 percent of the peak value of the specified test voltage. The applied potential is to be increased from zero at a substantially uniform rate so as to arrive at the specified test potential in approximately 5 seconds and then, is to be maintained at the test potential for 1 minute. Manual control of the rate of rise may be used.

34.7 The printed foil pattern of a printed wiring board provided with a conformal coating as mentioned in 18.6(a), shall withstand the potential specified in 34.1 and 34.2 applied between printed wiring traces of opposite polarity for 1 minute without breakdown. Clean dry samples with and without the conformal coating are to be tested. The samples shall have been subjected to the production-soldering process. The components may be omitted for this test.

### **35 Leakage Current, Insulation Resistance, and Dielectric Voltage Withstand as a Result of Moisture Test**

35.1 After being subjected to the conditions described in 35.4 or 35.5, whichever is applicable, a tool as mentioned in 35.4 and 35.5:

- a) Rated for a nominal 120 V or 240 V supply, shall comply with the requirements in 30.1 in a repeated leakage-current test, except that the test shall be discontinued when leakage current stabilizes.
- b) Other than as mentioned in (a), shall have an insulation resistance of 50,000 ohms or more between live parts and interconnecting dead metal parts.
- c) Shall withstand for 1 minute – without an indication of unacceptable performance, see Section 34 – the application of a 60-Hz essentially sinusoidal potential of 1000 V between live parts and interconnected dead metal parts.

35.2 After the dielectric evaluation required by 35.1, a tool that is likely or intended to be used with liquid shall be subjected to the test in 35.6 – 35.8. After the test, the leakage current shall not exceed 0.5 mA when measured in accordance with Section 30.

*Exception: If the tool is not subject to spillage of liquid in normal use, the tool is allowed to dry for 24 hours before conducting the test in 35.6 – 35.8.*

35.2 effective June 1, 1998

35.3 After being subjected to the conditioning described in 35.9, a tool that is likely or intended to be used with liquid is to be subjected to the leakage current evaluation detailed in Section 30. The leakage current shall not exceed 0.5 mA. The tool is also to be subjected to the dielectric strength test detailed in Section 34. The potential is to be applied in the humidity cabinet described in 35.9, or in a room at  $20 \pm 5^{\circ}\text{C}$  ( $38 \pm 9^{\circ}\text{F}$ ) and less than 80 percent relative humidity in which the samples were reassembled.

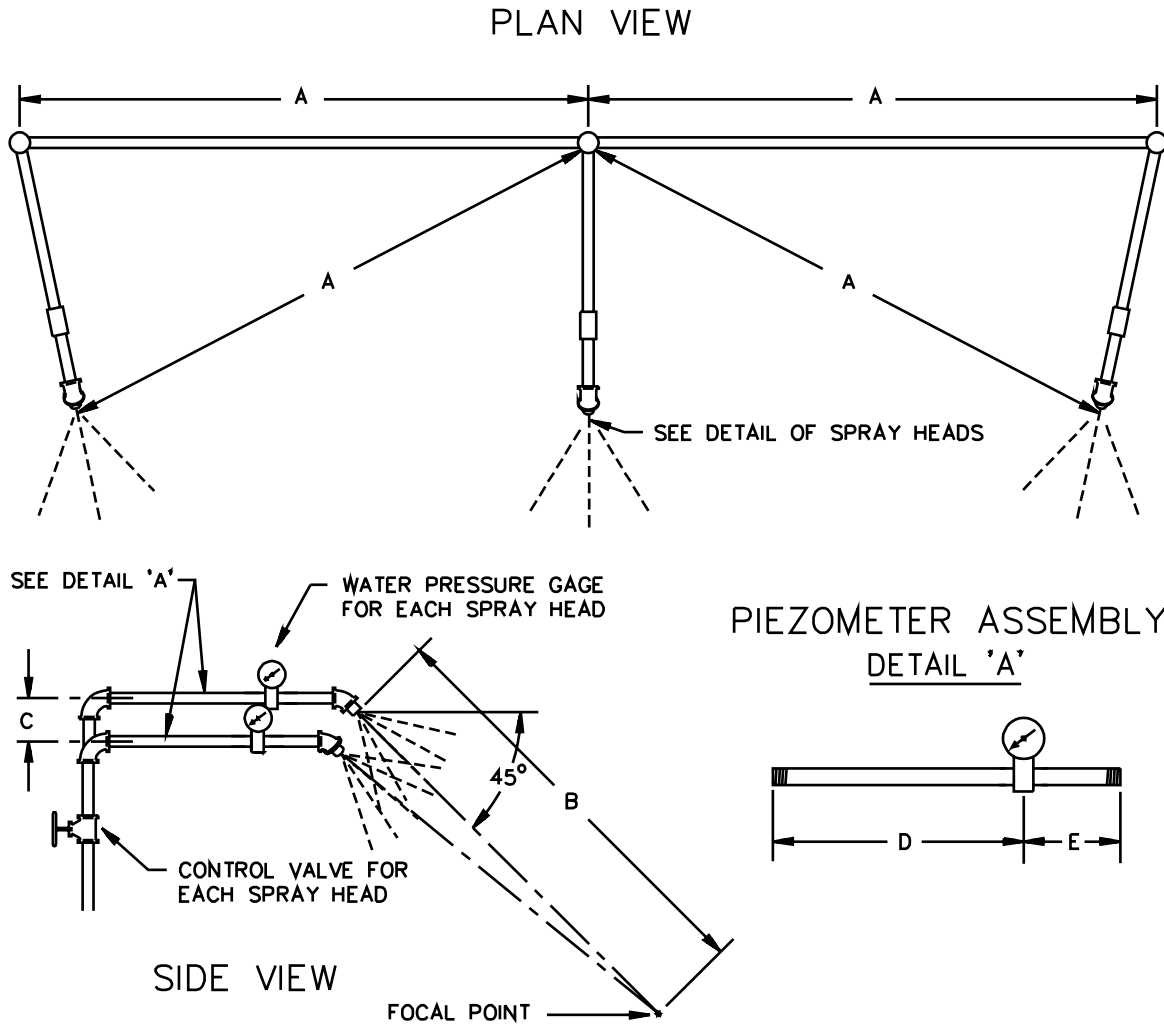
35.3 effective June 1, 1998

35.4 A concrete vibrator in which it is intended that electrical parts be immersed in concrete during operation and any other tool that is likely to be immersed in a conductive fluid during intended operation is to be conditioned by being immersed in water for 24 hours immediately prior to the test. The depth of the immersion is to be that which may be expected in the intended use.

35.5 A concrete vibrator of a type other than that described in 35.4 and any other tool intended to be used with a liquid or likely to be subjected to rain while in use is to be exposed for 2 hours to a water spray equivalent to a beating rain on its top and sides as described below. The water-spray test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 35.1. Spray heads are to be constructed in accordance with the details shown in Figure 35.2. The water pressure for all tests is to be maintained at 5 psi (35 kPa) at each spray head. The distance between the center nozzle and the unit is to be approximately 5 ft (1.5 m). The spray is to be directed at an angle of 45 degrees to the vertical and in the direction or directions most likely to cause water to enter. The test described in 35.1 is to be conducted immediately upon completion of the exposure, and is to be repeated one-half hour later.

35.5 effective June 1, 1998

Figure 35.1  
Water-spray piping

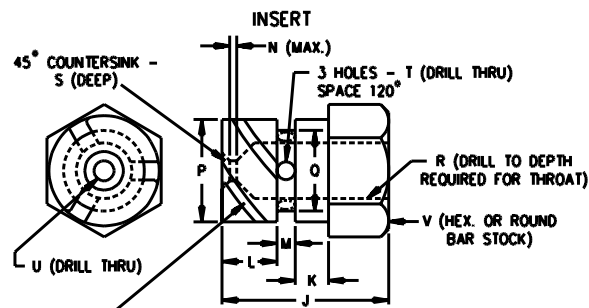
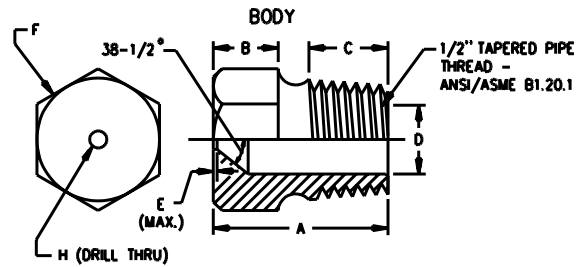
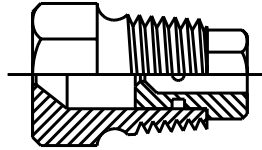


Item	inch	mm
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

RT101E

Figure 35.2  
Spray head

ASSEMBLY<sup>a</sup>



3 - SQUARE SECTION SLOTS - W WIDE x G DEEP - SPACE 120° - 60° HELIX - LEADING EDGES TANGENT TO RADIAL HOLES

Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0	Q	.576	14.63
D	.578	14.68	R	.453	11.51
E	.580	14.73	R	.454	11.53
F	1/64	0.40	S	1/4	6.35
G	c	c	S	1/32	0.80
H	.06	1.52	T	(No. 35) <sup>b</sup>	2.80
H	(No.9) <sup>b</sup>	5.0	U	(No. 40) <sup>b</sup>	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

<sup>a</sup> Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

<sup>b</sup> ANSI B94.11M Drill Size

<sup>c</sup> Optional - To serve as a wrench grip.



35.6 Prior to the test of 35.7, sealing rings of glands and other sealing means of a tool shall be aged by suspending them freely in a heating cabinet having a temperature of  $70 \pm 0.5^\circ\text{C}$  ( $158 \pm 3.6^\circ\text{F}$ ) and ventilated by natural circulation. The sealing rings are to be aged for 10 days. After the aging, the samples are to be removed from the cabinet and left at an ambient temperature of  $25 \pm 2^\circ\text{C}$  ( $77 \pm 3.6^\circ\text{F}$ ) for 16 hours. The tool is then to be reassembled for testing in accordance with 35.7. The glands and other sealing means are to be tightened to a value as indicated in Table 35.1.

35.6 effective June 1, 1998

**Table 35.1**  
**Torque test**

Table 35.1 effective June 1, 1998

Nominal diameter of screw (mm)	Torque (N-m)		
	a	b	c
Up to and including 2.8	.13	.26	.27
Over 2.8 up to and including 3.0	.16	.33	.33
Over 3.0 up to and including 3.2	.2	.4	.4
Over 3.2 up to and including 3.6	.26	.53	.4
Over 3.6 up to and including 4.1	.46	.8	.4
Over 4.1 up to and including 4.7	.53	1.2	.6
Over 4.7 up to and including 5.3	.53	1.3	.66
Over 5.3 up to and including 6.0	—	1.6	.8

<sup>a</sup> For metal screw without heads if the screw when tightened does not protrude from the hole.  
<sup>b</sup> For other metal screws, for screws of insulating material, and for nuts.  
<sup>c</sup> For other screws of insulating material.

35.7 A tool that is likely or intended to be used with liquid is to have all hoses, fittings, or vessels ruptured one at a time such that the entry of liquid into the tools is at its worst. A dry tool is to be used for each condition. The tool is then to be operated as in normal use and in any position recommended in the instruction manual for 1 minute. For a tool with sealing rings of glands, the tool shall be aged in accordance with 35.6 before conducting this test.

35.7 effective June 1, 1998

35.8 During the test described in 35.7, the leakage current shall not exceed 5 mA when measured in accordance with the Leakage Current Test, Section 30. After 24 hours of storage at room temperature and normal humidity, the leakage current shall not exceed 0.5 mA.

35.8 effective June 1, 1998

35.9 A tool that is likely or intended to be used with liquid is to be conditioned in a humidity cabinet at a temperature between  $20^\circ\text{C}$  and  $30^\circ\text{C}$  ( $68$  and  $86^\circ\text{F}$ ), and a relative humidity of  $93 \pm 2$  percent. The cabinet is to maintain the temperature with a tolerance of  $\pm 1^\circ\text{C}$  ( $1.8^\circ\text{F}$ ). Before being placed in the humidity cabinet, the sample is to be brought to the temperature of the humidity chamber [ $+4^\circ\text{C}$  ( $+7.2^\circ\text{F}$ ),  $-0^\circ\text{C}$  ( $-0^\circ\text{F}$ )], and then placed in the chamber for 7 days.

35.9 effective June 1, 1998

### 36 Leakage Current Following Humidity Test

36.1 A tool shall comply with the requirements for leakage current, Section 30, following exposure for 48 hours to moist air having a relative humidity of  $88 \pm 2$  percent at a temperature of  $32.0 \pm 2.0^\circ\text{C}$  ( $89.6 \pm 3.6^\circ\text{F}$ ).

- a) The tool is to be at a temperature just above the test chamber temperature when it is placed in a humidity chamber.
- b) The tool is to remain in the humidity chamber for 48 hours.
- c) Following this exposure, while still in the test chamber, the sample is to be tested unenergized as indicated in 30.6(a).
- d) The sample is then to be tested energized as indicated in 30.6 (b) and (c) except that the test may be discontinued when the leakage has stabilized or decreased. This test may be made in the test chamber or immediately after the sample has been removed from the test chamber.

### 37 Dew Point Test

37.1 A saw, hammer, drill and hammer-drill, disc and straight grinder, and disc sander shall not have a leakage-current greater than 2.0 mA after being conditioned as described in 37.1 and 37.2. Following conditioning, a tool that exceeds 0.5 mA shall be retested after a minimum of 10 hours storage at room temperature and normal humidity, or after 1 hour running at no load, after which the leakage current shall not exceed 0.5 mA.

37.2 The tool is to be conditioned in a cold chamber at  $5.0 \pm 2.0^\circ\text{C}$  ( $41.0 \pm 3.6^\circ\text{F}$ ) for at least 4 hours, then transferred from the cold chamber to a humidity chamber at  $88 \pm 2$  percent relative humidity and  $32.0 \pm 2.0^\circ\text{C}$  ( $89.6 \pm 3.6^\circ\text{F}$ ). The transfer time shall not exceed 1 minute.

37.3 The leakage current is to be measured from line to all exposed conductive surfaces and all gripping surfaces at 120 V or 240 V depending upon the rating of the tool, in static mode only (unenergized). The leakage current shall be monitored closely beginning from time of transfer from the cold chamber to humidity chamber until the leakage current stabilizes or drops. See 30.4 and 30.6(a).

### 38 Continuity of Grounding Connection Test

38.1 The grounding blade of the attachment plug and the dead metal parts of a tool as mentioned in 19.2 shall be electrically conductively connected, as determined by test.

38.2 Any indicating device, an ohmmeter, a low-voltage battery-and-buzzer combination, or the like, may be employed in the test mentioned in 38.1.

### 39 Strain Relief Test

39.1 When tested in accordance with 39.2, the strain relief means provided on a flexible cord shall withstand for 1 minute, without displacement, a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the tool disconnected.

39.2 A 35-lb (15.9-kg) weight is to be suspended on the cord and so supported by the tool that the strain relief means will be stressed from any angle that the construction of the tool permits. The strain relief is not acceptable if at any point of disconnection of the conductors there is such movement of the cord as to indicate that stress would have resulted on the connections.



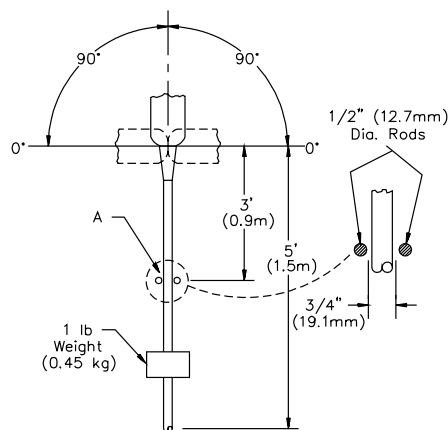
## 40 Cord Flexing Test

40.1 A power supply cord shall withstand 20,000 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.

40.2 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 (0.91 m) and 5 ft (1.52 m) from the cord entry point. Guides are to be provided 3 ft 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.

40.3 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. See Figure 40.1

**Figure 40.1**  
**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.

S2864

Inch	1/2	3/4	ft	3	5	lb	1
mm	12.7	19.1	m	0.91	1.52	kg	0.45

#### 40.4 After flexing:

- a) Each current-carrying conductor, shall be capable of carrying its rated ampacity (for the size conductor) as given in the National Electrical Code, ANSI/NFPA No. 70-1996, 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 (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.

#### 41 Pressure Pad Test

41.1 To determine compliance with 7.9, three samples of a soft rubber, neoprene, or polyvinyl chloride pressure pad, after conditioning in a full-draft, air-circulating oven maintained at a temperature of 20°C (36°F) more than the normal operating temperature for 168 hours, shall not undergo any change in dimension that will result in inability of the pad to hold down or maintain permanent position of an electrical part.

41.2 Three samples of the pad mentioned in 41.1 are to be conditioned for 18 hours in oil at a temperature of 20°C (36°F) more than the normal operating temperature. The oil to be used is IRM 902. The pads shall not undergo any change in dimension that will result in inability of the pad to hold down or maintain permanent position of an electrical part.

41.2 revised June 2, 1997

#### 42 Switch or Control Overload Test

42.1 A switch or other device, other than a speed-changing switch or a reversing switch, that controls the motor of a tool, unless so interlocked that it will never have to break the locked-rotor motor current, shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the tool. The switch shall be electrically and mechanically operable at the conclusion of the test, at which time the switch shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description that will diminish the usefulness and reliability of the switch.

*Exception: The tests required by 42.1 need not be performed on a switch with a hp rating having a locked-rotor current as specified in Table 430-151 of the National Electrical Code, ANSI/NFPA 70-1996.*

42.2 In a test to determine if a switch or other control device performs acceptably in the overload test mentioned in 42.1, the tool is to be connected to a grounded power-supply circuit of rated frequency and maximum rated voltage (see 28.1 and 33.12), with the rotor of the motor locked in position. During the test, exposed dead metal parts of the tool are to be connected to ground through a 3-A plug fuse, and the connection is to be such that any single-pole, current-interrupting device will be located in the ungrounded conductor of the supply circuit. If the tool is intended for use on direct current, or on direct current as well as on alternating current, the exposed dead metal parts of the tool are to be connected to be positive with respect to any single-pole, current-interrupting control device. The device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed with the concurrence of those concerned; and it is to be left in the on position as briefly as possible. The performance is unacceptable if the fuse in the grounding connection opens during the test.

42.3 A switch or other device for reversing the motor of a tool shall perform acceptably when subjected to a test consisting of 25 cycles of operation as described in 42.4. The switch shall be electrically and mechanically operable at the conclusion of the test, at which time the switch shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description that will diminish the usefulness and reliability of the switch.

42.4 For the test mentioned in 42.3, the tool is to be connected to a circuit of maximum rated voltage, without load. Each cycle of operation is to consist of throwing the switch to the position in which the tool rotates in one direction, giving it time to attain full operating speed in that direction, then (without pause in any intermediate off position unless the switch will not function otherwise) throwing the switch to the position in which rotation is reversed, giving the tool time to attain normal speed in that direction, and then reversing the rotation again by throwing the switch to the initial on position. Connections, including the grounding connection, are to be made as described in 42.2, and the performance is unacceptable if the fuse in the grounding connection opens during the test.

42.5 A switch or other device for changing the speed of the motor of a tool, other than an on-off switch, shall perform acceptably when subjected to a test consisting of 50 cycles of operation as described in 42.6. The switch shall be electrically and mechanically operable at the conclusion of the test, at which time the switch shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description that will diminish the usefulness and reliability of the switch.

42.6 For the test mentioned in 42.5, the tool is to be connected to a circuit of maximum rated voltage, without load. Each cycle of operation is to consist of making the tool operate at one speed, throwing the switch to cause operation at the other speed, and then changing the setting back to the position that results in the first value of speed again. During the test, the dead metal parts of the tool are to be connected to ground through a 3-A plug fuse, and the performance is unacceptable if this fuse opens during the test.

### **43 Electronic Components Test**

43.1 If a tool employs one or more capacitors, rectifiers, transistors, or similar components, a fire or electric shock condition shall not develop when the circuit between any two terminals of any such component is opened or shorted. Only one of the simulated fault conditions is to be imposed at one time.

43.2 The need for test of a specific component and the type of test needed is to be determined by analysis of the total system. The possible effect of one component fault on another, encapsulation, and the like are factors to be considered.

43.3 Short-circuit tests for determining whether a tool complies with the requirements in 43.1 are to take into account the normal usage of the tool. For example, if the tool is provided with a momentary-contact switch having no provision for being locked in the on position and if there is indication of malfunction (abnormal operation) of the tool (emission of smoke, failure of the tool to operate in the normal manner, or other indication), the test is to be discontinued when the malfunction becomes evident. Otherwise, the test is to be continued until ultimate results occur. Exposed dead metal parts of the tool are to be connected to ground through a 3 A fuse, and the results are unacceptable if the fuse opens during the test.

#### 44 Burnout Test

44.1 When a drill, grinder intended for use with a grinding wheel more than 2 inches (50.8 mm) in diameter, rotary hammer, hand motor tool, polisher, belt sander, disc sander, or circular saw is operated under the conditions described in 44.2:

- a) There shall be no adverse deterioration of the insulation to the extent that live parts are exposed; and
- b) The leakage current measured from accessible dead metal parts shall not be more than 5.0 mA, when monitored continuously as the tool reaches the end result using the methods described in 30.3 – 30.6, utilizing both positions of switch S2 and with the tool switching devices in all normal operating positions (speed control set for maximum speed).

44.2 To determine whether a tool complies with the requirements in 44.1, each of three previously untested samples of a complete tool is to be subjected to operation at 120 percent of rated load for 14-1/2 minutes followed by operation at no load for 1/2 minute. Following the initial 15 minutes of operation, the tool is to be subjected to consecutive 15 minute periods of operation – each period consisting of 14-1/2 minutes of operation with the load increased in each successive period by 10 percent of the rated current followed by 1/2 minute of operation at no load. The test is to be continued until the end result occurs (see 44.3) or the load reaches 200 percent of the rated load. If agreeable to those concerned, the overload conditioning may start at a higher load value, in 10 percent increments of rated load, up to 150 percent. If the end result occurs in less than 1/2 hour, the test is to be repeated using a different sample and starting at rated load instead of 120, 130, 140, or 150 percent. The exterior temperatures of the motor housing are to be monitored during the test by means of thermocouples. If the temperature of the motor housing exceeds 90°C (194°F) during operation under load, the tool is to be operated at no-load (other than the mechanical load provided by the loading device) until the housing temperature is stabilized; and upon stabilization, the test is to be resumed at the same load increment for the balance of the 14-1/2 minute load cycle. The loading cycle is to be resumed, as indicated above until the end result occurs or the tool has been operated for 6 hours.

*Exception No. 1: For a light-duty tool, the test may start at 100 or 110 percent.*

*Exception No. 2: Only a single sample of a tool employing an alternate magnet wire coating, see 28.4, is to be tested if the results are equivalent to the test results of the original construction tested. Equivalency is based upon the test duration, the enclosure temperature, and the leakage current being slightly higher, the same or less.*

44.3 With reference to 44.2, failure of the tool to operate is considered to have occurred if:

- a) Flame appears;
- b) An open circuit occurs;
- c) The tool stalls and will not run at rated load; or
- d) A short circuit develops in the winding that results in a spontaneous increase in current of 50 percent or more of the last adjusted value.

If condition (a) occurs, the flame is to be extinguished immediately. If a condition similar to (c) occurs, the tool stalls except that it will run at rated load, the load shall be reapplied at the highest level that the tool will operate under, until a failure of the tool to operate occurs. At the moment the end result occurs, switch S1 is to be opened and the leakage current monitored until stabilization.

44.4 If the end result occurs as a short circuit in the winding (condition (d) in 44.3), operation is to be continued for 30 seconds under load after the short circuit occurs, unless condition (a) (flame, which is to be extinguished immediately), condition (b) (open circuit), or condition (c) (stalling) occurs earlier. If condition (a), (b), or (c) occurs, operation is to be terminated immediately. If neither condition (a), (b), or (c) occurs during the 30-second interval, the tool is then to be given time to cool to room temperature. Without adjustment of the load from the value during the 30-second interval, operation of the tool is to be resumed for one period of up to 30 seconds until condition (a) (flame), condition (b) (open circuit), or condition (c) (stalling) occurs, whichever occurs first.

## **45 Resistance to Impact Test**

### **45.1 Brush cap**

45.1.1 A brush cap is considered to have acceptable strength if it will withstand, without cracking or breaking, an impact equal to that which would result from dropping the tool through a distance of 3 ft (0.91 m).

### **45.2 Grounding-type tool**

45.2.1 After being subjected to the impact described in 45.6.3 – 45.6.5, a tool that is provided with a means for grounding and has other than a thermoplastic enclosure shall:

- a) Comply with the dielectric voltage withstand requirements in 34.1 – 34.3;
- b) Not be so damaged that the risk of electric shock would be increased;
- c) Not make uninsulated live parts or internal wiring accessible to contact, as determined by the application of the probes shown in Figures 6.1 and 6.3; and
- d) Not cause damage to the strain relief means so that the tool will continue to comply with the strain relief requirements in 9.2.1 – 9.2.5.

### **45.3 Insulated handle**

45.3.1 Insulating material used as described in Section 20 shall not:

- a) Show holes, cracks, distortion, or other evidence of deterioration after conditioning as described in 45.3.2; or
- b) Break, crack, rupture, or show other adverse effects after being conditioned as described in 45.3.2 and then subjected to the impact test described in 45.3.3.

45.3.1 revised June 2, 1997

45.3.2 The conditioning mentioned in 45.3.1 is to consist of placing the tool in an air-circulating oven maintained at a temperature at least 10°C (18°F) more than the temperature observed on the handle or other gripping surface under conditions of intended operation, but in no case is the temperature to be less than 70°C (158°F). The tool is to remain in the oven for 7 hours.

45.3.3 The impact test mentioned in 45.3.1(b) is to be conducted after the tool is given time to cool to room temperature and is to consist of dropping the tool 3 ft (0.91 m) to strike a concrete surface. The tool is to be dropped in such a manner that each of the handles or areas likely to be grasped will receive an impact. For the test of a tool employing two handles, a single sample may be dropped twice, or two different samples may be used.

#### 45.4 Circular-saw retractile lower guard

45.4.1 To determine if a retractile lower guard of a circular saw complies with the requirement in 27.1.5(c), the closure time is to be measured without restoration of the guard in case of bending after a single sample is subjected to each of the following:

a) Sawing 200 linear feet (60 m) – 25 cuts 8 ft (2.4 m) long – of 1/2-inch (12.7-mm) thick fir plywood that has been stored indoors for 72 hours prior to the sawing. The saw is then to be conditioned for 24 hours in air at a relative humidity of 90 plus 5 minus 0 percent and a temperature of  $32 \pm 2^\circ\text{C}$  ( $90 \pm 4^\circ\text{F}$ ). Following the conditioning, the closure time is to be measured.

*Exception: A guard need not be conditioned as described in (a) if it is obvious that accumulation of sawdust will not affect the closure time of the guard.*

b) The saw, set for a 90-degree cut of maximum depth and oriented so that the lower guard will strike the floor with the table parallel to the floor, is to be dropped from a height of 3 ft (0.91 m) to a concrete surface. The closure time is then to be measured.

c) The saw, set for a 90-degree cut of maximum depth and oriented in a hand-carrying position intended for the particular tool, is to be dropped from a height of 3 ft (0.91 m) to a concrete surface. The closure time is then to be measured.

45.4.2 To determine if a retractile lower guard of a circular saw complies with the requirement in 27.1.5(d), the closure time is to be measured without restoration of the guard in case of deformation after a sample is subjected to the following test. The saw is to be set for a 90-degree cut of maximum depth and oriented in the horizontal plane. The retractile lower guard is to be cycled from the full closed position to the maximum open working position and then released for 50,000 cycles at a rate not less than 10 cycles per minute. Following the cycling, the closure time is to be measured. Upon completion of the test, the guard shall be fully functional.

*Exception No. 1: If agreeable to all concerned, the guard may be tested at a rate faster than 10 cycles per minute.*

*Exception No. 2: The sample used for this test may be positioned in a manner other than horizontal provided that it can be shown that the alternate position is equivalent.*

#### 45.5 Plate jointers

45.5.1 To determine if the guard of a plate jointer complies with the requirement in 27.4.2(c), the closure time is to be measured without restoration of the guard after a single sample is subjected to each of the following:

a) While set at the maximum depth of cut, plunge cutting 50 cuts in soft pine wood that has been stored indoors for 72 hours prior to the sawing. The tool is then to be conditioned for 24 hours in air at a relative humidity of 90 percent (plus 5 minus 0 percent) and at temperatures of  $32 \pm 2^\circ\text{C}$  ( $90 \pm 4^\circ\text{F}$ ). Following the conditioning, the closure time is to be measured.

*Exception: The tool need not be conditioned if it is obvious that accumulation of sawdust will not affect the closure time of the guard.*

b) The plate jointer, oriented so that the guard will impact the floor, is to be dropped from a height of 3 feet (0.91 m) to a concrete surface. The closure time is then to be measured.

c) The plate jointer, oriented in the hand-carrying position for the particular tool, is to be dropped from a height of 3 ft (0.91 m) to a concrete surface. The closure time is then to be measured.

*Exception: A separate sample may be used for each test specified by (a) – (c).*

## **45.6 Injury to persons**

45.6.1 A component as mentioned in 23.1 shall withstand the impact described in 45.6.4 and 45.6.5 without:

a) Cracking that might cause subsequent malfunction or breakage of the part, resulting in the intended function of that part being defeated;

b) Being affected to the extent that moving parts capable, upon contact, of causing injury to persons would be exposed to unintentional contact; and

c) Affecting the mechanical performance of the tool to the extent that the risk of injury to persons has been increased.

*Exception No. 1: As provided in 45.6.2.*

*Exception No. 2: The lower guard of a hand circular saw is not subject to this requirement. See 27.1.5.*

45.6.2 Breakage of a working component, such as a saw blade, a grinding wheel, or a screwdriver bit, is acceptable. Deformation of a guard is acceptable if it can be readily restored to its original shape or the deformation does not result in the risk of injury to persons.

45.6.3 A tool is to be subjected to the impact described in 45.6.4 and 45.6.5 once for compliance with the requirements in 45.2.1 and 45.6.1 or 45.6.1 and 47.3.1, or 45.6.1 and 48.9.1.

45.6.4 Except as noted in 45.6.5, each of three samples of a tool is to be dropped three times from a height of 3 ft (0.91 m) onto a concrete surface in such a manner as to test the tool most severely. The test is to be conducted with or without any accessories and attachments recommended by the manufacturer so as to result in the most severe test, except that the tool is not to be dropped in such a manner as to cause it to impact on a grinding wheel. The test is to be conducted so that, in each drop, the sample strikes the surface in a position different from those of the other drops.

45.6.5 Three individual samples may be employed for the test described in 45.6.4, or if the manufacturer so elects, fewer samples may be used in accordance with Figure 45.1. The overall performance is acceptable upon completion of any one of the procedures represented in the figure. Each series is to consist of three drops, and if any sample does not comply with the test criteria on the first series, the results of the test are unacceptable.

**Figure 45.1**  
**Procedure for impact test**

Series Number	Sample Number											
	1	2	3	1	2	3	1	2	3			
1	↓ A	N	N	↓ A	N	N	↓ A	N	N	↓ A	N	N
2	↓ A	N	N	↓ A	N	N	↓ U	↓ A	N	↓ U	↓ A	N
3	↓ A	N	N	↓ U	↓ A	N	↓ A	N		↓ U	↓ A	

Arrows indicate sequence of test procedure  
 A – Acceptable results from drop  
 U – Unacceptable results from drop  
 N – No test necessary

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## POLYMERIC ENCLOSURES

### 46 General

46.1 Except as noted in 46.2, a polymeric enclosure shall comply with the requirements in 47.1.1 – 47.5.9, except as indicated in 47.5.8, or Section 48, whichever apply.

46.2 The requirement in 46.1 does not apply if:

- All live parts within the enclosure are acceptably insulated or provided with internal enclosures independent of the outer enclosure;
- All leads connecting components inside the enclosure are mechanically secured so that displacement of any component resulting from distortion of the outer enclosure will not cause a stress on the junction between a lead and a terminal of the component (see 46.3);
- The power-supply-cord strain relief does not depend on the enclosure; and
- The material complies with 48.2.1.

46.3 With reference to 46.2(b), an integral lead of a component must be provided with acceptable strain relief, as determined by test.



## 47 Polymeric Materials as Described in 47.1.1 – 47.5.9

### 47.1 Oven conditioning test

47.1.1 Unless it has been found to be acceptable on the basis of the results of the Mold Stress Test and thermal index of the material, after an enclosure that is subjected to a temperature of more than 65°C (149°F) but not more than 95°C (203°F) during intended operation of the tool and has been conditioned as described in 47.1.2 or 47.1.4 and after it has cooled to room temperature, it shall comply with the applicable requirements relating to exposure of bare live parts, physical strength, flammability, support of parts, and the like. Except as noted in 47.1.3, any distortion in the enclosure shall be so limited that there will be no interference with the acceptable operation of the tool following the oven conditioning.

47.1.1 revised June 2, 1997

47.1.2 Three samples of the complete tool are to be placed in a circulating air oven for 1000 hours, except that the test need be conducted only on parts of the enclosure if such parts are representative of the complete tool with respect to the enclosure. The temperature of the oven is to be maintained at the value indicated in Table 47.1.

**Table 47.1**  
**Temperatures for oven conditioning**

Maximum operating temperature of enclosure during temperature test		Oven temperature
More than	Not more than	
65°C (149°F)	75°C (167°F)	85°C (185°F)
75°C (167°F)	85°C (185°F)	95°C (203°F)
85°C (185°F)	95°C (203°F)	105°C (221°F)

47.1.3 The oven conditioning may distort the enclosure to the extent that it is in a throw-away condition. Such a result is acceptable if the performance is evaluated several times during the oven test to determine that intermediate stages of distortion result in acceptable performance with respect to risk of fire, electric shock, and injury to persons.

47.1.4 As an alternative to the 1000-hour test described in 47.1.2, the acceptability of the enclosure may be determined by an aging test on the complete tool under service conditions. Service conditions are to be represented by a simulation of normal operation of the unit as specified in Table 29.1 or 33.1 for the life of the product (i.e., a single set of brushes wears out unless the manual specifies replacement of brushes, in which case until the tool becomes non-serviceable) under test conditions.

47.1.5 An enclosure that is subjected to a temperature of more than 95°C (203°F) during intended operation of the tool shall be acceptable for the purpose, as determined by an investigation.

## 47.2 Mold-stress evaluation test

47.2.1 When tested under the conditions described in 47.2.2, the enclosure shall comply with all the following:

- a) There shall not be softening of the material, as determined by handling immediately after the oven conditioning;
- b) There shall not be cracking of the material;
- c) There shall not be exposure of uninsulated live parts to the extent that the product would not comply with provisions of this standard that guard against unintentional contact with such parts; and
- d) Warping or distortion shall be so limited that the tool will continue to comply with the strain relief requirements in 9.2.1 – 9.2.5 and Section 39.

47.2.2 Three samples of the tool are to be placed in an oven for 7 hours at 10°C (18°F) higher than the maximum operating temperature of the material measured during the temperature test, but not less than 70°C (158°F) in any case. However, if the oven temperature during the conditioning described in 47.1.2 equals or is more than the value mentioned, examination as mentioned below may be conducted at the conclusion of the 1000-hour oven conditioning. Immediately following removal from the oven, the sample is to be examined with reference to 47.2.1(a). After cooling to room temperature, the sample is to be examined with reference to (b) and (c) and tested with reference to 47.2.1(d).

47.2.3 Crazing of the polymeric material is acceptable.

## 47.3 Resistance to impact test

47.3.1 A tool shall withstand the impact described in 47.3.2 and 47.3.3 without:

- a) Making live parts accessible to contact, or
- b) Producing any other condition that would increase the risk of electric shock of the tool (see 47.3.4).

47.3.2 A tool that is hand-supported and subject to movement is to be subjected to the impact test described in 45.6.4 and 45.6.5. If the tool is intended to rest on the floor or ground or be used on the floor or ground, each of three samples is to be subjected to an impact of 5 ft-lbf (6.8 J) on any surface that is exposed to a blow during intended use. This impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 lb (0.535 kg), from the height necessary to produce the specified impact. For surfaces other than the top of an enclosure, the steel sphere is to be suspended by a cord and caused to fall as a pendulum through the distance required to cause it to strike the surface with the specified impact. The tests are to be so conducted that, in each test, the sample receives an impact in a location different from those in the other two tests.

47.3.3 A tool that is not completely hand-supported in use, such as a magnetic drill stand, heavy paving breaker (hammer), is to be subjected to the impact that results from the tool being dropped from intended operating positions (on a bit position in the case of a paving breaker) to strike a concrete surface. The tool is also to be subjected to an impact of 5 ft-lbf (6.8 J) on any surface that is exposed to a blow during intended use, as described in 47.3.2.

47.3.4 With reference to 47.3.1(b), cracking of the enclosure is not to affect the function of any features protecting against risk of fire, electric shock, or injury to persons, constructional features such as thermostats, overload-protective devices, or strain relief. Cracking of the enclosure is not acceptable if a dust or moisture-tight enclosure is required.

#### **47.4 Abnormal operation test**

47.4.1 When tested in accordance with 47.4.2, there shall be no ignition of the enclosure material, exposure of live parts, emission of flame or molten metal, or glowing or flaming of the combustible material upon which the tool is placed.

*Exception: As provided in 47.4.3.*

47.4.2 The tool is to be operated under the most adverse condition of abnormal operation such as locked-rotor operation, operation with current-carrying parts short-circuited, and so forth. During the test, the tool is to be connected to a circuit containing a 30A fast acting supply fuse while resting on white tissue paper on a softwood surface and is to be operated continuously until the ultimate results have been determined. In most cases, continuous operation will be necessary until constant temperatures are reached, or the 30A fuse opens.

47.4.3 Warping, shrinkage, expansion, or cracking of the enclosure materials is acceptable, as is any emission of flame or molten metal through an opening that is provided in the enclosure (not an opening that occurs as a result of this test).

#### **47.5 Flame resistance test**

47.5.1 Except as indicated in 47.5.8 and 47.5.9, when tested in accordance with 47.5.2 – 47.5.6, the enclosure shall not support combustion for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame, nor shall there be complete destruction of the sample as a result of this test.

47.5.2 Except as indicated in 47.5.3, three samples of the enclosure are to be placed in an oven for 7 days at a uniform temperature not less than 10°C (18°F) higher than the maximum temperature of the material measured during the temperature test, but not less than 90°C (194°F) in any case. After cooling to room temperature, the samples are to be tested in accordance with 47.5.3 – 47.5.6.

47.5.3 The test described in 47.5.4 – 47.5.6 may be conducted on unconditioned samples if:

- a) The enclosure material has been determined previously, by a long-time thermal-aging program, not to show a reduction in its flame-resistant properties as a result of this aging; and
- b) Such an aging program included specimens at least as thin as the wall of the enclosure.

47.5.4 Three sections of the enclosure of the tool most likely to be ignited are to be selected. With a different sample in each case, each of such sections is to be subjected to the flame test described in 47.5.5. During the test, the tool is to be supported in its intended operating position in a draft-free location, and nonpolymeric portions of the enclosure in contact with or fastened to the polymeric portions are not to be removed, and, insofar as possible, the internal mechanism of the tool is to be in place.

47.5.5 The flame of a Bunsen burner is to be adjusted to have a 3/4-inch (19-mm) high yellow flame with no blue cone. Two 30-second applications of the tip of the flame are to be made to each section of the enclosure selected as indicated in 47.5.4 with a 1-minute interval between the applications.

47.5.6 With reference to 47.5.4, the sections most likely to be ignited are considered to be those adjacent to coil windings, splices, open-type switches, or other arcing or sparking parts.

47.5.7 Flame-retardant coatings or paints are not to be used to accomplish compliance with the requirements in 47.5.1 – 47.5.6.

47.5.8 An enclosure in which the strain relief is dependent on the enclosure may be accepted even though it does not comply with the flame-resistance requirements in 47.5.1– 47.5.6 if:

- a) No uninsulated live parts are enclosed by the polymeric material; and
- b) The material has a burning rate not less than that described in 48.2.1.

47.5.9 An enclosure of material classed V-0, V-1, or V-2 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, is exempt from the flame-resistance test if it is within the same or greater thickness range for which the material was classed.

47.5.9 revised January 5, 2000

## **48 Polymeric Materials as Described in 48.1.1 – 48.10.3**

### **48.1 General**

48.1.1 The enclosure shall comply with the requirements in 47.1.1 – 47.1.5.

### **48.2 Flame spread test**

48.2.1 The rate of burning of the polymeric material shall not be more than 1.5 inches (38.1 mm) per minute when tested in accordance with 48.2.2 – 48.2.6.

48.2.2 Three samples of the material, each 5 inches (127 mm) long, 1/2 inch (12.7 mm) wide, and nominally 1/8 inch (3.2 mm) thick – minimum thickness 0.120 inch (3.05 mm) – and having smooth edges are to be tested. On each sample, a line is to be marked across the width of the sample 1 inch (25.4 mm) from one end and a similar line is to be marked 1 inch (25.4 mm) from the other end.

48.2.3 The test apparatus is to consist of a Bunsen burner having a 3/8-inch (9.5-mm) diameter tube, a ring stand with two clamps adjustable to the desired angles or equivalent means of support, a 5- by 5-inch (127- by 127-mm) section of 20-mesh steel wire gauze, and a stop watch or other acceptable timing device.

48.2.4 A sample is to be clamped at one end with its longitudinal axis horizontal and its transverse axis inclined 45 degrees to the horizontal. The wire gauze is to be clamped horizontally beneath the sample, with a separation of 3/8 inch (9.5 mm) between the lower edge of the sample and the gauze and with the free end of the sample extending approximately 1/2 inch (13 mm) beyond the gauze. The Bunsen burner is to be adjusted to provide a blue flame approximately 1 inch (25.4 mm) high, and the tip of the flame is to be applied to the free end at the lower edge of the sample, the tube of the burner being in the same vertical plane as the longitudinal axis of the sample and inclined toward the end of the sample at an angle of approximately 45 degrees to the horizontal. The flame is to be applied for 30 seconds without changing the position of the burner and is to be then removed from the sample.



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48.2.5 If the sample continues to burn after removal of the test flame, the time for the flame to travel along the lower edge of the sample from one mark to the other is to be measured, and the rate of burning is thereby calculated in inches per minute (millimeters per minute).

48.2.6 If the samples undergo significant longitudinal shrinkage during the burning test because of relief of strains of molecular orientation by heat from the burning portion, as may be the case with a sample taken from a finished part, the dimensional change may be taken into account in determining the rate of burning. Measurements may be made of the changes in dimensions of the representative samples of the material after annealing between glass plates at an appropriate temperature, and a correction for such dimensional changes applied to the observed rate of burning, or the burning tests may be conducted on samples that have been annealed.

### **48.3 Resistance to hot-wire ignition test**

48.3.1 The polymeric material shall not ignite in less than 7 seconds when tested in accordance with 48.3.2 and 48.3.3.

*Exception: A polymeric material that complies with the Hot-Wire Ignition (HWI) Abnormal Overload Test as described in 48.4.1 – 48.4.15 need not be tested in accordance with 48.3.2 and 48.3.3.*

48.3.2 Each of three samples of the material, each 5 inches (127 mm) long, 1/2 inch (12.7 mm) wide, and having a thickness not more than the minimum thickness of the enclosure at any point, is to be wrapped with five turns of resistance wire, with a spacing of 1/4 inch (6.4 mm) between turns.

48.3.3 The wire is to be No. 24 AWG (0.21 mm<sup>2</sup>), iron-free, 20 percent chromium and 80 percent nickel, 0.020 inch (0.5 mm) in diameter, running 1.61 ohms per foot (5.28 ohms per meter) and 864 ft/lb (580 m/kg). The wire is to be approximately 10 inches (254 mm) long and is to be energized at a linear power density of 6.5 watts per inch (256 W/m) and the measurement of the time is to begin when the current begins to flow.

### **48.4 Hot-wire ignition (HWI) – abnormal overload test**

48.4.1 Materials that do not comply with 48.3.1 may be evaluated by an abnormal overload test that passes abnormal currents through current-carrying members as described in 48.4.2. Over-current values and times are shown in Table 48.1 as a function of the circuit overcurrent device rating.

*Exception: The abnormal overload test need not be conducted if the electrically live parts are spaced 1/32 inch (0.8 mm) or more from the material.*

48.4.2 A polymeric material shall be capable of withstanding the temperatures that are generated during or as a result of the abnormal overload test described in 48.4.5 and 48.4.6 without ignition.

48.4.3 If there is no overcurrent protective device as part of the tool or it cannot be relied upon, evaluation shall be based upon the available energy to the tool using percentages of the intended branch-circuit overcurrent device, but not less than a 30 A normal-acting protective device.

**Table 48.1**  
**Abnormal overload test**

Overcurrent protective device rating	110-percent current <sup>a</sup>	Minimum test time	
		135-percent current	200-percent current
0 – 30 amperes	7 hours	60 minutes	2 minutes
31 – 60	7	60	4
61 – 100	7	120	6
101 – 200	7	120	8
201 – 400	7	120	10

<sup>a</sup> The test may be terminated when the temperatures have stabilized, indicating that ultimate results have already been achieved.

48.4.4 If the overcurrent protective device is part of the tool, it shall be relied upon only if the protector is not user-serviceable unless substitution of a higher-rated protector value is prevented by keying, other constructional features, or if there is a permanent marking limitation.

48.4.5 To determine whether a polymeric material complies with 48.4.2, separate samples of the tool or representative sections of the tool are to be loaded to each indicated overcurrent values for the corresponding test times indicated in Table 48.1. Except as indicated in 48.4.6, only one sample need be subjected to each of the specified overload tests.

48.4.6 If a current-carrying conductor within any of the samples of the tool opens before the minimum test time tabulated in Table 48.1 has elapsed without resulting in ignition, then three samples are to be loaded to a lesser current value, as indicated in 48.4.10 (b) – (i) for the minimum test time tabulated in Table 48.1 corresponding to the largest overload value that does not result in a current-carrying conductor opening before the minimum test time, or 7 hours.

48.4.7 For the sequence of tests described in 48.4.10, if the abnormal overload test continues for 7 hours or the full test time indicated in Table 48.1 without a winding or an acceptable protective device opening, the remaining tests need not be conducted. For example, if the test described in 48.4.10(a) continues for 7 hours using 110 percent of the overcurrent protective device rating load (namely 33 A for a 30 A overcurrent protective device), 60 minutes using 135 percent of the overcurrent protective device rating load (namely 40.5 A), and 2 minutes using 200 percent of the overcurrent protective device rating load (namely 60 A) the tests described in items B–I need not be conducted.

48.4.8 The overload current value indicated in 48.4.10 (b) – (h) is the lesser overload value tabulated in Table 48.1 that resulted in a current-carrying conductor opening before the minimum test time. The base test current value indicated in 48.4.10 (b) – (i) is the largest overload value tabulated in Table 48.1 that does not result in a current-carrying conductor opening before the minimum test time. If a current-carrying conductor opens before 7 hours within the sample loaded to 110 percent of the overcurrent protective device rating, then the base test current value shall be the rated current of the tool.



48.4.9 For the purpose of illustration, consider the following two examples:

Example A:

Given the rated current of the tool under evaluation is 10 A and the overcurrent protective device rating is 30 A, one sample of the tool, designated sample 1, is then loaded to 33 amperes for 7 hours, another sample, designated sample 2, is loaded to 40.5 A for 60 minutes and a third sample, designated sample 3, is loaded to 60 A for 2 minutes.

If sample 1 continues for 7 hours and sample 2 continues for 60 minutes without a current-carrying conductor opening, but a current-carrying conductor in sample 3 opens before 2 minutes, then 3 samples of the tool, designated samples 4, 5 and 6, are subjected to the abnormal overload test for 60 minutes loaded to the base test current (40.5 A) plus 75 percent of the difference between the overload current (60 A) and the base test current (40.5 A), namely 55 A.

Example B:

Given the same information as Example A above except in samples 1, 2 and 3 a current-carrying conductor opens before 7 hours, 60 minutes and 2 minutes respectively, then 3 samples of the tool, designated samples 4, 5, and 6, are subjected to the abnormal overload test for 7 hours loaded to the base test current (rated current of 10 A) plus 75 percent of the difference between the overload current, (33 A) and the base test current (10 A), namely 27.25 A.

48.4.10 Loading the tool shall not result in ignition, undue distortion, or melting of the material being evaluated under any of the following conditions:

- a) Loading the tool to the specified overload values per Table 48.1.
- b) Loading the tool to a current equal to the base test current plus 75 percent of the difference between the overload current and the base test current.
- c) Loading the tool to a current equal to the base test current plus 50 percent of the difference between the overload current and the base test current.
- d) Loading the tool to a current equal to the base test current plus 25 percent of the difference between the overload current and the base test current.
- e) Loading the tool to a current equal to the base test current plus 20 percent of the difference between the overload current and the base test current.
- f) Loading the tool to a current equal to the base test current plus 15 percent of the difference between the overload current and the base test current.
- g) Loading the tool to a current equal to the base test current plus 10 percent of the difference between the overload current and the base test current.
- h) Loading the tool to a current equal to the base test current plus 5 percent of the difference between the overload current and the base test current.
- i) Loading the tool to the base test current.

48.4.11 To determine whether a material complies with the requirement in 48.4.6, three samples of the complete tool are to be subjected to each condition described in 48.4.10 (a) – (i).

48.4.12 For the loading conditions, a variable resistor is to be connected in series with the tool. The tests described in 48.4.10 (a) – (i) are to be continued for the test times indicated in 48.4.10 and Table 48.1, unless a current-carrying conductor within the tool or an acceptable protective device opens in a shorter time. In conducting the tests described in 48.4.10 (b) – (i), the variable resistance load is to be adjusted to the required value as quickly as possible and readjusted, if necessary, 1 minute after application of voltage to the tool.

48.4.13 For a tool that is provided with a built-in, acceptable, protective device (as indicated in 48.4.4) the tests described in 48.4.10 (a) – (h) are to be conducted if the protective device opens the circuit. If the protective device is of the automatic recycling type, the test is to be continued for the full time indicated in Table 48.1.

48.4.14 Samples for the abnormal overload tests are to be prepared as follows:

- a) The complete tool is to be placed on a white tissue paper covered softwood surface.
- b) The tool is to be connected to a suitable supply circuit, that may use a low voltage current source, fused at not less than 30 A.

48.4.15 Each abnormal-overload test is to be continued until ignition of the material occurs, the circuit under test burns open, or until the test time indicated in 48.4.6 and Table 48.1 is achieved.

## 48.5 Spacings to enclosure

48.5.1 The spacings between the polymeric enclosure and:

- a) A nonarcing uninsulated live part, such as a bus bar, a connecting strap, a terminal, or the like, shall be no less than 1/32 inch (0.8 mm).
- b) An arcing part, such as a commutator, unenclosed switch contacts, and the like, shall be no less than 1/2 inch (12.7 mm) except as indicated in 48.5.3. See 48.5.2.

48.5.2 The spacing mentioned in 48.5.1(b) is to be measured from the source of the arc – that is, from the interface of the brush and the commutator or from the interface of the switch contacts.

48.5.3 The spacing mentioned in 48.5.1(b) may be less than 1/32 inch (0.8 mm) if the polymeric material does not ignite when tested in accordance with 48.5.4 – 48.5.7.

48.5.4 Three samples of the polymeric material, each 5 inches (127 mm) long, 1/2 inch (12.7 mm) wide, and having a thickness not more than the minimum enclosure thickness, are to be tested.

48.5.5 The test utilizes a pair of electrodes and a variable-inductive impedance load connected in series to a high-capacity alternating-current source. The stationary electrode is a No. 8 AWG (8.4 mm<sup>2</sup>) solid copper conductor having a horizontal chisel point. The movable electrode is a 1/8-inch (3.2-mm) diameter stainless-steel rod with a pyramidal point. The major axis of each electrode is to be 45 degrees from the horizontal, and the major axes of both electrodes are to be in the same vertical plane. With the electrodes short-circuited, the variable-inductance impedance is to be adjusted until the current is 32.7 amperes at 240 V alternating current with a 50-percent power factor.

48.5.6 The sample is to be supported horizontally in air on a test stand. The movable electrode is to be provided with an insulated handle so that with the circuit energized, it can be manually moved to contact the fixed electrode and then to break the electrical circuit. The electrodes are to be supported at a distance above the sample equal to the distance from the arc source to the enclosure in the tool.

48.5.7 The movable electrode is to be moved in a horizontal direction to make and break electrical contact with the fixed electrode at a rate of 40 contacts per minute. The polymeric material is not acceptable unless each sample resists ignition during 60 arcs.

#### **48.6 Arc resistance test**

48.6.1 A material that does not comply with 48.5.1 – 48.5.7 may be evaluated by using the power (current, voltage, and power factor) of the circuit in the tool by conducting a short-circuit test using the procedures described in 48.6.2.

48.6.2 The current for the arcing test is to be based upon the maximum normal load-current rating that the tool draws and minimum power factor. The voltage used for the test is to be equal to the available voltage at the live part. The arc is to be established between the live part and any adjacent part where breakdown is likely to occur. The arc is to be used to attempt to ignite materials forming parts of the enclosure or to ignite materials located between the parts of different potential. The arc is to be established by means of a copper or stainless steel conductive probe. The conductive probe is to be used to create arc tracking or a carbon build-up across the surface of the insulating material at the rate of 40 arc separations per minute. (A rate of 30 arc separations per minute may be used if 40 arc separations per minute is not practical.)

#### **48.7 Overload test**

48.7.1 Except as indicated in 48.7.5, the no-load current input to a tool that has completed the procedure described in 48.7.2 or 48.7.3, whichever applies, without burning out electrically shall not be more than:

- a) For a general-use tool, 150 percent of rated current.
- b) For a special-use tool, 150 percent of the current measured during the input test, on a previously unconditioned tool, in accordance with Table 29.1.

48.7.2 A general-use tool is to be operated at no load for 1/2 hour and then at full load for 1/2 hour. The load is then to be increased every 15 minutes by 10 percent of the then-existing current until the current input equals approximately 150 percent of rated current or the tool burns out.

48.7.3 A special-use tool is to be operated continuously for 1/2 hour under the loading condition for the temperature test specified in Table 29.1.

48.7.4 During the overload test mentioned in 48.7.2 or 48.7.3, whichever applies, any overload-protective device provided with the tool is to be short-circuited. During this conditioning, the maximum temperature attained on the inside surface of the enclosure is to be noted.

48.7.5 A tool is to be operated until burnout occurs by continuing the overload conditioning if the tool:

- a) Does not burn out during the conditioning mentioned in 48.7.2 or 48.7.3, whichever applies; and
- b) Has a no-load current input more than the value indicated in 48.7.1.

48.7.6 If a tool burns out electrically during the overload conditioning described in 48.7.2, 48.7.3, or 48.7.5, the enclosure material shall not be ignited.

#### **48.9 Impact test**

48.9.1 The tool shall withstand the impact described in 45.6.3 – 45.6.5 without:

- a) Reducing spacings below the minimum acceptable values;
- b) Making uninsulated live parts or internal wiring accessible to contact;
- c) Such breaking, cracking, rupturing, and the like, as to produce adverse effect on the insulation; or
- d) Producing any other condition that would increase the risk of electric shock of the tool.

#### **48.10 Oven conditioning test**

48.10.1 Conditioning of the tool as described in 48.10.3 shall not:

- a) Reduce spacings below the minimum acceptable values;
- b) Make any uninsulated live part or internal wiring accessible to contact;
- c) Have any adverse effect on the insulation;
- d) Produce any other condition that might increase the risk of fire or electric shock of the tool; or
- e) Cause warping or distortion to the extent that the tool will not continue to comply with the strain relief requirements in 9.2.1 – 9.2.5 and Section 39.

48.10.2 After being conditioned as described in 48.10.3 and when operated at no load and at rated voltage:

- a) A general-use tool shall have an input current not more than 150 percent of rated current.
- b) A special-use tool shall have an input current not more than 150 percent of the current measured during the input test conducted in accordance with Table 29.1.

48.10.3 Three samples of the tool are to be placed in a circulating-air oven maintained at a temperature at least 10°C (18°F) more than the temperature observed on the enclosure during the conditioning described in 48.7.2 or 48.7.3, whichever applies, but in no case is the temperature to be less than 70°C (158°F). The samples are to remain in the oven for 7 hours.

## TESTS BY THE MANUFACTURER

### 49 Dielectric Voltage Withstand Test

49.1 The manufacturer shall determine by routine production-line test that each tool produced will withstand without an indication of unacceptable performance, the application of potential between live parts and dead metal parts. The test potential shall be applied for 1 minute and shall be:

- a) 1000 V for a tool employing a universal motor, regardless of its horsepower rating, and for a tool employing a motor of any other type rated at 250 V or less and 1/2 horsepower (373 W output) or less; or
- b) 1000 V plus twice the rated voltage for a tool employing any other motor; except that the duration of application may be 1 second if the test potential is 120 percent of the value specified for the 1-minute test.

49.2 The tool may be in a heated or unheated condition for the test.

49.3 The test shall be conducted with the tool complete and fully assembled. It is not intended that the tool be unwired, modified, or disassembled for the test.

*Exception No. 1: Parts such as snap covers, auxiliary handles, or friction-fit knobs that would interfere with the performance of the test need not be in place.*

*Exception No. 2: The test may be performed before final assembly if such a test represents that of the completed tool.*

49.4 If the tool employs a solid-state component that can be damaged by the test potential, the test on each tool may be conducted before the component is electrically connected. In such a case, additional testing is to be made of a random sampling of each day's production with the circuitry rearranged to reduce the likelihood of damage to any solid-state component but retaining representative dielectric stress of the circuit.

49.5 The test equipment, when adjusted for production-line testing, is to produce an output voltage that is not less than the factory test value specified, and is not more than 120 percent of the specified test potential when the tester is used in each of the following conditions:

- a) If the test duration is 1 second, the output voltage is to be maintained within the specified range:
  - 1) When only a voltmeter having an input impedance of at least 2 megohms and a specimen of the product being tested are connected to the output terminals; and
  - 2) When a relatively high resistance is connected in parallel with the voltmeter and the product being tested, and the value of the resistance is reduced by increments that are not greater than 25 percent of the preceding value to the point where an indication of unacceptable performance just occurs.

*Exception: The product being tested may be omitted.*

- b) If the test duration is 1 minute, the output voltage is to be maintained within the specified range, by manual or automatic means, throughout the 1 minute duration of the test or until there is an indication of unacceptable performance.

49.6 The specified control of the applied voltage, manual or automatic, shall be maintained under conditions of varying line voltage. Higher test potentials may be used if the higher dielectric stress is not likely to adversely affect the insulating systems of the product.

49.7 In addition to the characteristics indicated in 49.5, the test equipment is to have the following features and characteristics:

- a) A means of indicating the test voltage that is being applied to the tool under test. This may be accomplished by sensing the voltage at the test leads or by an equivalent means.
- b) An output voltage that has a sinusoidal waveform, has a frequency that is within the range of 40 – 70 Hz, and has a peak value of the waveform that is not to be less than 1.3 and not more than 1.5 times the root-mean-square value.
- c) A means of effectively indicating unacceptable performance. The indication is to be:
  - 1) Auditory if it can be readily heard above the background noise level;
  - 2) Visual if it commands the attention of the operator; or
  - 3) A device that automatically rejects an unacceptable product.

If the indication of unacceptable performance is auditory or visual, the indication is to remain active and conspicuous until the test equipment is reset manually.

d) When the test equipment is adjusted to produce the test voltage and a resistance of 120,000 ohms is connected across the output, the test equipment is to indicate an unacceptable performance within 0.5 second. A resistance of more than 120,000 ohms may be used to produce an indication of unacceptable performance, if the manufacturer elects to use a tester having higher sensitivity.

49.8 There is not to be any transient voltage applied to the tool under test that results in the instantaneous voltage applied to the product exceeding 120 percent of the peak value of the test voltage that the manufacturer elects to use for this test. This requirement applies for the entire duration of the test, including the time that the voltage is first applied to the product and the time that the voltage is removed from the product.

49.9 During the test, a sufficient number of primary switching components shall be in the on position so that all primary circuitry will be stressed. Both sides of the primary circuit of the appliance are to be connected together to one terminal of the test equipment. The second equipment terminal is to be connected to accessible dead metal.

*Exception: Tools utilizing motors, relays, coils, or transformers, having circuitry not subject to excessive secondary build-up in case of indication of unacceptable performance during the test, may be tested with only one side of the primary circuit connected to the dielectric test equipment.*

## **50 Grounding Continuity Test**

50.1 The manufacturer shall determine, by routine production-line test, that each tool produced complies with the requirement in 38.1 for continuity of the grounding connection.

## RATING

### 51 Details

51.1 A tool shall be rated in volts, frequency (expressed in one of the following terms: hertz, Hz, cycles-per-second, cps, cycles/second, cs, ac-dc, or ac only), and except as noted in 51.2, amperes. If a tool is intended for use on a poly-phase circuit, the number of phases shall be included in the rating.

51.2 Instead of the current rating mentioned in 51.1, a tool may be rated in watts if the full-load power factor is 0.80 or more, or if the rating of a cord-connected tool is 50 W or less.

51.3 For a tool having a single voltage rating, such as 115 V, rather than being rated for a range of voltage, such as 110 – 120 V, maximum rated voltage is considered to be that single value of voltage. If the voltage rating is given in terms of a range, the maximum rated voltage is considered to be the highest value of the range.

## MARKING

### 52 Details

52.1 A tool shall be plainly marked, where the marking will be readily visible with:

- a) The manufacturer's name, trade name, or trademark, or other descriptive marking by which the organization responsible for the product may be identified;
- b) A distinctive (catalog) (model) number or the equivalent;
- c) The electrical rating; and
- d) The date or other dating period of manufacture not exceeding any three consecutive months.

*Exception No. 1: The manufacturer's identification may be in a traceable code if the tool is identified by the brand or trademark of a private labeler.*

*Exception No. 2: The date of manufacture may be abbreviated or in an established, accepted code, or a code affirmed by the manufacturer. The code shall not require reference to the manufacturer's records to determine when the product was manufactured.*

52.2 A battery-operated portable tool with an integral battery intended to be connected to a separate (that is, non-integral) charger shall be marked: "For use only with \_\_\_\_\_ charger," or the equivalent. The charger may be identified by a catalog number, a series number, or the equivalent.

52.3 A battery-operated portable tool provided with a user replaceable battery or battery pack shall be marked: "For use only with \_\_\_\_\_ battery (battery pack)," or the equivalent. The battery pack may be identified by a catalog number, a series number, or the equivalent.

52.4 A separable battery pack shall be marked "For use only with \_\_\_\_\_ charger," or the equivalent. The charger may be identified by a catalog number, series number, or the equivalent.

52.5 Each tool provided with a rotating output means (drills, circular saws, grinders, and the like) shall include a statement that indicates the maximum no-load speed or the equivalent in rpm on the nameplate. A tool provided with more than one speed (by mechanical or electrical means) shall be marked with the highest possible speed. A grinder may additionally be marked to identify the recommended accessory speed. See 32.5.

*Exception: The above does not apply to:*

- a) Nut setters, screwdrivers, and drain cleaners; and*
- b) Belt sanders, band saws, and other tools with predominantly linear work function motion.*

52.6 If a manufacturer produces or assembles tools at more than one factory, each finished tool shall have a distinctive marking, which may be in code, by means of which it may be identified as the product of a particular factory.

52.7 If a tool employs a single motor as its only electric-energy consuming component, the electrical rating given on the motor name plate need not be shown elsewhere on the tool if this name plate is readily visible after the motor has been installed.

52.8 If a tool employs a dual-voltage motor and if the motor name plate is employed to give the electrical rating of the tool as indicated in 52.7, the tool shall be additionally marked, not necessarily in a permanent manner, to indicate the voltage for which it is connected when shipped from the factory. Instructions shall be provided to indicate the type of attachment plug that should be used if the tool is reconnected for the alternate voltage.

52.9 If the tool is provided with a power-supply cord less than 18 inches (457 mm) in length or with a motor-attachment plug in accordance with 9.1.4(a), a statement advising of the availability of extension cords and the importance of using one of these cords shall be marked on the tool or shall be included in the instruction book or other literature regularly furnished with the tool.

52.10 A two-speed drill shall be plainly and permanently marked to indicate the maximum size of the drill to be used during high-speed operation unless, at high speed, the drill performs acceptably with the largest drill that the chuck will accommodate.

52.11 A required marking shall be permanent and shall be located on a part that cannot be removed without impairing the operation of the tool.

*Exception: Unless a specific requirement indicates otherwise, a required marking may be located on a tag on the power supply cord. See 52.12 and 52.13.*

52.12 With reference to the exception to 52.11, the tag shall be permanently attached to the power supply cord. The tag material and means of attachment to the power supply cord shall be evaluated under the requirements specified in Section 54. The tag may contain warning instructions other than the instructions required by 52.1, 52.6, 52.15, 52.16, 52.34, and 61.1.

52.12 effective June 1, 1998



52.13 The tag referenced in 52.12 and in the exception to 52.11 shall be of a size that facilitates legibility of the required markings, and all exposed surfaces shall have a clear plastic overlay, or the equivalent, to protect the marking. The tag shall comply with one of the following:

- a) A flag-type tag having a hole to permit securement to the power-supply cord by a strap that cannot be removed without cutting; or
- b) A flag-type tag with an adhesive back. The tag is to be wrapped tightly once around the cord and is to adhere to the power supply cord.

52.14 A speed-control device shall be marked with the catalog number or equivalent identification, as well as with the name or other identification of the manufacturer, of the tool with which it is intended for use, unless the device is integral with or is permanently electrically connected to the tool.

52.15 A tool shall be permanently marked "CAUTION – For safe operation, see instruction manual" or with an equivalent marking.

52.16 A circular saw shall be additionally marked with the following items. Equally definitive wording may be used for other than the signal word.

- a) "WARNING – To reduce the risk of injury to persons, check lower guard before each use. Support and clamp work. Wear eye protection."
- b) "DANGER – To reduce the risk of injury to persons, keep hands away from blade. Keep your body to the side of the blade."

52.17 The markings specified in 52.16 shall be located so that they are visible, with the saw fully assembled from either the operator's position during the cutting operation or during the blade change or blade adjustment operation. The markings shall not be located on the bottom or on the lower guard portions of the saw.

52.18 The marking mentioned in 52.15:

- a) Need not be located with other required markings, and
- b) May be repeated on a detachable tag or the like.

52.19 A safety tag shall be provided with a battery-operated circular saw. The tag shall be attached to the circular saw assembly so that it will remain with the assembly unless or until it is intentionally removed by the user. See 52.20 and 52.21.

52.20 The safety tag mentioned in 52.19 for a battery operated circular saw with a removable battery pack shall also be provided with the caution marking: "Remove battery pack or battery pack connection from tool when not in use, changing blades, or making adjustments."

*Exception: For a circular saw employing a lock-off switch, the instruction required may be replaced with "Remove battery pack or battery pack connection from tool when changing blades or making adjustments."*

52.21 The safety tag for a battery operated circular saw with an integral battery shall be marked with the word "CAUTION" and the following or equivalent wording: "Tool is always in active mode and can be unintentionally operated with the switch. Use caution when changing blades or making adjustments."

52.22 If a name plate that must be removed for normal servicing of the tool carries a required marking, the construction shall be such that the name plate must be returned to its proper location for the tool to be operable.

52.23 A caution marking shall be permanent and shall be located on a part permanently attached to the tool or on a part that cannot be removed without impairing the operation or the appearance of the tool.

52.24 A permanent marking shall be etched, molded, die-stamped, paint-stenciled; permanently secured, stamped, or etched metal; or indelibly stamped lettering on pressure-sensitive labels secured by adhesive. Ordinary usage, handling, storage, and the like, of the tool will be considered in determination of the permanence of marking.

52.25 A caution marking intended to instruct the operator shall be legible and visible.

52.26 A marking intended to protect against injury to persons shall be prefixed by the word "CAUTION," "WARNING," or "DANGER" in letters not less than 3/32 inch (2.4 mm) high.

52.27 Two or more cautionary markings may be combined using a single prefix word and precautionary statement if the word (and statement) are the same.

52.28 An accessory or an attachment, or the package in which it is marketed, shall be marked with a catalog number or equivalent means of identification.

*Exception: The accessories and attachments mentioned in Table 52.1 and comparable components need not be marked with catalog numbers or the equivalent.*

**Table 52.1**  
**Accessories and attachments**

Accessory or attachment	Tools for which recommended by the manufacturer
Drill Bit	Drill
Screwdriver Bit	Drill or screwdriver
Mounted grinding wheel less than 2 inches (50.8 mm) in diameter	Drill
Rotary file or rasp	Drill
Solid (not a carbide-tipped) saw blade	Saw
Sanding disc or belt	Sander
Router bit	Router or trimmer
Polishing pad and buff	Drill
Hole saw	Drill
Chuck	Drill
Socket	Drill
Backing disc and pad	Drill

52.29 The literature accompanying a package containing a basic appliance and attachments, intended to be marketed as a complete unit, shall indicate which attachments are intended for use with the basic appliance if use of such attachments exposes the user to a risk of injury.

*Exception: Those attachments referenced in Table 52.1 may be referenced generically for the indicated tool types.*

52.30 An attachment that is packaged and marketed separately from the basic appliance, and recommended by the manufacturer for use on the basic appliance, shall be identified for use with the basic appliance with which it is intended to be used. The identification shall appear in at least one of the following locations:

- a) On the attachment;
- b) On the package housing the attachment;
- c) In the instruction book for the basic appliance; or
- d) In information furnished with the attachment.

*Exception: Those attachments referenced in Table 52.1 may be referenced generically for the indicated tool types.*

52.31 A reciprocating saw, drill [up to and including 1/2-inch (12.7-mm) chuck size], sabre saw, or hammer drill in compliance with 20.1 shall be provided with a marking on the tool or in the instruction book warning of the danger of cutting into wiring in a wall and describing how the danger can be minimized by holding the tool properly.

52.32 A double-insulated or battery-operated drill or hammer drill shall be provided with a marking on the tool or in the instruction book warning that the chuck and exposed metal surfaces of the tool may be made live if the tool drills into wiring in a wall and that the operator shall always hold the tool by insulated surfaces when drilling into an area that may conceal wiring. See also 20.1.

52.33 A circular saw that has an anti-kickback device shall be provided with instructions that describe the operation of that device and any accessory adjustment.

52.34 A grinder shall be marked with the following readily visible and permanent markings:

- a) A statement that a grinding wheel acceptable for the particular speed involved should be used.
- b) If the grinder is acceptable without a guard in accordance with 27.3.5(a), a marking to indicate that it should be used with a mounted grinding wheel 2 inches (50.8 mm) or less in diameter.
- c) If a guard is required, a grinder shall be marked with the word "WARNING" and the following or the equivalent, "To reduce the risk of injury, always use a guard and eye protection."

d) If a portable drill recommended for use as a grinder is acceptable without a guard in accordance with 27.3.5(c), a marking to indicate that it should be used with Type 1 grinding wheels 2 inches (50.8 mm) or less in diameter, not more than 1/2 inch (12.7 mm) thick and that eye protection should always be worn.

*Exception: The marking of (d) may be included in the instruction manual.*

e) If a grinder is acceptable without a guard in accordance with 27.3.5(d), a marking to indicate that it should be used with Type 1 reinforced grinding wheels 3 inches (76.2 mm) or less in diameter, not more than 1/4 inch (6.4 mm) thick and that both eye and face protection should always be worn.

*Exception: The marking of (e) may be included in the instruction manual.*

52.35 If a tool is shipped from the factory with a required guard detached, the carton of the tool (its individual marketing container) shall be legibly and permanently marked with the word, "WARNING" and with the following or equivalent phrase: "To reduce the risk of injury, always use guard and eye protection. See enclosed instruction manual for recommended accessories and attachments, guards, assembly, and instructions."

52.36 The carton or individual marketing container of a tool whose required guard is not enclosed in the same carton or container with the tool shall be marked:

a) With the following or equivalent phrase "Guard assembly, Part No. \_\_\_\_\_, furnished with this product provided in separate carton." The blank space is to be filled in by the manufacturer to identify the recommended guard and mounting hardware or guard assembly by their respective part number(s); and

b) To identify the complete contents of the carton or container by product or part name and model or part number.

52.37 The carton or individual marketing container for the guard assembly shall be marked to identify the complete contents of the carton by product or part name and part number. Guards shall be identified by size and type designation, for example – 9 inch (230 mm) Type 27 depressed-center wheel guard. Mounting hardware shall be specifically identified if hardware or fastening devices are required.

*Exception: The carton or container may be marked "See enclosed parts list for contents" or with equivalent wording with the guard size and type designation.*

52.38 If the manufacturer recommends the use of other guards for different wheel configurations that are not packaged with the grinder, each such guard shall be clearly identified by name, specific part number and wheel type intended to be used with the guard:

a) By a specific marking on the carton or individual marketing container of the tool; or

b) By including in detail in the instruction manual provided with the tool and marking the carton with the following statements or equivalent phrases except for the word "WARNING":

"This tool may be used with additional accessories for other sanding or grinding operations. Refer to enclosed instruction manual for recommended accessories, guarding details, and assembly, operation, and safety instructions.

WARNING – To reduce the risk of injury, always use proper guards when grinding and wear eye protection."

52.39 A carton marking shall:

- a) Clearly convey the message and be so located as to be readily visible to the consumer at the time of purchase;
- b) Contrast with its background either by color, projection, or indentation;
- c) Be in the English language; other languages may also be included, if appropriate;
- d) Appear in lettering of a height not less than 3/32 inch (2.4 mm), with those words shown in capital letters in the precautionary markings appearing in capital lettering; and
- e) Appear on a panel of the carton that will not be damaged when the carton is opened in its intended manner.

### **53 Permanency of Marking**

#### **53.1 General**

53.1.1 After being subjected to the conditions described in 53.2.1 – 53.4.1, a pressure sensitive label or a label secured by cement or adhesive is considered to be of a permanent nature if immediately following removal from each test medium and after being exposed to room temperature for 24 hours following removal from each medium:

- a) Each sample demonstrates good adhesion and the edges are not curled.
- b) The label resists defacement or removal as demonstrated by scraping across the test panel with a flat steel blade, held at right angles to the test panel. The blade is to be 1/32 inch (0.8 mm) thick and of any convenient width.
- c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

#### **53.2 Oven-aging test**

53.2.1 Three samples of the label applied to test surfaces as in the intended application are to be placed for 240 hours in an oven maintained at the temperature specified in Table 53.1.

**Table 53.1**  
**Temperatures, oven-aging**

Maximum temperature during temperature test of surface to which applied		Oven temperature	
°C	°F	°C	°F
60 or less	140 or less	87	189
80 or less	176 or less	105	221
100 or less	212 or less	121	250
125 or less	257 or less	150	302
150 or less	302 or less	180	356
Over 150	Over 302	a	

<sup>a</sup> A label that is applied to a surface attaining a temperature greater than 150°C (302°F) during the temperature test is to be oven-aged at a temperature representative of the temperature attained by the appliance during intended use and abnormal use.

### 53.3 Immersion tests

53.3.1 Six samples of the test panels are to be placed in a controlled atmosphere maintained at 23.0 ±2.0°C (73.4 ±3.6°F) with a 50 ±5 percent relative humidity for 24 hours. Three samples are then to be immersed in water and three samples immersed in IRM 903 oil at a temperature of 21.0 ±2.0°C (69.8 ±3.6°F) for 48 hours in each case.

53.3.1 revised June 2, 1997

### 53.4 Standard atmosphere test

53.4.1 Three samples of the label applied to test surfaces as in the intended application are to be placed for 72 hours in a controlled atmosphere maintained at 23.0 ±2.0°C (73.4 ±3.6°F) with a 50 ±5 percent relative humidity.

## 54 Test for Permanence of Cord Tag

### 54.1 General

54.1.1 To determine compliance with 52.12, representative samples that have been subjected to the tests described in 54.2.2 – 54.3.1 shall meet the following requirements:

- a) The tag shall resist tearing for longer than 1/16 inch (1.6 mm) at any point;
- b) The tag shall not separate from the power supply cord;

- c) The tag shall not slip or move along the length of the power supply cord more than 1/2 inch (12.7 mm);
- d) There shall be no permanent shrinkage, deformation, cracking, or any other condition that will render the marking on the tag illegible; and
- e) Overlamination shall remain in place and shall not be torn or otherwise damaged. The printing shall remain legible.

54.1.1 effective June 1, 1998

## 54.2 Test conditions

54.2.1 For each type of conditioning specified in 54.2.2 – 54.2.4, three samples of the tag applied to the power supply cord in the intended manner are to be used. If tags are applied by an adhesive, tests are to be conducted no sooner than 24 hours after application of the tag.

54.2.1 effective June 1, 1998

54.2.2 Three samples are to be tested as received.

54.2.2 effective June 1, 1998

54.2.3 Three samples are to be tested at the end of 30 minutes of conditioning at a room temperature of  $23 \pm 2^{\circ}\text{C}$  ( $73.4 \pm 3.6^{\circ}\text{F}$ ) and  $50 \pm 5$  percent relative humidity, following conditioning in an air-circulating oven at  $60 \pm 1^{\circ}\text{C}$  ( $140 \pm 1.8^{\circ}\text{F}$ ) for 240 hours.

54.2.3 effective June 1, 1998

54.2.4 Three samples are to be tested within 1 minute after exposure for 72 hours to a humidity of  $85 \pm 5$  percent at  $32 \pm 2^{\circ}\text{C}$  ( $89.6 \pm 3.6^{\circ}\text{F}$ ).

54.2.4 effective June 1, 1998

## 54.3 Test method

54.3.1 Each sample is to consist of a length of power supply cord to which the tag has been applied. The power supply cord, with the attachment plug pointing up, is to be held tautly in a vertical plane. A force of 5 pounds (22.2 N) is to be applied for 1 minute to the uppermost corner of the tag farthest from the power supply cord, within 1/4 inch (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord. In determining compliance with 54.1.1(d), manipulation is permissible, such as straightening of the tag by hand. To determine compliance with 54.1.1(e), each sample is to be scraped 10 times across printed areas and edges, with force of approximately 2 pounds (8.9 N), using the edge of a 5/64 inch (2.0 mm) thick steel blade held at a right angle to the test surface.

54.3.1 effective June 1, 1998

## INSTRUCTIONS

### 55 Instruction Manual

55.1 An instruction manual shall be provided with a tool. The manual shall specifically warn the user against each potential source of injury and state the precautions that should be taken to guard against that source of injury. For a variable-speed tool, the instructions shall indicate the speed at which the tool shall be operated in accordance with pertinent factors such as:

- a) The dimensions and material of the work piece; and
- b) The size and type of the accessory, such as a drill bit or a saw blade.

The instructions pertaining to a risk of injury shall be separated in format from the other instructions, and shall appear before the operating instructions in the manual. The instructions shall be legible, visible, and contrast with the background. Specific identification and warning information applicable to accessories and attachments shall be included in the manual in accordance with 56.4.

55.2 The instruction manual shall include instructions and caution statements for user-maintenance operations recommended by the manufacturer, and shall warn the user that any other servicing should be performed by an authorized service representative.

55.3 The instruction manual shall include the name and address, street, city, state, zip code of the manufacturer or private labeler.

55.4 The instruction manual for a circular saw shall include, in addition to those items that apply to circular saws in 55.1 – 55.3, the following applicable operating instructions.

- a) A statement, "WARNING – It is important to support the work properly and to hold the saw firmly to prevent loss of control which could cause personal injury. Figure \_\_\_\_ illustrates typical hand support of the saw."

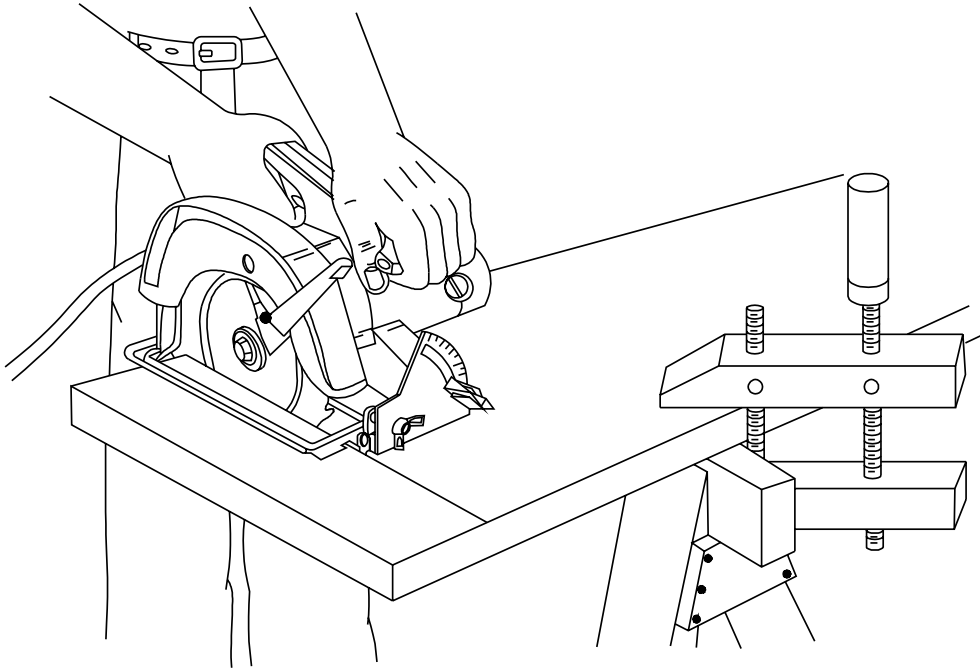
The figure number of equivalent reference is to be specified by the manufacturer. Equivalent wording, other than for the signal word WARNING may be used. Any additional instructions deemed necessary by the manufacturer may also be included.

- b) A drawing shall be provided that depicts the user with proper hand support, proper work support, and supply cord routing away from the work area (for example refer to Figure 55.1).
- c) A statement, "When operating the saw, keep the cord away from the cutting area and position it so that it will not be caught on the work piece during the cutting operation." Equivalent wording may be used.
- d) A description of the function of a switch lock-off device if the tool is equipped with one.
- e) For saws with cords shorter than 6 feet (1.3 m) or with motor attachment plug, a statement that the manufacturer has proper extension cords available unless the extension cord is provided. For a grounded-type saw, a 3-wire extension cord shall be the type available.

*Exception: This item does not apply to a battery-operated portable tool.*



**Figure 55.1**  
**A typical illustration of proper hand support, work support, and supply cord routing**



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55.5 If the motor for a tool is packaged or shipped separately from the tool base, the instruction manual for the motor shall positively identify (by catalog number, a model designation, or the equivalent) the base with which it is suitable. The identification on the base shall correspond to the instruction.

## 56 Important Safety Instructions

56.1 The important safety instructions shall include the following phrases. The phrases "Read All Instructions" and "SAVE THESE INSTRUCTIONS" shall appear and shall be the first and last items, respectively. The phrase "Read All Instructions" shall be preceded by the statement "WARNING: When using electric tools, basic safety precautions should always be followed to reduce the risk of fire, electric shock, and personal injury, including the following:." Equivalent wordings in equally definitive terminology may be used, except for the signal word which is to remain "WARNING."

56.2 The instruction manual shall include important safety instructions with (a) or (b), whichever is appropriate, (c), and where applicable, (d), (e), or (f). Other important safety instructions considered necessary by the manufacturer may be included. Equivalent wordings in equally definitive terminology may be used whenever appropriate.

### a) For All Grounded Tools

#### 1) Grounding Instructions

This tool should be grounded while in use to protect the operator from electric shock. The tool is equipped with a 3-conductor cord and 3-prong grounding type plug to fit the proper grounding type receptacle. The green (or green and yellow) conductor in the cord is the grounding wire. Never connect the green (or green and yellow) wire to a live terminal. If your unit is for use on less than 150 V, it has a plug that looks like that shown in sketch (A) in Figure 56.1. If it is for use on 150 to 250 V, it has a plug that looks like that shown in sketch (D). An adapter, see sketches (B) and (C), is available for connecting sketch (A) type plugs to 2-prong receptacles. The green-colored rigid ear, lug, or the like, extending from the adapter must be connected to a permanent ground, such as a properly grounded outlet box. No adapter is available for a plug as shown in sketch (D).

#### 2) Extension Cords

Use only 3-wire extension cords that have 3-prong grounding-type plugs and 3-pole receptacles that accept the tool's plug. Replace or repair damaged cords.

### b) For All Double-Insulated Tools:

#### 1) Replacement Parts

When servicing use only identical replacement parts.

#### 2) Polarized Plugs

To reduce the risk of electric shock, this equipment has a polarized plug (one blade is wider than the other). This plug will fit in a polarized outlet only one way. If the plug does not fit fully in the outlet, reverse the plug. If it still does not fit, contact a qualified electrician to install the proper outlet. Do not change the plug in any way.

## c) For All Tools:

## 1) Keep Work Area Clean

Cluttered areas and benches invite injuries.

## 2) Consider Work Area Environment

Don't expose power tools to rain.

*Exception: This requirement does not apply to battery-operated portable tools.*

Don't use power tools in damp or wet locations.

*Exception: This requirement does not apply to a tool that complies with the requirements in 35.1, or a battery-operated tool.*

Keep work area well lit.

Do not use tool in presence of flammable liquids or gases.

## 3) Guard Against Electric Shock

Prevent body contact with grounded surfaces. For example; pipes, radiators, ranges, refrigerator enclosures.

## 4) Keep Children Away

Do not let visitors contact tool or extension cord.

All visitors should be kept away from work area.

## 5) Store Idle Tools

When not in use, tools should be stored in dry, and high or locked-up place – out of reach of children.

## 6) Don't Force Tool

It will do the job better and safer at the rate for which it was intended.

## 7) Use Right Tool

Don't force small tool or attachment to do the job of a heavy-duty tool.

Don't use tool for purpose not intended – for example – don't use circular saw for cutting tree limbs or logs.

*Exception: For a tool other than a circular saw, another example may be substituted for this example if it is determined that the substitution is appropriate.*

#### 8) Dress Properly

Do not wear loose clothing or jewelry. They can be caught in moving parts. Rubber gloves and non-skid footwear are recommended when working outdoors.

Wear protective hair covering to contain long hair.

#### 9) Use Safety Glasses

Also use face or dust mask if cutting operation is dusty.

#### 10) Don't Abuse Cord

Never carry tool by cord or yank it to disconnect from receptacle. Keep cord from heat, oil, and sharp edges.

*Exception: This requirement does not apply to battery operated portable tools.*

#### 11) Secure Work

Use clamps or a vise to hold work. It's safer than using your hand and it frees both hands to operate tool.

#### 12) Don't Overreach

Keep proper footing and balance at all times.

#### 13) Maintain Tools With Care

Keep tools sharp and clean for better and safer performance.

Follow instructions for lubricating and changing accessories.

Inspect tool cords periodically and if damaged, have repaired by authorized service facility.

*Exception: This requirement does not apply to battery-operated portable tools.*

Inspect extension cords periodically and replace if damaged.

*Exception: This requirement does not apply to battery-operated portable tools.*

Keep handles dry, clean, and free from oil and grease.

#### 14) Disconnect Tools

When not in use, before servicing, and when changing accessories, such as blades, bits, cutters.

#### 15) Remove Adjusting Keys and Wrenches

Form habit of checking to see that keys and adjusting wrenches are removed from tool before turning it on.

16) Avoid Unintentional Starting

Don't carry tool with finger on switch. Be sure switch is off when plugging in.

17) Extension Cords

Make sure your extension cord is in good condition. When using an extension cord, be sure to use one heavy enough to carry the current your product will draw. An undersized cord will cause a drop in line voltage resulting in loss of power and overheating. Table \_\_\_\_ (See Table 56.1) shows the correct size to use depending on cord length and nameplate ampere rating. If in doubt, use the next heavier gage. The smaller the gage number, the heavier the cord.

*Exception: The reference to the table and the table itself may be omitted if a statement indicating the appropriate gage and length is incorporated into the instruction.*

18) Outdoor Use Extension Cords

When tool is used outdoors, use only extension cords intended for use outdoors and so marked.

*Exception: This requirement does not apply to battery-operated portable tools.*

19) Stay Alert

Watch what you are doing. Use common sense. Do not operate tool when you are tired.

20) Check Damaged Parts

Before further use of the tool, a guard or other part that is damaged should be carefully checked to determine that it will operate properly and perform its intended function. Check for alignment of moving parts, binding of moving parts, breakage of parts, mounting, and any other conditions that may affect its operation. A guard or other part that is damaged should be properly repaired or replaced by an authorized service center unless otherwise indicated elsewhere in this instruction manual.

Have defective switches replaced by authorized service center.

Do not use tool if switch does not turn it on and off.

d) Circular Saws:

1) Keep Guards in Place and in Working Order.

Never wedge or tie lower guard open. Check operation of lower guard before each use. Do not use if lower guard does not close briskly over saw blade. CAUTION: If saw is dropped, lower guard may be bent, restricting full return.

2) Keep Blades Clean and Sharp

Sharp blades minimize stalling and kickback.

3) DANGER: Keep Hands Away From Cutting Area.

Keep hands away from blades. Do not reach underneath work while blade is rotating. Do not attempt to remove cut material when blade is moving. CAUTION: Blades coast after turn off.

4) Support Large Panels.

Large panels must be supported as shown in Figure \_\_\_\_ to minimize the risk of blade pinching and kickback. (For example, refer to Figure 56.2.)

When cutting operation requires the resting of the saw on the work piece, the saw shall be rested on the larger portion and the smaller piece cut off.

5) Use Rip Fence

Always use a fence or straight edge guide when ripping.

6) Guard Against Kickback

Kickback occurs when the saw stalls rapidly and is driven back towards the operator.

Release switch immediately if blade binds or saw stalls.

Keep blades sharp.

Support large panels as shown in Figure \_\_\_\_\_. (For example, refer to Figure 56.2.)

Use fence or straight edge guide when ripping.

Don't force tool.

Stay alert – exercise control.

Don't remove saw from work during a cut while the blade is moving.

7) Lower Guard

Raise lower guard with the retracting handle.

8) Adjustments

Before cutting be sure depth and bevel adjustments are tight.

## 9) Use Only Correct Blades in Mounting

Do not use blades with incorrect size holes. Never use defective or incorrect blade washers or bolts.

## 10) Avoid Cutting Nails

Inspect for and remove all nails from lumber before cutting.

## e) Grinders:

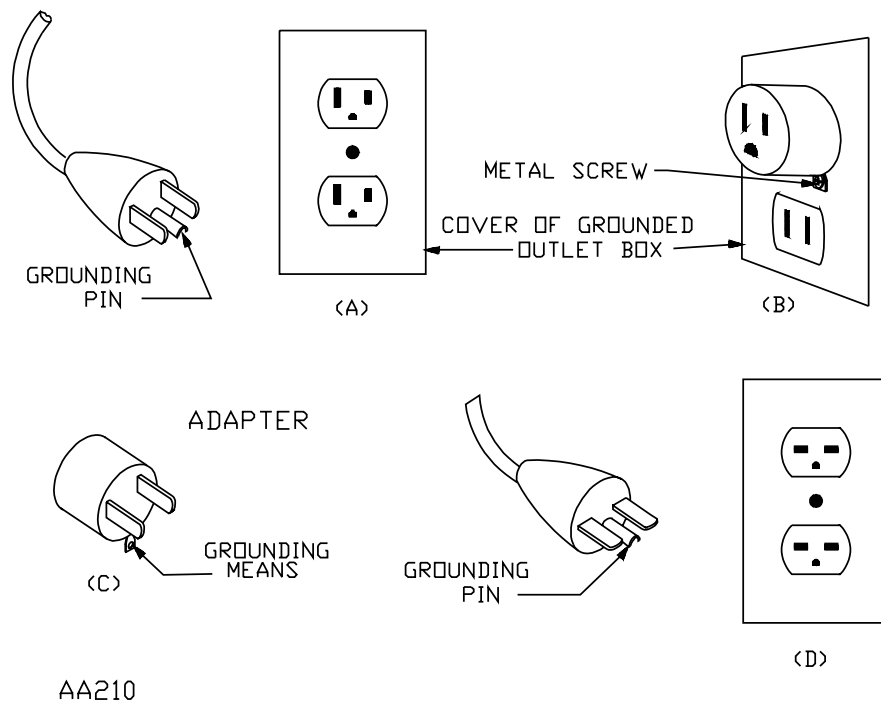
1) Keep guards in place.

2) Use only grinding wheels having a maximum operating speed at least high as "No Load RPM" marked on the tool's nameplate.

## f) Hammers:

1) Wear ear protectors when using for extended periods.

**Figure 56.1**  
**Grounding methods**



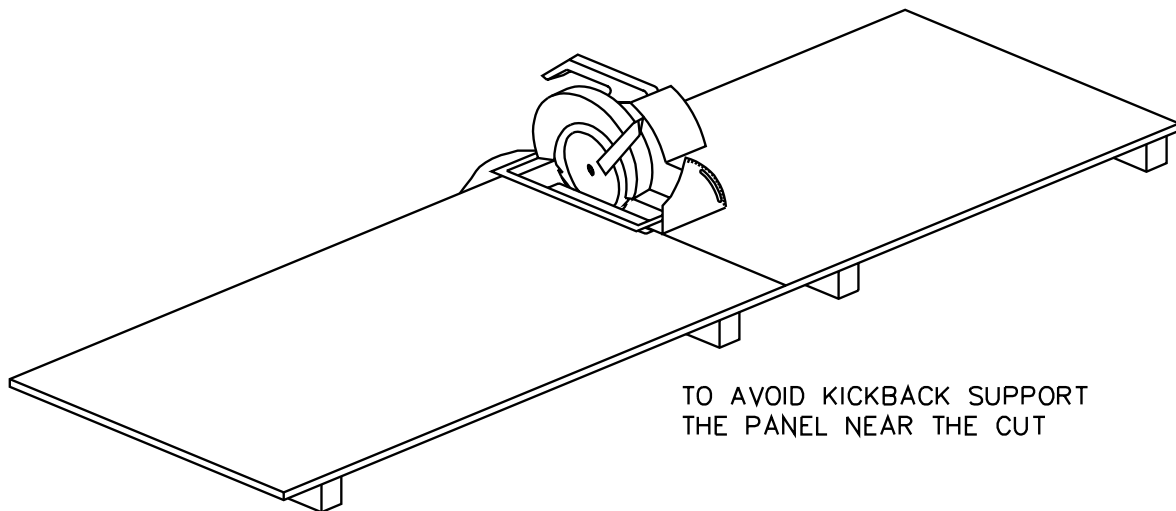
**Table 56.1**  
**Minimum gage for cord sets<sup>a</sup>**

		Volts		Total length of cord in feet			
		120V		0 – 25	26 – 50	51 – 100	101 – 150
		240V		0 – 50	51 – 100	101 – 200	201 – 300
Ampere rating		AWG					
More than	Not more than						
0 – 6		18	16	16	14		
6 – 10		18	16	14	12		
10 – 12		16	16	14	12		
12 – 16		14	12	Not recommended			

<sup>a</sup> Only the applicable parts of the Table need to be included. For instance, a 120-volt product need not include the 240-volt heading.

**Figure 56.2**  
**A typical illustration of support large panels**

Figure 56.2 revised August 7, 1998



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56.3 With reference to 56.2(c)(2), the important safety instructions warning against exposure to rain and use in a damp or wet location may be omitted from the instruction manual for a tool that complies with the requirements in 35.1.

56.4 The instruction manual provided with a tool shall:

- a) Specify only those accessories and attachments that have been found to be acceptable for use with the tool (see 56.5 and 56.6),
- b) Warn the operator that use of any other accessory or attachment might present a risk of injury to persons, and
- c) Instruct the operator in the proper use of the accessory or attachment if necessary to minimize the risk of injury to persons.

56.5 The manufacturer need not specify in the manual all accessories and attachments that have been found to be acceptable. When a new accessory or attachment is made available the manufacturer may, as an interim measure, refer to such device on an individual sheet stapled or otherwise acceptably attached to the manual.

56.6 For an accessory or attachment described in Table 52.1, the information required in 56.4(a) may be given in a form such as "For use with drill bits \_\_\_\_\_ inches or less in diameter" or "For use with saw blades \_\_\_\_\_ inches or less in diameter (or length)." For any other accessory or attachment, the instruction manual shall give the catalog number or any other identification as mentioned in 52.2.8. See 56.7.

56.7 For a tool for which a large number of basically similar accessories or attachments are available, the numbers of the acceptable devices may be indicated in the instruction manual by reference to a general catalog.

56.8 The instruction manual of a dual voltage tool shall include instructions, illustrations, or both for changing the voltage and to indicate that, if the tool is reconnected to operate at a voltage other than that for which it was connected when shipped from the factory, all attachment plugs and any receptacles shall be replaced with devices rated for the voltage and current for which the motor is reconnected.

## **DOUBLE-INSULATED TOOLS**

### **57 Scope**

57.1 These requirements cover portable double-insulated electric tools. Coverage is restricted to tools that are intended for use in accordance with the National Electrical Code on branch circuits involving potentials of not more than 150 V to ground.

57.2 An appliance provided with double insulation shall comply with the applicable requirements in Sections 1 – 56 supplemented by – and, in some cases, amended by – the requirements in Sections 58 – 61.

### **58 Construction**

#### **58.1 Glossary**

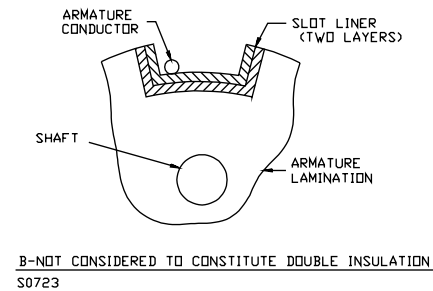
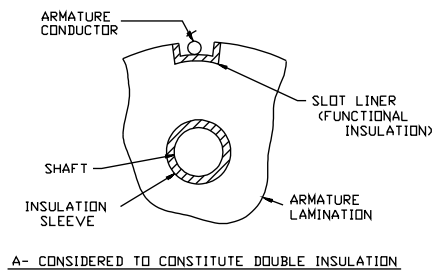
58.1.1 BASIC INSULATION (FORMERLY FUNCTIONAL INSULATION) – The insulation applied to live parts to provide basic protection against electric shock. Basic insulation does not necessarily include insulation used exclusively for functional purposes.

58.1.2 SUPPLEMENTARY (PROTECTIVE) INSULATION – An independent insulation provided in addition to the basic (formerly functional) insulation to protect against electric shock in case of mechanical rupture or electrical breakdown of the basic (formerly functional) insulation. An enclosure of insulating material may form a part or the whole of the supplementary insulation.

58.1.3 DOUBLE INSULATION – An insulation system comprised of basic (formerly functional) insulation and supplementary insulation, with the two insulations physically separated and so arranged that they are not simultaneously subjected to the same deteriorating influences, such as temperature and contaminants, to the same degree. See Figure 58.1.

**Figure 58.1**  
**Examples illustrating 58.1.3**

Figure 58.1 revised August 7, 1998



58.1.4 REINFORCED INSULATION – An improved basic insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as double insulation. It may consist of one or more layers of insulating material. Its acceptance in place of double insulation is described in 58.2.2.

58.1.5 LIVE PART – Denotes a part consisting of electrically conductive material conductively connected to the power-supply circuit under conditions of intended use of the tool.

58.1.6 DEAD METAL PART – A metal or other electrically conductive part, accessible or inaccessible, that is not conductively connected to a live part.

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58.1.7 ACCESSIBLE – Denotes accessible to contact by persons. In a determination of whether a part, live or dead metal, is accessible to such contact, the criteria specified in 58.3.1 and 58.3.2 are to be applied.

## 58.2 General

58.2.1 Except as noted in 58.2.2, the tool shall be so constructed that double insulation or acceptable through-air spacing as indicated in Table 58.1 is interposed:

- a) Between all live parts and all accessible surfaces of the tool, and
- b) Between all live parts and all inaccessible dead metal parts that are conductively connected to accessible dead metal parts.

**Table 58.1**  
**Minimum acceptable spacings**

Parts between which spacings are measured	Minimum acceptable spacings
1. Live parts and dead metal parts that are separated by basic insulation only, other than reinforced insulation, except as indicated in (4). See 58.2.5.	Not less than the through-air and over-surface spacings required in 18.1
2. Accessible dead metal parts <sup>a</sup> and dead metal parts separated from live parts by basic insulation only; this ordinarily is a spacing resulting from supplementary insulation.	Not less than the through-air and over-surface spacings required in 18.1
3. Live parts and accessible dead metal parts <sup>a</sup> separated by double insulation or by reinforced insulation, where acceptable, except as indicated in (4).	3/16 inch (4.8 mm) through-air and over-surface
4. Live parts and accessible dead metal parts at a commutator or other location in which foreign materials can build up.	5/16 inch (7/9 mm) over-surface
5. Uninsulated live parts, including film-coated wound in the form of a coil and reliably held in place, and the interior surface of insulating material that serves as supplementary insulation.	1/32 inch (0.8 mm)
6. Outer surface of a wrapped coil and the interior surface of insulating material that serves as supplementary insulation	1/32 inch (0.8 mm)
<sup>a</sup> The term accessible dead metal part includes: <ol style="list-style-type: none"> <li>a) Inaccessible dead metal parts that are conductively connected to accessible dead metal parts; and</li> <li>b) If the outer surface of the enclosure consists wholly or partially of insulating material, metal foil wrapped tightly around and in intimate contact with the enclosure. The foil is to be drawn tightly across any opening in the enclosure to form a flat plane across such opening. See Figure 58.3.</li> </ol>	

58.2.2 Reinforced insulation is acceptable in place of double insulation in only the following places:

- a) At a brush cap. See 58.8.1 and 59.1.2.
- b) At a commutator or at end turns of the armature winding. See 58.9.1 and item 4 of Table 58.1.
- c) At points at which insulated internal wiring, including insulated splices, contacts protective insulation. See 58.6.2 and 58.6.3.
- d) At points inside the tool at which the power-supply cord contacts protective insulation. See 58.4.1.4.
- e) At a brush holder that complies with the restrictions indicated in 58.11.1 and 58.11.2.
- f) At a switch that complies with the restrictions indicated in 58.10.1.
- g) Anywhere in the tool if the reinforced insulation consists of one or more layers, in contact with adjacent layers in a multilayer assembly, with a total thickness of not less than 3/16 inch (4.8 mm).

58.2.3 The thickness and the resistance to deterioration with aging of insulation employed as protective insulation shall not be less than that which would be required for the same material employed as basic insulation. A greater thickness of protective insulation may be required if this appears to be necessary.

58.2.4 The tool shall be so constructed that the added protection provided by the additional insulation will not be reduced by the intended use and anticipated abuse (see 59.5.1 – 59.5.12) to which the tool is likely to be subjected.

58.2.5 A live part, a dead metal part that is insulated from live parts by basic insulation only (unless it is reinforced insulation as covered in 58.2.2), and basic insulation itself (unless it is reinforced insulation as covered in 58.2.2) shall not be accessible.

58.2.6 Protective insulation that comprises the outer enclosure of the tool is considered to be resistant to physical abuse if the tool complies with the requirements in 59.5.1 – 59.5.5.

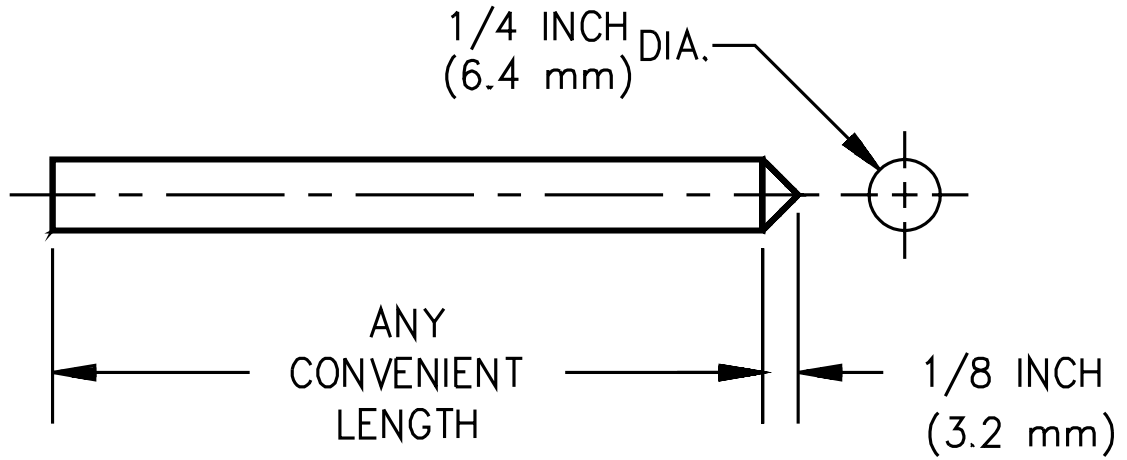
58.2.7 Unless protected by the outer enclosure of the tool or by some other guard, protective insulation shall be resistant to physical abuse.

### **58.3 Accessibility of live parts**

58.3.1 A probe as illustrated in Figure 58.2 shall not enter an enclosure through an opening for more than 1/8 inch (3.2 mm) when the probe is inserted point first, and the probe shall not touch any uninsulated live part or film-coated wire.

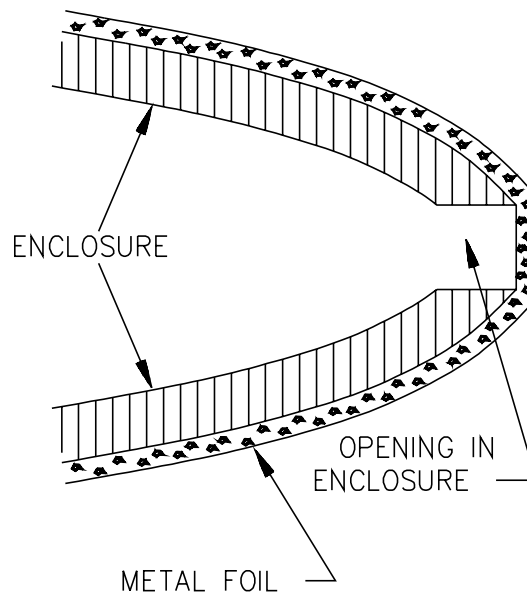
**Figure 58.2**  
**Probe**

Figure 58.2 revised August 7, 1998



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**Figure 58.3**  
**Method of covering enclosure with foil for measurement and tests**



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58.3.2 During the examination of a tool in connection with the requirements in 58.3.1, a part of the outer enclosure that may be removed without the use of tools by the user (for the attachment of accessories, to allow access to means for making operating adjustments, or for another reason) is to be disregarded – that is, it will not be assumed that the part in question affords protection against electric shock.

## 58.4 Flexible cord

### 58.4.1 General

58.4.1.1 The supply cord shall be Type S, SE, SO, ST, SJ, SJE, SJT, or SJO, and shall not include a grounding conductor.

*Exception: A hand-motor tool intended principally for hobby use, weighing 20 oz (0.57 kg) or less without the cord, and having a chuck size not larger than 1/8 inch (3.2 mm) may employ Type SV, SVE, SVO, SVT, or SVTO cord having individual strands not larger than No. 36 AWG (0.0127 mm<sup>2</sup>). It shall not include a grounding conductor.*

58.4.1.2 Inside the tool, the power-supply cord shall not contact an accessible dead metal part, or an inaccessible dead part that is conductively connected to an accessible dead metal part.

58.4.1.3 Inside the tool, the power-supply cord may be insulated from an accessible dead metal part and an inaccessible dead metal part that is conductively connected to an accessible dead metal part by insulation in one of the following forms:

- a) An insulating liner;
- b) A coating of insulating material; or
- c) A sleeve around the cord, if the sleeve is loose-fitting and is secured at one end to the enclosure.

58.4.1.4 If the power-supply cord contacts protective insulation inside the tool, the cord insulation and the protective insulation shall be such that they will not be affected to the same degree by deteriorating influences such as heat, contaminants, and the like.

### 58.4.2 Strain relief

58.4.2.1 Unless the clamp is insulated from the cord, a metal strain relief clamp shall not be accessible and shall not make contact with an accessible dead metal part or an inaccessible dead metal part that is conductively connected to an accessible dead metal part.

### 58.4.3 Bushings

58.4.3.1 A bushing of insulating material shall be provided at each point at which the flexible cord passes through a dead metal part. A bushing of rubber, neoprene, polyvinyl chloride, or similar material is not acceptable for this application.

## 58.5 Attachment plug

58.5.1 A tool shall be provided with a polarized attachment plug. The plug shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498. See 9.1.5 and 14.3.



## 58.6 Internal wiring

58.6.1 Internal wiring – including an insulated splice on which the insulation is at least the equivalent of that on the conductors involved in the splice – shall be spaced at least 1/32 inch (0.8 mm) from:

- a) An accessible dead metal part; and
- b) An inaccessible dead metal part that is conductively connected to an accessible dead metal part.

58.6.2 If internal wiring – including an insulated splice on which the insulation is at least the equivalent of that on the conductors involved in the splice – contacts an enclosure of insulating material, the insulation on the wire and the enclosure of insulating material shall be such that they will not be affected to the same degree by deteriorating influence such as heat, contaminants, and the like.

58.6.3 Tubing of adequate thickness is acceptable protective insulation between internal wiring – including an insulated splice on which the insulation is at least the equivalent of that on the conductors involved in the splice – and accessible dead metal parts, and inaccessible dead metal parts that are conductively connected to accessible dead metal parts if:

- a) The tubing is loose-fitting on the conductors;
- b) The tubing is so fixed in position that there will not be relative movement between the tubing and the metal;
- c) The length of the leads is such that there will not be any tension during assembly or repair;
- d) The tubing does not contact sharp bends, projections, corners, and the like, nor is it subjected to tension or compression;
- e) The wiring is not subject to flexing other than that resulting from normal vibration; and
- f) The materials of the tubing and the insulation on the wire are such that they will not be affected to the same degree by deteriorating influences such as heat, contaminants, and the like.

58.6.4 Appliance-wiring material employed as internal wiring shall be acceptable for the purpose.

58.6.5 A tool shall be so constructed that if:

- a) A wire breaks, loosens, or otherwise becomes free to move at a termination; or
- b) A connecting strap, a screw, a washer, a spring, or the like

breaks, loosens, or otherwise becomes free to move, the enclosure will not be made live and no live part will project from the enclosure.

58.6.6 Compliance with the requirement in 58.6.5 can be accomplished by use of barriers, by relative placement of parts, by physical restraint of the conductor in addition to that resulting from its electrical connections, or by other means.

58.6.7 The requirement in 58.6.5 necessitates that a brush holder be constructed so that, upon removal of the cap, the spring will not touch accessible metal.

58.6.8 In determining whether a tool complies with the requirements in 58.6.5, consideration will be given to the natural lay of the wire, the tension or stress upon the wire, and the like.

58.6.9 Internal wiring that is exposed to handling during user servicing, such as replacement of lamps, shall be so secured, at each end of the exposed length that it will not be dislodged from its intended position to such extent as to expose basic insulation or uninsulated live parts or to result in disruption of the electric circuit.

58.6.10 A length of double-insulated wiring that is protected by only a decorative housing of a type that is removed during evaluation of the insulating features of the tool is considered to be exposed to handling during user servicing.

58.6.11 The connection of a lead to a switch and the connection of a lead to a conductor of the power-supply cord shall be so made that, if the switch or power-supply cord is to be replaced, it will not be necessary:

- a) To sever a conductor;
- b) To disconnect a soldered and taped splice between two conductors; or
- c) To disconnect a soldered joint between a lead and a bus bar or strap.

58.6.12 A supplementary part, such as an insulating barrier or liner, necessary to maintain the level of insulation shall be so secured to the tool that it will remain in place when the power-supply cord or the switch is being replaced.

## **58.7 Capacitors**

58.7.1 The dielectric in a capacitor shall not be depended upon as a protective insulation.

## **58.8 Brush caps**

58.8.1 An accessible cap:

- a) Shall be so recessed that when it is mounted, its top is behind the plane of the opening in the surrounding portion of the enclosure of the tool; and
- b) Shall be entirely of insulating material. See also 59.5.6 and 59.5.7.

## **58.9 Commutators and armature end turns**

58.9.1 Reinforced insulation may be employed between the commutator segments and the shaft, between the ends turns and the shaft, or in both locations. Such insulation may be either:

- a) Sheet mica or other inorganic insulation having properties equivalent to those of sheet mica; or
- b) An acceptable organic insulation. See 59.8.1 – 59.8.5.

58.9.2 Sheet mica as mentioned in 58.9.1(a) shall not be less than 0.005 inch (0.13 mm) thick.

58.9.3 If used under the commutator segments, the insulation mentioned in 58.9.1(b) shall not be less than 0.080 inch (2.03 mm) thick.

58.9.4 If used under the end turns, the insulation mentioned in 58.9.1(b) shall not be less than 0.040 inch (1.02 mm) thick, or the length of the air gap, whichever is larger.

58.9.5 If either or both of the constructions described in 58.9.3 and 58.9.4 are used, the armature laminations shall be insulated from the shaft by either:

- a) Sheet mica or other inorganic insulation having properties equivalent to those of sheet mica; or
- b) An acceptable organic insulation.

58.9.6 Sheet mica as mentioned in 58.9.5(a) shall not be less than 0.005 inch (0.13 mm) thick.

58.9.7 The insulation mentioned in 58.9.5(b) shall not be less than 0.040 inch (1.02 mm) thick, or the length of the air gap, whichever is larger.

## 58.10 Switches

58.10.1 Reinforced insulation is acceptable in place of double insulation at a switch having its own enclosure of insulating material if all of the following conditions are met:

- a) All live parts of the switch, other than terminals, are to be completely enclosed in the switch enclosure.
- b) No dead metal part that extends outside the switch enclosure is to enter the arc chamber.
- c) The plunger, toggle, or the like that contacts live parts is to be wholly of insulating material.
- d) With the exposed external parts of the plunger, toggle or the like completely removed, including parts which extend into the enclosure, no live part inside the switch enclosure is to be accessible.

*Exception: This requirement need not be applied if the switch complies with the impact test described in 59.5.11 and 59.5.12.*

- e) Metal mounting screws or rivets by which the switch is secured to accessible dead metal of the tool are not to pass through the body of the switch enclosure but may pass through tabs, ears, or other projections from the switch body, including a piece of insulating material secured to the switch.
- f) A portion of a switch or switch enclosure that contains arcing parts and may therefore be subjected to arcing is to be separated from exposed dead metal of the tool by mica not less than 0.005 inch (0.13 mm) thick or by other insulation having equivalent properties, and metal switch-assembly screws, rivets, clamps, or other devices that pass through or around the body of the switch enclosure are to be insulated from the dead metal to which the switch is secured.

## 58.11 Brush holders

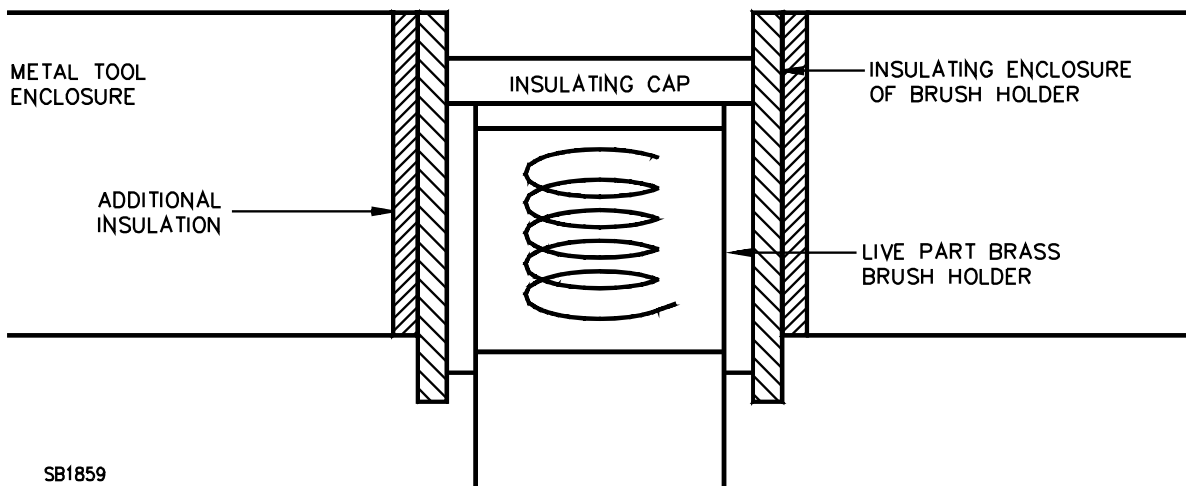
58.11.1 Reinforced insulation is acceptable in place of double insulation at a brushholder assembly that is supported in the insulating-material housing of the equipment. The total insulation thickness shall not be less than 3/16 inch (4.8 mm) provided that any path between parts of the enclosure is broken by barriers or the like so that there is no direct path from the outside to live parts of the brushholder assembly.

58.11.2 Reinforced insulation is acceptable at a brushholder assembly having its own enclosure of insulating material if both of the following conditions are met:

- a) All live parts of the brushholder assembly are to be enclosed, except wiring terminals and the brush itself; and
- b) The enclosure of the brushholder assembly is to be separated from dead metal parts by additional insulation, see Figure 58.4, of either:
  - 1) Mica not less than 0.005 inch (0.13 mm) thick;
  - 2) Other insulation having equivalent properties; or
  - 3) Acceptable insulating material not less than 1/16 inch (1.6 mm) thick.

**Figure 58.4**  
**Examples illustrating 58.11.2**

Figure 58.4 revised August 7, 1998



**58.12 Spacings**

58.12.1 Spacings shall be in accordance with Table 58.1 except that larger spacings may be required at points at which carbon dust, lubricants, or other conductive contaminants exist or might accumulate.

58.12.2 The spacing specified as the minimum acceptable in item 1 of Table 58.1 does not apply to the inherent spacings of a component, such as a snap switch, or a tool. The acceptability of spacings on a component is based on the requirements for that component.

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## 59 Performance

### 59.1 Dielectric voltage withstand test

59.1.1 A tool shall withstand for 1 minute without an indication of unacceptable performance the application of a potential applied as described in Table 59.1.

**Table 59.1**  
**Points of application and voltages for dielectric voltage withstand test**

Points between which potential is to be applied <sup>a</sup>	Test potential in volts
1. Live parts and inaccessible dead metal parts.	Voltage prescribed for dielectric voltage withstand test in 34.1 and 34.2.
2. Inaccessible dead metal parts and accessible dead metal parts or, for a tool with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure.	2000 V plus twice the rated voltage of the tool.
3. Accessible dead metal parts, or the foil mentioned in item 2, and metal foil in contact with the inner surfaces of insulating barriers provided for spacings involving supplementary or reinforced insulation and to accomplish compliance with the requirement in 58.6.5.	2000 V plus twice the rated voltage of the tool.
4. Accessible dead metal parts and: <ul style="list-style-type: none"> <li>a. Metal foil wrapped around the power supply cord inside the inlet bushings, cord guards, strain relief clamps, and the like; or</li> <li>b. A metal rod of the same cross-sectional dimensions as the cord and inserted in its place.</li> </ul>	
5. Live parts and accessible dead metal parts, or the foil mentioned in item 2, insulated from each other by insulation as described in 58.2.2.	3500 V plus twice the rated voltage of the tool.
<sup>a</sup> If part of the tool involves a combination of basic and supplementary insulation and another part involves insulation as described in 58.2.2, the two parts are to be tested separately.	

59.1.2 The tool shall be in a heated condition during the conduct of the test described in 59.1.1.

59.1.3 To determine whether a tool complies with the requirement in 59.1.1, the test potential is to be applied as described in 34.5 by means of test equipment having characteristics outlined in 34.6.

### 59.2 Leakage current test

59.2.1 The leakage current of a tool when tested in accordance with 59.2.2 – 59.2.8 shall not be more than:

- a) 0.5 mA for accessible dead metal parts;
- b) 3.5 mA for inaccessible dead metal parts; and
- c) 0.5 mA between accessible and inaccessible dead metal parts.

59.2.2 Prior to measurement of the leakage current, the tool is to be operated at no load, but with normal air flow through the tool, for 100 hours or until the brushes wear out if the latter condition occurs in less than 100 and in more than 25 hours of operation. If the brushes wear out in less than 25 hours of operation, they are to be replaced and operation is to be continued until the tool has operated for a total of 25 hours. Operation is to be continuous unless the motor is not intended for such operation.

59.2.3 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between dead metal parts, accessible and inaccessible, of a tool and ground or other dead metal parts of a tool.

59.2.4 All dead metal parts, accessible and inaccessible, are to be tested for leakage currents. The leakage currents from these parts are to be measured to the grounded supply conductor individually as well as collectively and from one part to another. These measurements apply to terminals operating at voltages that are considered to constitute risk of electric shock.

*Exception: If inaccessible dead metal parts, such as an armature of a motor, move during operation, measurements involving the moving parts are to be made with switch S1 open. Reference Figure 30.1.*

59.2.5 If an accessible part other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil wrapped tightly around the tool. The metal foil is not to remain in place long enough to affect the temperature of the tool.

59.2.6 The measurement circuit for leakage current is to be as shown in Figure 30.1. The measurement instrument is defined in (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

- a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15  $\mu\text{F}$ .
- 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  $\mu\text{F}$  capacitor to 1500 ohms. At an indication of 0.5 or 3.5 mA, the measurement is to have an error of not more than 5 percent at 60 Hz.
- d) Unless the meter is being used to measure leakage from one part of a tool to another, the meter is to be connected between the dead metal parts and the grounded supply conductor.

59.2.7 A sample of a tool is to be tested for leakage current after the conditioning described in 59.2.2. The supply voltage is to be adjusted to 120 V or 240 V, depending upon the rating of the tool. The test sequence, with reference to the measuring circuit, Figure 30.1, is to be as follows:

- a) With switch S1 open, the tool is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all of their normal operating positions.



b) Switch S1 is then closed energizing the tool, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all their normal operation positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is considered to be obtained by operation as in the temperature test.

59.2.8 An individual measurement is to be made of the leakage current to each dead metal part that is insulated from other dead metal parts. Leakage current, as measured in this test, includes current resulting from any distributed capacitance as well as current through leakage resistance.

### 59.3 Normal operation test

59.3.1 After the dielectric evaluation required by 59.1.1, a tool that is likely or intended to be used with liquid shall be subjected to the test in 59.3.2. After the test, the leakage current shall not exceed 0.5 mA for accessible dead metal parts when measured in accordance with 59.2.1 – 59.2.8.

*Exception: If the tool is not subject to spillage of liquid in normal use, the tool is to be allowed to dry for 24 hours before conducting the test in 59.3.2.*

59.3.1 effective June 1, 1998

59.3.2 A tool that is likely or intended to be used with liquid is to have all hoses, fittings, or vessels ruptured one at a time such that the entry of liquid into the tool is at its worst. A dry tool is to be used for each condition. The tool is then to be operated as in normal use and in any position recommended in the instruction manual for one minute. For a tool with sealing rings or glands, the tool is to be aged in accordance with 35.6 before conducting this test.

59.3.2 effective June 1, 1998

59.3.3 During the test described in 59.3.2, the leakage current shall not exceed 2 mA when measured in accordance with 59.2.5 – 59.2.8 for accessible dead metal parts. After 24 hours of storage at room temperature and normal humidity, the leakage current shall not exceed 0.5 mA.

59.3.3 effective June 1, 1998

### 59.4 Insulation resistance test

59.4.1 For a tool the outer enclosure of which consists wholly or partly of insulating material, the term accessible dead metal parts used in 59.4.2 signifies metal foil tightly wrapped around the exterior of the enclosure.

59.4.2 After conditioning as described in 59.4.3, a tool shall have an insulation resistance not less than that indicated below:

- a) Between live parts and accessible dead metal parts – two megohms;
- b) Between live parts and inaccessible dead metal parts – one megohm; and
- c) Between inaccessible dead metal parts and accessible dead metal parts – one megohm.

59.4.3 The insulation-resistance test is to be conducted on the sample that was used for the current-leakage test unless it was necessary to modify the sample or introduce extraneous conditions in measuring the currents to inaccessible parts. If a different sample must be used, it is to be conditioned in the same manner as for the current-leakage test. In preparation for the test, the tool is to be kept in an enclosure for 48 hours at 20.0 – 30.0°C (68.0 – 86.0°F) and a relative humidity of 88 ±2 percent. The specified relative humidity at room temperature prevails inside a closed compartment where a saturated solution of potassium sulphate (K<sub>2</sub>SO<sub>4</sub>) is kept in a tightly enclosed container. The measurements of insulation resistance are to be made in the conditioning chamber or immediately after the tool has been removed from the conditioning chamber.

59.4.4 In the determinations of insulation resistance, a direct-current potential of 500 V is to be employed, and the value of the insulation resistance is to be determined 10 seconds after the application of the test potential. A megohmmeter may be used for conducting the insulation-resistance test, or other equivalent means may be employed. The tool is not to be running during this test.

## 59.5 Resistance to impact test

59.5.1 The tool shall withstand the impact described in 59.5.2 and 59.5.3 without:

- a) Reducing spacings below the minimum acceptable values;
- b) Making accessible to contact live parts and dead metal parts that are insulated from live parts by basic insulation only;
- c) Such breaking, cracking, rupturing, or the like, as to produce adverse effect on the insulation; and
- d) Producing any other condition that would increase the risk of electric shock of the tool.

59.5.2 Each of three samples of a tool that is intended to be completely hand supported in use is to be subjected to the impact that results from the tool being dropped through a distance of 6 ft (1.83 m) to strike a concrete surface in the positions most likely to produce adverse results. A tool not intended to be hand-supported in use is to be subjected to an impact of 5 ft-lbf (6.8 J) on any surface that is exposed to a blow during normal use. This impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 lb (0.535 kg), from the height necessary to produce the specified impact.

59.5.3 A tool that is not intended to be completely hand-supported in use, such as a heavy paving breaker (hammer), is to be subjected to the impact that results from the tool being dropped from its operating positions (on the bit position in the case of a paving breaker) to strike a concrete surface; and the tool is also to be subjected to an impact of 5 ft-lbf (67.8 J) on any surface that is exposed to a blow during intended use, as described in 59.5.2.

59.5.4 Following the impact test described in 59.5.2 and 59.5.3, the tool shall withstand for 1 minute without breakdown the application for a 60 Hz essentially sinusoidal potential of 1000 V plus twice rated voltage of the tool between live parts and metal foil wrapped tightly around the enclosure.

59.5.5 With reference to 59.5.2 and 59.5.3, the tests on a tool that is intended to be hand supported are to be so conducted that each sample strikes the surface in a position different from those of the other two samples. Three individual samples may be employed for the tests, or if the manufacturer so elects, fewer samples may be used in accordance with Figure 59.1. The overall performance is acceptable upon completion of any one of the procedures represented in the figure. If any sample does not comply with the test criteria on the first drop in any of three positions, the results of the test are unacceptable.

**Figure 59.1**  
**Procedure for 6-ft (1.83-m) Impact test**

Figure 59.1 revised August 7, 1998

Series Number	Sample Number											
	1	2	3	1	2	3	1	2	3	1	2	3
1	↓ A	N	N	↓ A	N	N	↓ A	N	N	↓ A	N	N
2	↓ A	N	N	↓ A	N	N	↓ U	↓ A	N	↓ U	↓ A	N
3	↓ A	N	N	↓ U	↓ A	N	↓ A	N		↓ U	↓ A	

Arrows indicate sequence of test procedure  
 A – Acceptable results from drop  
 U – Unacceptable results from drop  
 N – No test necessary

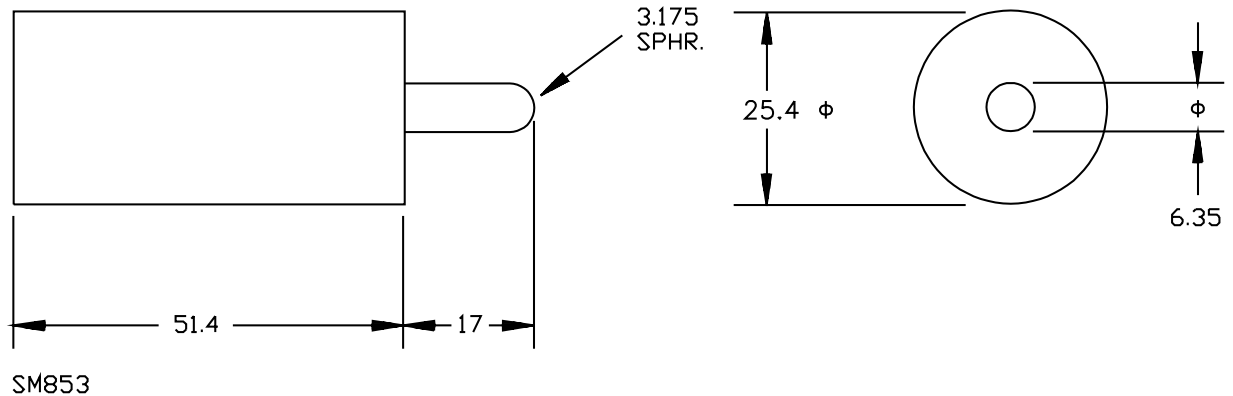
SA1162

59.5.6 An accessible brush cap shall withstand an impact of 1 ft-lbf (1.36 J) without cracking and without exposing live parts.

59.5.7 The impact specified in 59.5.6 is to be applied through a hardened steel rod having a diameter of 1/4 inch (6.4 mm). See Figure 59.2.

### Figure 59.2 Impact rod

Figure 59.2 revised August 7, 1998



59.5.8 A switch handle, knob, operating button, or the like consisting of a metal insert covered with an exterior layer of insulating material shall withstand an impact of the magnitude specified in 59.5.12 without cracking or breaking the insulating material (or the inner layer of insulation if there is more than one layer) or dislodging the handle from its intended position.

59.5.9 Except as noted in 59.5.10, a switch handle, knob, operating button, or the like consisting entirely of insulating material shall withstand an impact of the magnitude specified in 59.5.12 without dislodging the handle from its intended position.

59.5.10 The requirement in 59.5.9 does not apply if, with the handle completely removed from the switch, no live part and no normally inaccessible dead metal part are accessible.

59.5.11 As indicated in the exception to 59.10.1(d), a switch handle, knob, operating button, or the like in a switch with reinforced insulation in lieu of double insulation shall withstand an impact of the magnitude specified in 59.5.12 without a live part inside the switch enclosure becoming accessible.

*Exception: The impact test need not be conducted if, with the exposed external parts of the plunger, toggle, or the like completely removed, including parts which extend into the enclosure, a live part inside the switch enclosure is not accessible.*

59.5.12 In a determination of whether a switch handle, or similar part, complies with the requirements in 59.5.8 and 59.5.9, whichever applies, two samples of the tool are to be tested. If the tool is intended to be hand supported while in use, each sample is to be dropped through a distance of 6 ft (1.83 m) to strike a concrete surface, with the point of impact at the switch handle, button, or the like; except that, if the switch handle, and the like, is located so that it cannot strike the concrete surface when the test is being conducted, it is to be subjected to an impact of 5 ft-lbf (6.8 J). If the tool is not intended to be hand supported while in use, the switch handle, and the like, is to be subjected to an impact of 5 ft-lbf (6.8 J). The 5-ft-lbf (6.8-J) impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 lb (0.535 kg) from a height of 51 inches (1.3 m). These tests are to be conducted in addition to those required in 59.5.1 and 59.5.2. The results are acceptable if the switch merely becomes inoperable.

## **59.6 Resistance to heat test**

59.6.1 Unless it is made of a material previously demonstrated to be acceptable for the application, the enclosure of the tool, after being conditioned as described in 59.6.2, shall show no holes, cracks, distortion, or other evidence of unacceptable conditions if such holes, cracks, or the like, would result in noncompliance with the constructional requirements in 39.1, 58.3.1, and 58.3.2.

59.6.2 For a determination of whether it complies with the requirement in 59.6.1, the tool is to be kept for 7 hours in an oven at a temperature that is 10°C (18°F) higher than the temperature attained by the enclosure under conditions of intended operation, but not less than 70°C (158°F) in any case.

## **59.7 Overload test**

### **59.7.1 General**

59.7.1.1 During the running-overload operation, any protective device provided with the tool, which can be reset, replaced, repaired or otherwise modified by the user, is to be short-circuited, and the branch circuit protection is to be of high enough capacity to withstand the test currents without opening the circuit. The objective of the test is to determine the integrity of the tool insulation and not the effectiveness of a protective device, other than a thermal-cutoff type, specified in 59.7.1.2.

No Text on This Page

59.7.1.2 A one-shot, nonresettable or nonreplaceable thermal cutoff, permanently embedded in the motor, may be used to limit the end result of the running-overload burnout test, specified in 59.7.1.5, if the thermal cutoff, upon opening, renders each motor part it is intended to protect permanently inoperative and requires that these parts be replaced in order to return the tool to a functional condition.

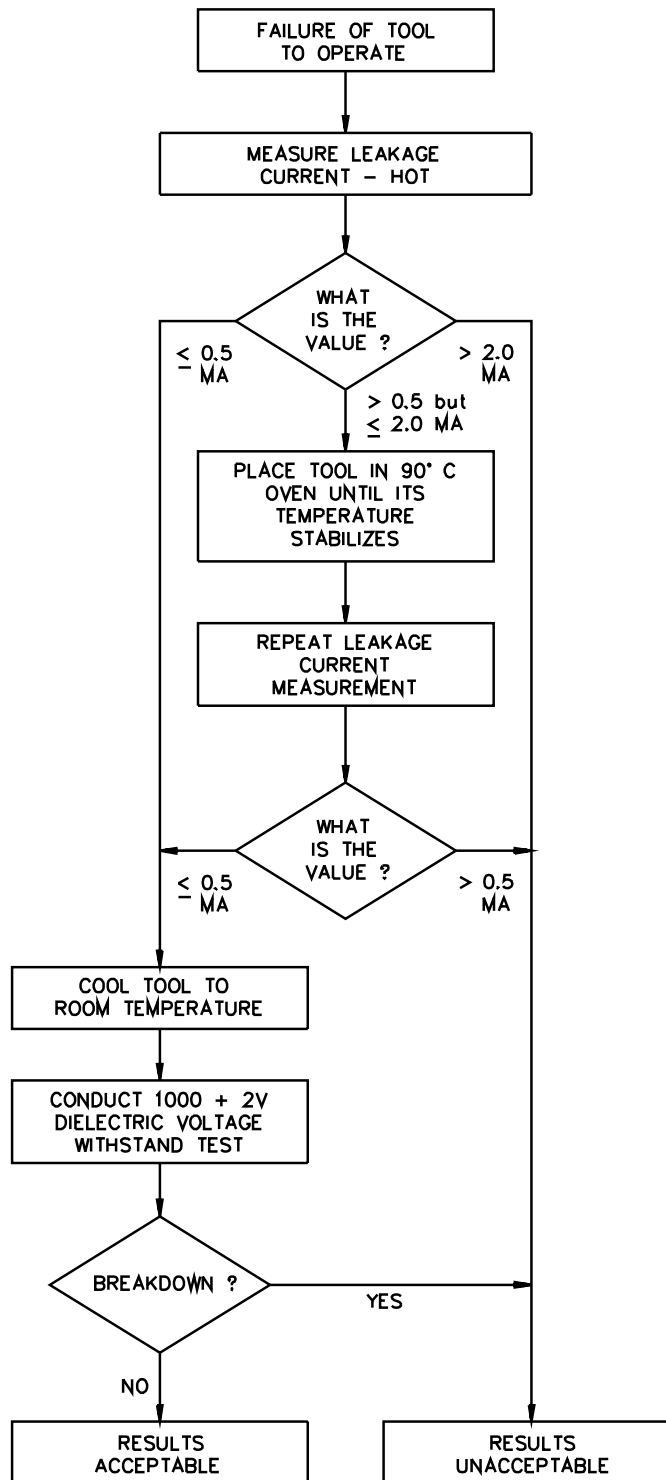
59.7.1.3 When a tool is operated under the conditions described in 59.7.1.5:

- a) There shall be no adverse deterioration of the insulation to the extent that live parts are exposed.
- b) The leakage current measured from accessible dead metal parts shall not be more than:
  - 1) The values indicated in 59.7.2.1 – 59.7.2.3 and Figure 59.3, if the tool fails to operate or reaches end point, or
  - 2) The values indicated in 59.7.3.1 – 59.7.3.3 and Figure 59.4, if the tool is still functional.

The leakage current shall be monitored continuously as the tool reaches the end result, using the methods described in 59.2.3, 59.2.4, or 59.2.6, utilizing both positions of switch S2 and with the tool switching devices in all intended operating positions (speed control set for maximum speed).

- c) The tool shall comply with the requirements in 59.7.2.2, if failure of the tool to operate occurs or in 59.7.3.2, if the tool is still functional.

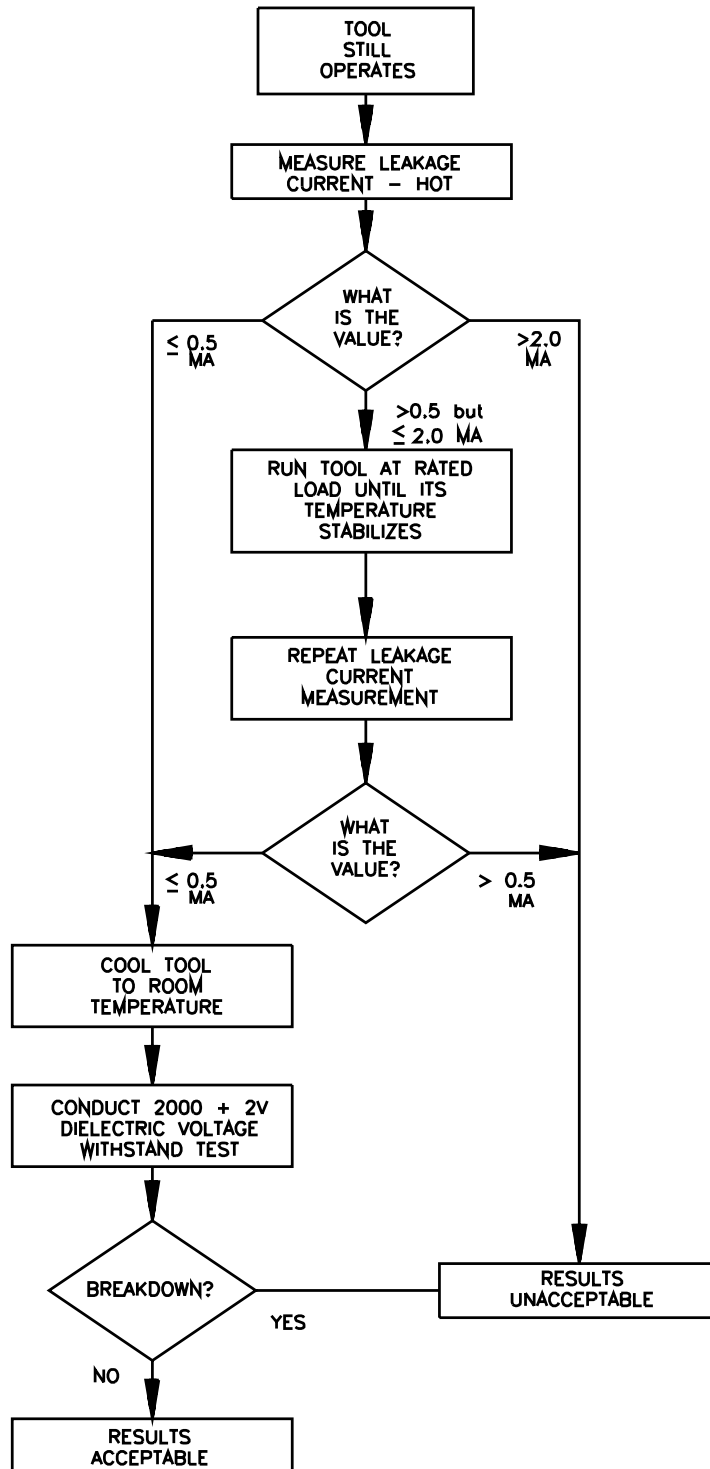
Figure 59.3  
Failure of tool to operate (reach end point)



SA1677



Figure 59.4  
 Tool still operates (6 hours or 200 percent rated load reached)



SA1678

59.7.1.4 If an accessible part other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a single layer of metal foil applied tightly around the tool. The foil is to remain in place for the running overload test described in 59.7.1.5 and is to be applied around the tool in such fashion so as not to restrict ventilation and to minimize the effect of the foil on the operating temperatures of the tool.

59.7.1.5 To determine whether a tool complies with the requirements of 59.7.1.3, each of three previously untested samples of a complete tool is to be subjected to operation at 120 percent of rated load for 14-1/2 minutes followed by operation at no-load for 1/2 minute. Following the initial 15 minutes of operation, the tool is to be subjected to consecutive 15 minute periods of operation – each period consisting of 14-1/2 minutes of operation with the load increased in each successive period by 10 percent of the rated current followed by 1/2 minute of operation at no-load. The test is to be continued until the end result occurs (see 59.7.1.7) or the load reaches 200 percent of the rated load. If agreeable to those concerned, the overload conditioning may start at a higher load value, in 10 percent increments of rated load, up to 150 percent. If the end result occurs in less than 1/2 hour, the test is to be repeated using a different sample and starting at rated load instead of 120, 130, 140, or 150 percent. The exterior temperatures of the motor housing are to be monitored during the test by means of thermocouples. If the temperature of the motor housing exceeds 90°C (194°F) during operation under load, the tool is to be operated at no-load (other than the mechanical load provided by the loading device) until the housing temperature is stabilized; and upon stabilization, the test is to be resumed at the same load increment, for the balance of the 14-1/2 minute load cycle. The loading cycle is to be resumed, as indicated above until the end result occurs or the tool has been operated for 6 hours.

*Exception No. 1: For a light-duty tool, the test may start at 100 or 110 percent.*

*Exception No. 2: Only a single sample of a tool employing an alternate magnet wire coating, see 28.4, is to be tested if the test results are equivalent to the test results of the original construction tested. Equivalency is based upon the test duration, the enclosure temperature, and the leakage current being slightly higher, the same or less and acceptable dielectric voltage withstand test results.*

59.7.1.6 To determine whether a tool employing a solenoid complies with the requirements of 59.7.1.3, each of three previously untested samples of a complete tool is to be subjected to operation without load at a rate of one cycle per second for a period of 1/2 hour. Following the 1/2 hour period, the tool is to be operated without load (for example, without staples in the case of a stapler) as quickly as possible until the end result occurs (see 59.7.1.7). Circuitry employed to limit the operating time cycle of the tool is to be by-passed.

59.7.1.7 With reference to 59.7.1.5, failure of the tool to operate is considered to have occurred if:

- a) Flame occurs;
- b) An open circuit occurs;
- c) The tool stalls and will not run at rated load; or
- d) A short circuit develops in the winding that results in a spontaneous increase in current of 50 percent or more of the last adjusted value.

If condition (a) occurs, the flame is to be extinguished immediately. If a condition similar to (c) occurs, the tool stalls but will run at rated load, the load shall be reapplied at the highest level the tool will operate until failure of the tool to operate occurs. At the moment the end result occurs, switch S1 is to be opened and the leakage current monitored until stabilization.

59.7.1.8 If the end result occurs as a short-circuit in the winding (condition (d) in 59.7.1.7), operation is to be continued for 30 seconds under load after the short circuit occurs, unless condition (a) (flame, which is to be extinguished immediately), condition (b) (open circuit), or condition (c) (stalling) occurs earlier. If condition (a), (b), or (c) occurs, operation is to be terminated immediately. If neither condition (a), (b), or (c) occurs during the 30-second interval, the tool is then to be given time to cool to room temperature. Without adjustment of the load from the value during the 30-second interval, operation of the tool is to be resumed for one period of up to 30 seconds or until condition (a) (flame), condition (b) (open circuit), or condition (c) (stalling) occurs, whichever occurs first.

#### 59.7.2 Failure of tool to operate

59.7.2.1 If the overload conditioning mentioned in 59.7.1.5 is terminated for failure of the tool to operate, see Figure 59.3, (reaches end point), the leakage current shall be continued to be monitored with the tool still at maximum temperatures, using the methods described in 59.2.3, 59.2.4, and 59.2.6. The leakage current measured from accessible dead metal parts, including metal foil wrapped around the enclosure of insulating material, shall not be more than 2.0 mA.

59.7.2.2 If the value of leakage current measured, as specified in 59.7.2.1, does not exceed 0.5 mA, the tool is to be given time to cool to room temperature and shall withstand for 1 minute, without breakdown, the application between live parts and accessible dead metal parts (or the foil as mentioned in note (a) of Table 58.1) and between all inaccessible dead metal parts and accessible dead metal parts (or the foil mentioned in note (a) of Table 58.1) of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage.

59.7.2.3 If the value of leakage current measured, as specified in 59.7.2.3 exceeds 0.5 mA but does not exceed 2.0 mA, the tool is to be placed in a circulating-air oven maintained at a temperature of 90°C (194°F) until its temperatures stabilizes. The leakage current measurement is to be repeated and shall not exceed 0.5 mA. The tool is then to be given time to cool to room temperature and shall withstand for 1 minute, without breakdown, the application between live parts and accessible dead metal parts (or the foil as mentioned in note (a) of Table 58.1) and between all inaccessible dead metal parts and accessible dead metal parts (or the foil mentioned in note (a) of Table 58.1) of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage.

#### 59.7.3 Test terminated – tool still operates

59.7.3.1 If the overload conditioning mentioned in 59.7.1.5 is terminated at the end of 6 hours or at the end of the 200 percent load period, without failure of the tool to operate, (see Figure 59.4), the leakage current is to be measured immediately, with the tool still at maximum temperatures, using the methods described in 59.2.3, 59.2.4, and 59.2.6. The leakage current measured from accessible dead metal parts, including metal foil applied around the enclosure of insulating material, shall not be more than 2.0 mA.

59.7.3.2 If the value of leakage current measured as specified in 59.7.3.1, does not exceed 0.5 mA, the tool is to be given time to cool to room temperature and shall withstand, for 1 minute, without breakdown, the application of a 60-Hz essentially sinusoidal potential of 2000 V plus twice the rated voltage between live parts and accessible metal parts (or the foil mentioned in note (a) of Table 58.1) and between all inaccessible dead metal parts and accessible dead metal parts (or the foil mentioned in note (a) of Table 58.1).

59.7.3.3 If the value of leakage current measured as specified in 59.7.3.1 exceeds 0.5 mA but does not exceed 2.0 mA, the tool is to be loaded to its nameplate rating and operated until temperatures stabilize. The leakage-current measurement is to be repeated and shall not exceed 0.5 mA. The dielectric voltage withstand test mentioned in 59.7.3.2 is to be conducted after the tool is given time to cool to room temperature.

*Exception: If the tool fails to operate before temperatures stabilize while being loaded to its nameplate rating, it is to be placed in a circulating-air oven maintained at 90°C (194°F) until its temperatures stabilize and shall then comply with the balance of 59.7.2.3.*

## 59.8 Armature investigation test

59.8.1 If a construction as described in 58.9.1(b) is employed, each of three samples of the armature shall be conditioned and conform to the requirements of 59.8.2 – 59.8.8.

59.8.2 The three samples mentioned in 59.8.1 are first to be kept in an oven for 500 hours at a temperature that is 20°C (36°F) higher than the temperature of the armature winding measured during the temperature test.

59.8.3 One armature sample is then to be caused to carry the locked-rotor current of the tool, another is to be caused to carry one-half of the locked-rotor current, and the third is to be caused to carry one-fourth of the locked-rotor current. The specified current is to flow in each sample for 4 hours unless breakdown of the basic insulation occurs before the end of that interval. Breakdown of the basic insulation is considered to have occurred if:

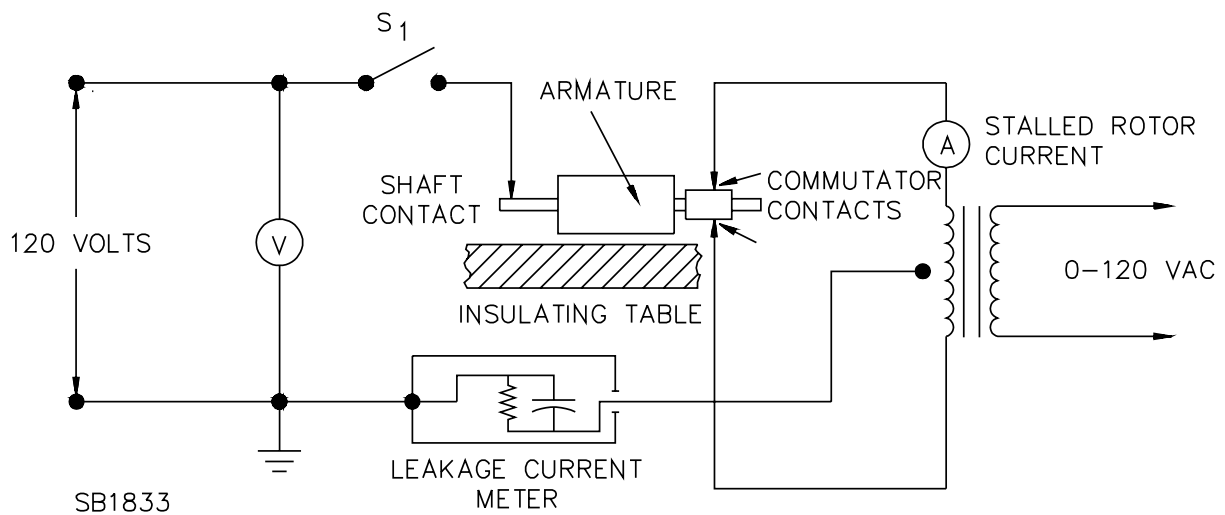
- a) Flame occurs;
- b) An open circuit occurs; or
- c) A short circuit develops in the winding that results in a spontaneous increase in current of 50 percent or more of the last adjusted value; see 59.8.7.

If condition (a) occurs, the flame is to be extinguished immediately. At the moment the end result occurs, the circuit supplying the current causing the armature burnout is to be opened. If breakdown of the basic insulation of a given sample does not occur before the end of the 4-hour period, the test is to be continued as long as is necessary to accomplish that result, with the current during each additional hour being increased by 50 percent of the initial value.

*Exception: Only a single unconditioned sample of a tool armature employing an alternate magnet wire coating, see 28.4, is to be tested, if the test results are equivalent to the test results obtained from a single unconditioned sample armature employing the original magnet wire coating, when both are tested at one-fourth of the locked-rotor current. Equivalency is based upon the duration of the tests and the leakage current being slightly higher, the same or less and acceptable dielectric voltage withstand test results.*

59.8.4 During the test described in 59.8.3 and after breakdown of the basic insulation, leakage current measured between the commutator segments and the armature shaft shall not exceed 2.0 mA. The leakage current is to be measured with 120 V applied between the commutator segments and the armature shaft using the meter described in 59.2.6. (See Figure 59.5).

**Figure 59.5**  
**Leakage-current measurement circuit for armature investigation**



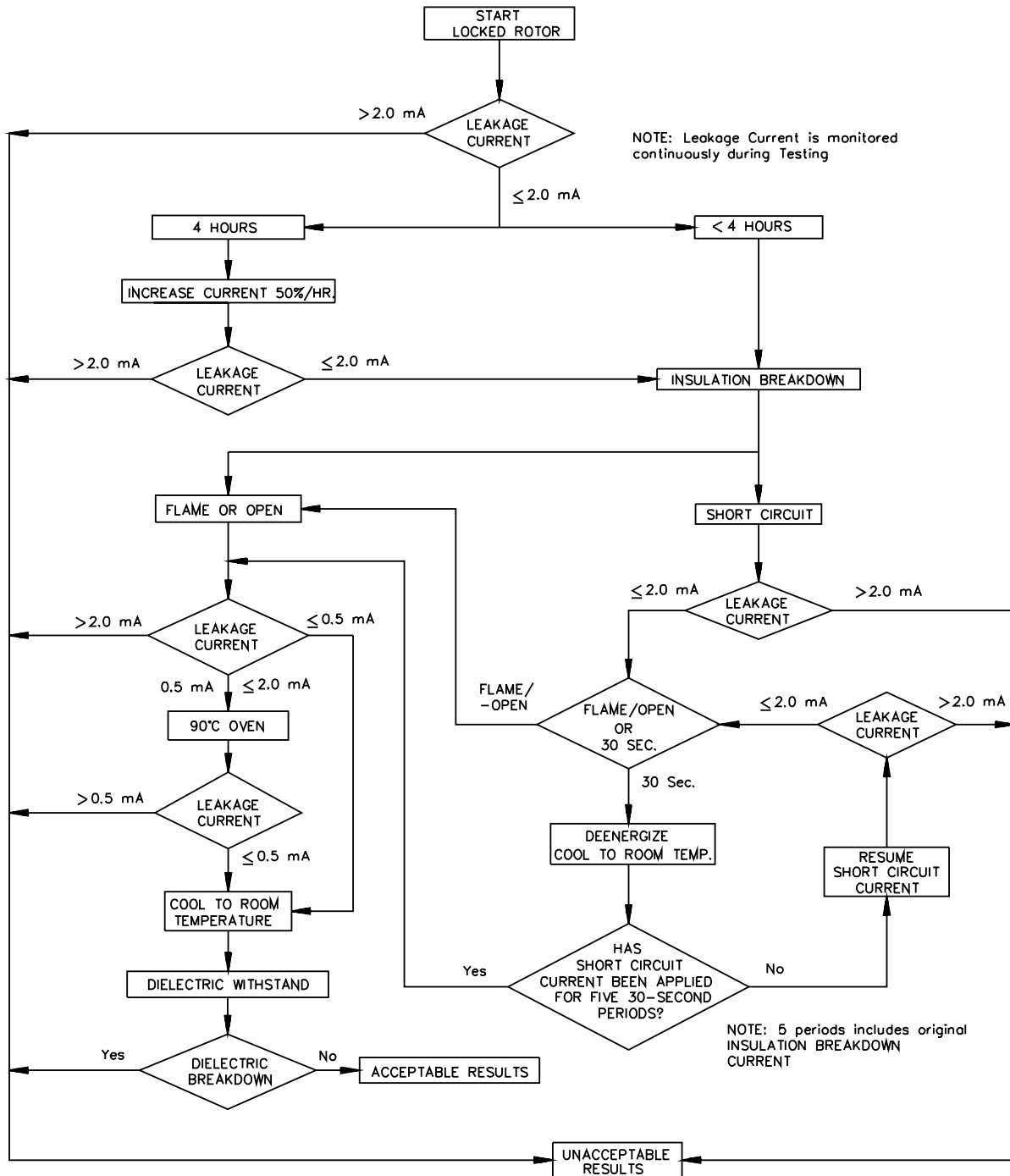
Before conducting leakage current measurements with this circuit, switch  $S_1$  should be opened. Both circuits should be energized and the leakage currents at the meter observed to determine that the stray leakage currents are negligible. Caution: The clip lead to the armature shaft is at line potential.

59.8.5 If the value of leakage current, measured as specified in 59.8.4, does not exceed 0.5 mA, the armature shall be given time to cool to room temperature. The armature shall then withstand for 1 minute, the application between the armature winding and accessible dead metal parts of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage without breakdown.

59.8.6 If the value of leakage current, measured as specified in 59.8.4, exceeds 0.5 mA but does not exceed 2.0 mA, the armature shall be placed in a circulating-air oven maintained at a temperature of 90°C (194°F) until its temperature stabilizes. The leakage-current measurement shall be repeated and the value shall not exceed 0.5 mA. The armature, after it has cooled to room temperature, shall withstand for 1 minute the application between the armature winding and accessible dead metal parts of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage without breakdown.

59.8.7 If breakdown of the basic insulation occurs as a short circuit in the winding (Condition (c) in 59.8.3), the current flow is to be continued for 30 seconds after the short circuit occurs, unless Condition (a) (flame) or Condition (b) (burnout) occurs earlier. If Condition (a) or (b) occurs, operation is to be terminated immediately. If neither Condition (a) nor (b) occurs during the 30-second interval, the armature is then to be given time to cool to room temperature. The current flow is then to be resumed without readjustment until Condition (a) (flame) or Condition (b) (burnout) occurs or until 30 seconds elapse, whichever occurs first. This procedure is to be repeated three more times, giving the armature time to cool to room temperature each time, making a total of five 30-second periods of current flow after the period in which breakdown of the basic insulation was first noted, except that the procedure is to be finally terminated at any time flame appears or burnout occurs, if flame occurs, it is to be extinguished immediately. See Figure 59.6.

**Figure 59.6**  
**Armature investigation – locked rotor**



SB 2313

Flow chart indicates sequence of testing described in 59.8.3 – 59.8.7.

59.8.8 Each sample is then to be rotated at its normal no-load speed for 1 minute by any conventional external means. After cooling to room temperature, each sample shall withstand for 1 minute, without breakdown, the application of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage between the armature winding and the shaft.

### 59.9 Leakage current following humidity test

59.9.1 A tool shall be operated as in 59.2.2 and following exposure for 48 hours to moist air having a relative humidity of  $88 \pm 2$  percent at a temperature of  $32.0 \pm 2.0^\circ\text{C}$  ( $89.6 \pm 3.6^\circ\text{F}$ ) shall comply with the requirements for leakage current, 59.2.1, 59.2.3 – 59.2.6, and 59.2.8.

- a) The tool is to be at a temperature just above the test chamber temperature when it is placed in the humidity oven.
- b) The tool is to remain in the humidity chamber for 48 hours.
- c) Following this exposure, while still in the test chamber, the sample is to be tested unenergized. The measurement circuit is to be as shown in Figure 30.1 with switch S1 open. Leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all of their normal operating positions.
- d) The sample is then to be tested energized with switch S1 closed and within a period of 5 seconds the leakage current is then to be measured using both positions of switch S2, and with the tool switching devices in all their normal operating positions. Leakage current is then to be monitored under the no-load condition until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. The test may be discontinued when the leakage current has stabilized or decreased. This test may be made in the test chamber or immediately after the sample has been removed from the test chamber.

### 59.10 Dew point test

59.10.1 A saw, hammer, drill and hammer-drill, disc and straight grinder, and disc sander shall not have a leakage current greater than 0.5 mA after being conditioned as described in 59.10.2 and 59.10.3.

59.10.2 The tool is to be conditioned in a cold chamber at  $5.0 \pm 2.0^\circ\text{C}$  ( $41.0 \pm 3.6^\circ\text{F}$ ) for at least 4 hours, then transferred from the cold chamber to a humidity chamber at  $88 \pm 2$  percent relative humidity and  $32.0 \pm 2.0^\circ\text{C}$  ( $89.6 \pm 3.6^\circ\text{F}$ ). The transfer time shall not exceed 1 minute.

59.10.3 The leakage current is to be measured from line to all exposed conductive surfaces and all gripping surfaces at 120 V in static mode only (unenergized). The leakage current is to be monitored closely beginning from time of transfer from cold chamber to humidity chamber until leakage current stabilizes or drops. See 59.2.5 and 59.2.7(a).

## 60 Tests by the Manufacturer

60.1 The manufacturer shall determine, by a routine production-line test, that each tool produced will withstand for 1 second without an indication of unacceptable performance the application of a potential as indicated in Table 60.1.

**Table 60.1**  
**Dielectric voltage withstand test potential**

Points between which potential is to be applied	Test potential in volts
1. Live parts and dead metal parts insulated from each other by basic insulation.	1200
2. Accessible dead metal parts or, for a tool with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure and inaccessible metal parts including metal foil in contact with the insulating barriers provided for spacings involving supplementary or reinforced insulation and to accomplish compliance with the requirement in 58.6.5.	1500
3. Live parts and accessible dead metal parts or, for a tool with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure.	2500

Note A: If necessary because of the inaccessibility of parts, test in accordance with items 1 and 2 of Table 60.1 may be conducted on sub-assemblies of the tool, and, in this case, the test indicated in item 3 is to be conducted. If the tests in accordance with item 1 and 2 are conducted on the completely assembled tool, the tests indicated in item 3 may be omitted if there is no reinforced insulation.

Note B: Those parts of the tests described in items 2 and 3 of Table 60.1 that include application of metal foil to outer enclosures of insulating material may be waived if the manufacturer has an acceptable quality control program. This program is to determine that the insulating material in question is free from cracks and metal inclusions, and that it has the physical and electrical strength required for the application. To determine that the material is free of cracks or metal inclusions, a 100 percent visual inspection is required. Periodic physical-property test on molded parts shall also be conducted.

Note C: The test of item 3 may be waived for accessible metal parts, such as assembly screws, that are:

- (1) isolated by an outer enclosure of insulating material that is subject to the control program indicated in Note B, and
- (2) are so located that they are remote from live parts and from inaccessible metal parts separated from live parts by basic insulation only.

The remoteness is to include consideration of possible displacement of parts as the result of improper assembly.

60.2 The tool may be in a heated or unheated condition for the test.

60.3 To determine whether a tool complies with the requirement in 60.1, the test potential is to be applied as described in 49.5 and 49.6 by means of test equipment having characteristics outlined in 49.7.

60.4 If the tool employs a solid-state component that can be damaged by the test potential, the test on each tool may be conducted before the component is electrically connected. In such a case, additional testing is to be made of a random sampling of each day's production with the circuitry rearranged to reduce the likelihood of damage to any solid-state component but retaining representative dielectric stress of the circuit.

60.5 There is not to be any transient voltage applied to the tool under test that results in the instantaneous voltage applied to the product exceeding 120 percent of the peak value of the test voltage that the manufacturer elects to use for this test. This requirement applies for the entire duration of the test, including the time that the voltage is first applied to the product and the time that the voltage is removed from the product.



60.6 During the test, a sufficient number of primary switching components shall be in the on position so that all primary circuitry will be stressed. Both sides of the primary circuit of the appliance are to be connected together to one terminal of the test equipment. The second equipment terminal is to be connected to accessible dead metal.

*Exception: Tools utilizing motors, relays, coils, or transformers, having circuitry not subject to excessive secondary build-up in case of indication of unacceptable performance during the test, may be tested with only one side of the primary circuit connected to the dielectric test equipment.*

## 61 Markings

61.1 A tool that complies with these requirements shall be permanently marked with the words "double insulation – when servicing, use only identical replacement parts." The words "double insulated" may be used instead of "double insulation" in the marking.

61.2 Equipment rated in the voltage range 220 – 250 V shall be marked on the tool or indicated in the instruction manual, "Use only on \_\_\_-volt (indicate tool voltage rating) circuits of 150 V or less to ground" or equivalent.

61.3 The "double insulation" or "double-insulated" marking mentioned in 61.1 and the marking mentioned in 61.2 are to be one of the following:

- a) Painted or paint-stencilled on a metal name plate in letters at least 1/16 inch (1.6 mm) high that contrast in color with the background (see 61.4);
- b) Molded into the enclosure in letters at least 3/32 inch (2.4 mm) high and raised or recessed 0.005 inch (0.13 mm);
- c) On a permanent pressure-sensitive label in letters at least 1/16 inch (1.6 mm) high that contrasts in color with the background (see 61.5); or
- d) Die-stamped or etched on a metal name plate of dull finish, in letters at least 3/32 inch (2.4 mm) high and of sufficient depth to be clearly and distinctly legible.

61.4 A metal nameplate as mentioned in 61.2 (a) or (d) is to be secured by rivets or one-way screws.

*Exception: A metal nameplate may be secured by an adhesive if its edges are recessed or it is otherwise positioned so that its edges are not subject to being lifted. The metal nameplate shall be applied to a flat or curved surface with the nameplate preformed to the curvature of the surface.*

61.5 A pressure-sensitive label as mentioned in 61.3(c) is to have its edges recessed or is to be otherwise positioned so that its edges are not subject to being lifted. This requirement applies only to the words "double insulated" or "double insulation" as required by 61.1.

## ACCESSORIES AND ATTACHMENTS

### 62 Scope

62.1 These requirements cover accessories and attachments for use with portable electric tools that are referred to by catalog number (or equivalent product designation) in the instruction manual accompanying a tool, or packaged with the tool. See 1.6 and 1.7.

62.2 An accessory or attachment shall comply with all applicable requirements of this standard supplemented by and in some cases, amended by the requirements in Sections 63 – 66.

62.3 An accessory or attachment not explicitly covered in this standard is to be investigated on the basis of compliance with the requirements of this standard, insofar as they are applicable, and further appropriate examination and tests to determine acceptability for its intended use.

62.4 These requirements cover carbide-tipped circular saw blades having a maximum diameter of 12-1/2 inches (318 mm), carbide-tipped planer cutters, and carbide-tipped masonry drill bits. Solid, that is not carbide-tipped, blades, cutters, and bits are not covered.

62.5 These requirements cover wire brushes of all types.

62.6 A guard or rotating backing pad may either be investigated for use with a specific tool or as an accessory.

## **63 Construction**

### **63.1 General**

63.1.1 If a tool is converted by an attachment to perform the intended function (or functions) of another tool, the combination shall comply with the applicable requirements for the tool whose function it has been converted to perform.

63.1.2 A handle, lever, knob, or other control shall be so located that when the accessory or attachment is installed on the intended tool, and when reaching for the control, it is not necessary to traverse an area where the likelihood of injury to persons is present. An area where the likelihood of injury to persons exists, adjacent to the control, shall be so guarded or located that it cannot be entered unintentionally.

63.1.3 An adjustable component, such as a table mounted on a column, shall be so constructed that, even if it should become loosened, it will not fall or otherwise present a condition where the risk of injury to persons exists.

63.1.4 The shank of an accessory or attachment to be gripped in a chuck or the like shall be such that it can be clamped firmly in the holding device of the tool for which it is recommended, or a representative holding device if the accessory or attachment is intended for use with a variety of tools.

63.1.5 An accessory or attachment that is intended to be fixed with relationship to the tool shall have provision for being securely mounted in a manner that does not present a risk of injury to persons.

### **63.2 Materials**

63.2.1 The material of a part, the malfunction of which might result in the likelihood of injury to persons, shall have properties acceptable for the expected conditions of intended use. See Section 64.

63.2.2 The physical properties and the thicknesses of materials used in a cutting tool shall be adequate to meet the stresses of intended use. See Section 64.

## 64 Performance

### 64.1 Impact testing

64.1.1 An attachment, intended for use with a portable tool shall withstand either the ball-impact test described in 64.1.5, or the drop test described in 64.1.6 as applicable. Except as noted in 64.1.2 – 64.1.4, the part shall withstand the appropriate test or tests:

- a) Without cracking that affects the function of the part so as to increase the risk of injury to persons;
- b) Without being affected to the extent that a moving part, likely to cause injury to persons, is exposed to unintentional contact; and
- c) Without affecting the mechanical performance of the accessory or tool so as to increase the risk of injury to persons.

64.1.2 A part that becomes disassembled or detached during the ball-impact or drop test is acceptable if:

- a) The damage is obvious and it can be reassembled readily to function properly; or
- b) The disassembly or detachment of the part does not result in the risk of injury to persons.

64.1.3 Breakage of a part that makes an accessory or an attachment inoperable is acceptable if no increase in the risk of injury to persons can occur and the product can not be used.

64.1.4 Deformation of a guard or other part during the ball-impact or drop test is acceptable if:

- a) The part can be readily restored to its functional shape; or
- b) The deformation does not result in the risk of injury to persons.

64.1.5 For an attachment, where the combination is not hand supported or hand held, each of three samples of the attachment is to be subjected to an impact of 5 foot-pounds (6.8 J) on any surface that may be exposed to a blow during intended use. The impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 lb (0.535 kg), from the height necessary to produce the specific impact. For surfaces that cannot be impacted from above, the steel sphere is to be suspended by a cord and allowed to fall from rest as a pendulum through the distance required to cause it to strike the surface with the specified impact. During the test, the sample is to be installed on the recommended tool in the intended manner, or the intended manner of installation is to be simulated.

64.1.6 For an attachment, where the combination is hand held or hand supported, each of three samples is to be dropped three times from a height of 3 feet (0.9 m) to strike a concrete surface in the positions most likely to produce adverse results. The test is to be conducted with the attachment in place on the recommended tool. The test is to be conducted so that each sample strikes the surface in a position different from those of the other two samples.

64.1.7 Three individual samples may be employed for the tests described in 64.1.5 and 64.1.6 or, if the manufacturer so elects, fewer samples may be used in accordance with Figure 64.1. The overall performance is acceptable upon completion of any one of the procedures represented in the figure. Each series is to consist of one ball impact or three drops; and if any sample does not comply with the test criteria on the first series, the results of the test are unacceptable.

**Figure 64.1**  
**Procedure for drop test**

Figure 64.1 revised August 7, 1998

Series Number	Sample Number											
	1	2	3	1	2	3	1	2	3	1	2	3
1	↓ A	N	N	↓ A	N	N	↓ A	N	N	↓ A	N	N
2	↓ A	N	N	↓ A	N	N	↓ U	↓ A	N	↓ U	↓ A	N
3	↓ A	N	N	↓ U	↓ A	N	↓ A	N		↓ U	↓ A	

Arrows indicate sequence of test procedure  
 A – Acceptable results from drop  
 U – Unacceptable results from drop  
 N – No test necessary

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64.1.8 If the attachment consists of plastic or other nonmetallic material, the ball-impact test described in 64.1.5 or the drop test described in 64.1.6 and 64.1.7, as applicable, are to be performed on the samples in the as received condition. The test is then to be repeated on a different sample or samples that have been cooled to room temperature after exposure to an air oven at 70°C (158°F) for 7 hours. A part when conditioned in the oven is to be supported in the same manner that it is supported on the tool.

64.1.9 Upon removal from the oven and before being subjected to the ball-impact test described in 64.1.5 or the drop test described in 64.1.6 and 64.1.7, no sample shall show cracking, distortion, or other deleterious effects from the oven conditioning sufficient to increase the risk of injury to persons during operation of the tool.

## 64.2 Sharp edges and projections

64.2.1 An edge, projection, or corner of an accessory or attachment shall not be sufficiently sharp to constitute a likelihood of injury to persons in intended use or during operator maintenance.

*Exception: An edge that must be sharp to enable the accessory or attachment to perform its intended function.*

### 64.3 Rotating members

64.3.1 A rotating member, the malfunction of which may create risk of injury to persons, shall be constructed of such material and in such manner as to minimize the likelihood of:

- a) Bending, breaking, or other malfunction of parts; or
- b) The release or loosening of parts, except for wires of a wire brush.

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64.3.2 To determine if a part complies with the requirements in 64.1.5, it is to be rotated as indicated in Table 64.1 without breakage (separation of carbide tips from blade), or other effect that may result in risk of injury to persons.

*Exception No. 1: A wire brush may discharge wires but shall not burst.*

*Exception No. 2: The test may be waived if evaluation of the manufacturer's design calculations or examination of the product indicates that the part or parts are adequately strong.*

**Table 64.1**  
**Rotating members test**

Rotating member	Time or number of revolutions	Speed of rotation, percent of maximum rotating member speed
Carbide-tipped saw blades	1,000,000 Rev.	150
Flexible backing pads	1 Hour	120
Wire brushes with shank, all sizes	1 Hour	120
Wire brushes without shank,		
2 to 6 inches (50 to 150 mm)	1 Hour	120
6 to 9 inches (150 to 230 mm)		130
9 inches (230 mm) and larger		150
All other rotating members	1 Hour	150

## 64.4 Stability

### 64.4.1 General

64.4.1.1 Bases, cabinets, legs, stands, tables, and similar attachments shall comply with the applicable stability test described in 64.4.2.1 – 64.4.3.3. The attachment is to be investigated in combination with the tool, and installed in accordance with the manufacturer's instructions.

### 64.4.2 Bench top attachments

64.4.2.1 The stability of a bench-top attachment shall be such that it will not be overturned readily while in any position that might be encountered during intended use, including positions that might be encountered prior to and after operation.

64.4.2.2 To determine if an attachment complies with the requirement in 64.4.2.1, the combination of the attachment and a representative tool, mounted in accordance with the manufacturer's instructions, is to be placed, with the motor switched off, on a plane inclined at an angle of 7 degrees to the horizontal. The power-supply cord is to rest on the inclined plane in the most unfavorable position. If, however, the attachment is such that, were it to be tilted to an angle of 7 degrees when standing on a horizontal plane, a part of it not normally in contact with the supporting surface would touch the horizontal plane, the attachment is to be placed on a horizontal support and tilted in the most unfavorable direction through an angle of 7 degrees. The results are considered to be acceptable if the combination does not overturn.

64.4.2.3 Tests are to be conducted under the most unfavorable conditions, but with the motor unenergized. The attachment is to be placed on the inclined plane with all doors, drawers, and other movable or adjustable parts in the position tending to decrease the stability. If tested on a horizontal plane, the attachment is to be tipped in the direction of least stability. The attachment is to be tested in all possible positions that might typically be encountered while the attachment:

- a) Is in a position of being assembled or prepared prior to operation – for example, positioning parts of the attachment prior to adding functional parts;
- b) Is in position as if being used to perform one of its intended functions; and
- c) Is in a position of being disassembled or cleaned after operation – for example, with applicable functional parts removed.

#### 64.4.3 Floor supported attachments

64.4.3.1 A floor supported attachment that weighs 10 lb (44.8 kg) or more in combination with the recommended tool, mounted in accordance with manufacturer's instructions, shall not tip over when it is placed at the center of an inclined plane that makes an angle of 7 degrees with the horizontal and turned to the position most likely to cause tip-over.

64.4.3.2 The test mentioned in 64.4.3.1 is to be separately conducted under conditions most likely to cause tip-over. Consideration shall be given to all parts or options intended for use with the attachment. The attachment, with or without being installed on the tool, shall be arranged in its intended position with all doors, drawers, casters, wheels, and other appurtenances in the position that results in the least stability. The assembly is to be tipped in the direction most likely to overturn the unit. Legs and other means of support may be blocked to preclude the assembly from sliding.

64.4.3.3 An attachment provided with wheels or casters for mobility shall be retractable or of a locking design, or other means shall be provided to reduce unexpected movement of the tool during operation.

### 65 Marking

65.1 An accessory and an attachment shall be marked as indicated in 52.28 – 52.30.

65.2 A carbide tipped circular saw blade, flexible backing pad, and wire brush shall be permanently marked with the maximum speed, " \_\_\_\_\_RPM," or equivalent. The speed marking shall be located as indicated in Table 65.1.

**Table 65.1**  
**Location of speed marking**

Type of accessory	Location of marking
Circular-saw blades	On blade
Flexible backing pads	On pad
Wire brushes	On brush



65.3 A grinding wheel 4 inches (102 mm) or larger in diameter shall have the maximum operating speed in rpm clearly marked on the wheel. A grinding wheel less than 4 inches in diameter shall be marked either on the wheel or package.

65.4 A marking intended to protect against injury to persons shall be prefixed by the word "CAUTION," "WARNING," or "DANGER" in letters no less than 3/32 inch (2.4 mm) high. The marking shall also include an affirmative statement of the principal condition and the precautionary measure or instructions as to how to minimize the risk of injury.

65.5 A cautionary marking shall be permanent and shall be located on a permanent part of the accessory or attachment, or on a part that cannot be removed without impairing the operation of the accessory if there is sufficient room. If there is not sufficient room, the cautionary markings shall be in the instructions furnished with the accessory or attachment.

65.6 A permanent marking shall be:

- a) Etched;
- b) Molded;
- c) Die-stamped;
- d) Paint-stenciled;
- e) Stamped or etched on a permanently secured metal plate; or
- f) Indelibly stamped on pressure-sensitive labels secured by adhesive.

Ordinary usage, handling, storage, and the like of the accessory, attachment, or the tool with which the accessory or attachment is intended to be used shall be considered in determination of the permanence of the marking. See Section 53.

65.7 A wire brush shall be permanently marked "Wear eye protection," or the equivalent.

*Exception: If there is not sufficient room on the wire brush, the marking shall be in the instructions furnished with the wire brush.*

65.8 If the function of a handle, lever, knob, or other electrical or mechanical control is not obvious, it shall be identified either on the attachment or in instructions furnished with the attachment.

## **66 Instructions**

### **66.1 General**

66.1.1 An accessory or attachment shall be provided with instructions. The instructions may be packaged with the accessory or attachment or for small attachments may be printed on the package. The instructions shall specifically warn the user of each potential source of injury and shall state precautions necessary to guard against that condition. When attachment is packaged with the tool, see 56.4.

## 66.2 All accessories and attachments

66.2.1 The instructions shall include the following as applicable:

- a) The type or types of tools with which the attachment is intended to be used.
- b) "WARNING," and "To minimize the risk of eye injury, always use eye protection," or equivalent statement.

## 66.3 Specific accessories

66.3.1 The following statement or equivalent wording shall appear either on the packaging of a wire brush or in the instructions provided with the wire brush: "Allow wire brushes to run at operating speed for at least 1 minute before using wheel. During this time no one is to stand in front or in line with the brush.."

## BATTERY OPERATED TOOLS

### INTRODUCTION

#### 67 General

67.1 A battery-operated portable tool shall comply with the requirements in Sections 69 – 80, along with all applicable requirements in Sections 2 – 5, 8, 20 – 27, 52 – 56, and 62 – 66, and 45.3.1 – 45.6.5, 47.1.1 – 47.2.3, 47.5.1 – 47.5.7, 47.5.9, 48.1.1 – 48.2.6, and 48.10.1. The requirement in 47.2.2 applies to both HB and V-rated materials.

*Exception: The electrical ratings required in 52.1 need not be marked on a battery-operated tool.*

67.2 A battery-operated portable tool having a battery operating voltage greater than 30 V shall comply with the requirements listed in 67.1 along with all other requirements that are appropriate.

67.3 Unless otherwise specified, tests conducted on a battery-operated portable tool that involve discharging the battery supply shall be performed on one fully charged supply (battery package, and the like).

#### 68 Terminology

68.1 For the purpose of the requirements for battery-operated tools in Sections 70 – 80, the following definitions apply.

68.2 DETACHABLE BATTERY – A battery which is contained in a separate enclosure from the tool and is intended to be removed from the tool for charging purposes.

68.3 INTEGRAL BATTERY – A battery which is contained within the tool and is not removed from the tool for charging purposes. A battery that is to be removed from the tool for disposal or recycling purposes only is considered to be an integral battery.

68.4 SEPARABLE BATTERY – A battery which is contained in a separate enclosure from the tool and is connected to the tool by a cord.

## 69 Switches

69.1 A switch employed in a battery-operated portable tool shall comply with the Standard for Special-Use Switches, UL 1054, and have an electrical rating acceptable for the application.

*Exception: A switch complying with the requirements in Section 80 is acceptable for use in a battery-operated portable tool.*

## CONSTRUCTION

### 70 Battery Enclosure

70.1 A battery operated tool or battery pack and its enclosure along with their mounting means shall be constructed so as to withstand the Crush Test in Section 76, and the applicable impact test(s) in 45.6.3 – 45.6.5 without the following occurring:

- a) Externally caused mechanical damage to the jacket of a battery provided with the product if such damage might result in user contact with battery electrolyte.
- b) Dislodging of the battery from its intended position if such dislodging could result in short circuiting of the battery terminals or exposure of parts that might result in a short circuit.
- c) Internal short circuiting of the battery.

70.2 A battery or battery pack and its enclosure, along with the battery mounting means, shall be constructed so as to limit accidental or unintentional short-circuiting of the battery terminals after battery installation and during any other user servicing operation not involving battery replacement.

70.3 An enclosure of a battery or battery cell shall be provided with ventilation openings so located as to permit the circulation of air for dispersion of gases that may be generated under abnormal battery or charging conditions.

70.4 Holes provided in corners of the enclosure and openings at seams, joints, and splices typical of fabrication processes, will be considered to provide required ventilation for dispersion of battery gases.

### 71 Batteries, Battery Leads, and Connectors

71.1 A battery lead and insulation, if present, shall be resistant to acids or alkalies, unless a lead is not likely to be exposed to them.

71.2 A battery lead, connector, or other component in the charging circuit shall be routed, fixed, or spaced to reduce the likelihood of a short-circuit.

71.3 The configuration of a terminal pin or blade or any contact of a portable tool for connection to the battery circuit shall be constructed so that an appliance plug, flatiron plug, cord connector and attachment plug having conventional configurations as shown in the Standard for Attachment Plugs and Receptacles, UL 498, cannot be inserted to the extent that electrical contact is made.

## 72 Spacings

72.1 Spacing between uninsulated current-carrying parts of opposite polarity of a battery-supply circuit shall be:

- a) Not less than 1/64 inch (0.4 mm) for a circuit of 15 V or less not involving a risk of injury to persons;
- b) Not less than 1/32 inch (0.8 mm) for a circuit of 15 V or less involving a risk of injury to persons;
- c) Not less than 1/32 inch (0.8 mm) for a circuit of more than 15 V and not more than 30 V not involving a risk of injury to persons; and
- d) Not less than 1/16 inch (1.6 mm) for a circuit of more than 15 V and not more than 30 V involving a risk of injury to persons.

*Exception No. 1: The inherent spacings of a component, such as a snap switch, shall comply with the requirements for the component involved.*

*Exception No. 2: The minimum spacings are not required when no increased risk of fire exists as a result of shorting of two live parts of a tool located on a softwood surface covered by two layers of white tissue paper and covered with one layer of cheesecloth. A risk of fire exists when there is flame or charring of the tissue paper or cheesecloth either during or after the test.*

72.1 revised June 2, 1997

72.2 An insulating liner or barrier, made of vulcanized fiber or a similar material, and employed where spacings would otherwise be less than the minimum acceptable value, shall not be less than 1/64 inch (0.4 mm) thick. An insulating liner or barrier shall be so located or made of such material that it will not be adversely affected by arcing.

72.3 If an insulating liner or barrier is made of a material other than as mentioned in 71.2, it may be used provided the material is found – upon investigation – to have electrical insulating and mechanical properties that are equivalent to or better than 1/64 inch (0.4 mm) thick vulcanized fiber.

72.4 Spacings between an enclosure of polymeric material with a flammability rating of HB and a non-arcing uninsulated current-carrying part (for example, a busbar, a connecting strap, or a terminal) shall not be less than 1/32 inch (0.8 mm).

*Exception No. 1: Spacings may be less than 1/32 inch (0.8 mm) provided that it is determined that the reduced spacings will not result in igniting of the enclosure due to abnormal conditions.*

*Exception No. 2: Spacings may be less than 1/32 inch (0.8 mm) provided that the polymeric material used for the enclosure (flammability rating of HB) has a hot wire ignition (HWI) Performance Level Class (PLC) of 0, 1, or 2, determined according to the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.*

72.4 revised January 5, 2000

72.5 Spacings between an enclosure of polymeric material with a flammability rating HB and an arcing part (for example, a commutator or an unenclosed switch contact) shall not be less than 1/4 inch (6.3 mm). Spacings are to be measured from the source of the arc.

*Exception No. 1: Spacings may be less than 1/4 inch (6.3 mm), but not less than 1/32 inch (0.8 mm), provided that it is determined that the reduced spacings will not result in igniting of the enclosure due to abnormal conditions.*

*Exception No. 2: Spacings may be less than 1/4 inch (6.3 mm), but not less than 1/32 inch (0.8 mm), provided that the polymeric material used for the enclosure (flammability rating of HB) has a high-current arc ignition (HAI) Performance Level Class (PLC) of 0 or 1 determined according to the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.*

72.5 revised January 5, 2000

72.6 Spacings to enclosures of material with a flammability rating V-2 or better are not required to be measured.

72.6 revised January 5, 2000

72.7 Uninsulated current-carrying parts of a battery supply circuit that may present a risk of fire or injury to persons if bridged, shall be so located or enclosed that they can not be bridged by a 2 inch (50.8 mm) long, 1/4 inch (6.3 mm) diameter, probe inserted through any opening in the enclosure.

72.8 In applying the probe mentioned in 72.7, any part of the enclosure that can be removed without the use of a tool (that is, covers used to allow access to the interior for making operating adjustments, or other similar reasons), is to be removed.

### **73 Internal Wiring**

73.1 Internal wires that are required to be insulated shall be appliance wiring material having a minimum 1/64 inch (0.4 mm) thickness of insulation.

73.2 Insulating tubing employed in lieu of required wire insulation shall have at least a nominal wall thickness of 1/64 inch (0.4 mm).

73.3 The thickness of insulation on a splice requiring insulation shall be 1/64 inch (0.4 mm) or more. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other tubing is acceptable, consideration is given to such factors as its dielectric properties, heat-resistant and moisture-resistant to characteristics and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

73.4 In lieu of the thickness specified in 73.1 – 73.3, insulation employed in a battery operated tool shall not be less than 1/64 inch (0.4 mm) unless the wiring material is found upon investigation to have electrical and mechanical properties acceptable for the application.

73.4 added June 2, 1997

### **74 Battery Charger**

74.1 A battery charger or a battery charging circuit shall comply with the Standard for Class 2 Power Units, UL 1310, or the Standard for Power Units Other Than Class 2, UL 1012, as applicable for the particular charger or charging circuit and as applicable for the load to which the charger or charging circuit is connected.

## PERFORMANCE

### 75 Charging Input Test

75.1 After being discharged in accordance with 75.3 – 75.5, a battery operated tool shall be tested in accordance with 75.2.

75.2 The tool shall be operated in the charge mode, and the charger output amperage is to be monitored and recorded after five minutes. The test shall be conducted in all modes in which charging of the batteries is possible. The output current during the charging operation of a tool employing a charger that complies with the requirements in UL 1310, the Standard for Class 2 Power Units, or UL 1012, the Standard for Power Units Other Than Class 2, shall not exceed the marked charger rating at any time during charging.

*Exception: The output current of the charger that complies with UL 1012 or UL 1310 may exceed the marked charger rating during charging provided the tool battery and charger combination complies with the Temperature Test requirements of the applicable charger standard.*

75.3 If the tool is to use a lead-acid battery or batteries, each battery is to be discharged to 1.75 volts per cell at a rate not to exceed the discharge rate assigned by the battery manufacturer, but in any case, the rate of the discharge is not to exceed one-sixth of the ampere-hour capacity of the battery.

75.4 If the tool uses a typical 1.2 Volt per cell nickel-cadmium battery or batteries, each battery is to be discharged to 0.9 volts per cell. The discharge is to be conducted by placing a variable resistance across the battery initially adjusted to result in eight times the ampere-hour rating of the battery. No further adjustment of the resistance is to be made during the discharge procedure.

75.5 If the tool uses a battery or batteries other than those specified in 75.3 and 75.4, the battery is to be discharged in accordance with the battery manufacturer's maximum recommended discharge rate to an appropriate discharge voltage.

### 76 Crush Test

76.1 Three samples of each of the following are to be tested:

- a) For a tool with internal batteries, that section of the enclosure that houses the batteries.
- b) For a tool with a removable battery pack, that section of the tool that houses the battery pack is to be tested with the battery pack in the tool; the battery pack enclosure is also to be tested with the battery pack removed from the tool.
- c) The battery enclosure of a tool with a separable battery pack connected to the tool by an interconnecting cord (not enclosed by the tool when used).

76.2 The samples shall withstand for one minute a crushing force of 250 lbf (1,112 N) applied in any direction at right angles to its major axis. Any testing equipment that can apply a steady force of 250 lbf to the enclosure may be employed. The enclosure is to be tested between two 1/2 inch (12.7 mm), or thicker, parallel flat maple blocks, having dimensions sufficient to completely cover the tool. The crushing force is to be applied gradually. Following the test, the samples are to be examined for compliance with the requirement of 70.1.

## 77 Temperature Test

77.1 The temperature rise on the surfaces which may be contacted by the user and the internal electrical components of a battery-operated portable tool shall not exceed those given in Table 33.1. The temperature rises are to be measured while the tool is operated when loaded in accordance with 77.2, until thermal equilibrium or battery discharge is obtained. The test is to be started with a fully-charged battery as specified by the instructions provided with the tool.

*Exception No. 1: The temperature limits do not apply to a cutting edge of a tool or the coils of a motor.*

*Exception No. 2: The temperature rise is not required to be measured on an internal component whose failure would not result in a risk of injury to persons.*

*Exception No. 3: The temperature rise is not required to be measured on an internal component that still operates as intended at the end of the Abnormal Operation Tests, Section 79.*

77.2 In accordance with the loading condition specified in 77.1, the tool is to be operated in accordance with one of the following:

- a) The tool is to be loaded in accordance with the manufacturer's instructions; or
- b) The tool is to be loaded at the dc no-load current of the tool.

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## 78 Dielectric Voltage Withstand Test

78.1 A battery operated tool which could cut into an area which may conceal wiring shall withstand without breakdown for one minute the application of a 60 Hz essentially sinusoidal potential of 1000 V between the insulating grasping surfaces of the tool and accessible dead metal surfaces which may become energized. For examples of tools likely to cut into concealed wiring, see 20.9.

78.2 To determine whether a battery-operated portable tool complies with the requirements in 78.1, the test potential is to be applied as described in 34.6 by means of test equipment having the characteristics outlined in 34.5.

## 79 Abnormal Operation Tests

79.1 If a battery-operated portable tool employs one or more semiconductors or capacitors, or a combination of both, no risk of fire or injury to persons shall result when:

- a) The terminals of any capacitor are short- or open-circuited;
- b) Any two terminals of a semiconductor are short- circuited; or
- c) Any semiconductor terminals are open-circuited.

*Exception: This requirement does not apply to components located within a switch.*

79.2 If an accessible cord is used between the battery and charger, a direct short shall be introduced in the cord and maintained until ultimate results are obtained. The short is to be introduced at that point in the cord most likely to produce adverse results. The cord is to be covered with a 1/2 inch (12.7 mm) layer of dry absorbent surgical cotton. A fire shall not result in the tool, cord, charger, or cotton.

79.3 One sample of the battery operated tool is to be placed on a softwood surface covered by two layers of white tissue paper. The sample is to be covered with one layer of cheesecloth. A short circuit is to be introduced at the motor terminals. The switch is then to be energized and the short-circuit current is to flow until ultimate results are obtained. There shall be no evidence of flame or charring of the tissue paper or cheesecloth either during or after the test.

79.4 One sample of the battery operated tool is to be placed on a softwood surface covered by two layers of white tissue paper. The sample is to be covered with one layer of cheesecloth. The rotor of the application is to be locked in an on position, and the tool is to be energized. This locked rotor condition is to be maintained until burnout occurs. There shall be no evidence of flame or molten metal external to the unit as a result of this test.

79.5 One sample of the removable battery or battery pack is to be placed on a softwood surface covered by two layers of white tissue paper. The sample is to be covered with one layer of cheesecloth. The terminals of the battery are to be short-circuited using a 24 inch (610 mm) length of 4 AWG (21.15 mm<sup>2</sup>) cable until ultimate results are obtained. There shall be no evidence of flame or charring of the tissue paper or cheesecloth either during or after the test.

*Exception No. 1: A battery having terminals that are recessed or otherwise protected against the risk of electrical short need not be subjected to this test.*

*Exception No. 2: A smaller gage wire may be used if it is suitable for the ampacity.*

79.6 A battery used for the test described in 79.2 shall be fully-charged and capable of delivering its rated capacity when in the fully charged condition.

79.7 A battery used for the test described in 79.2, 79.3, 79.4, and 79.5 shall be fully-charged and capable of delivering its rated capacity when in the fully charged condition.

## **80 Switch Tests**

### **80.1 General**

80.1.1 A switch referred to in the exception to 69.1 is to be subjected to the overload and endurance tests described in 80.2.1 and 80.3.1. The tests shall not result in an increase in the risk of fire or injury to persons. There shall be no ignition of the switch materials. The switch shall be capable of completing the tests without resulting in the possibility of loss of off control or unexpected turn on of the tool due to switch failure.

### **80.2 Overload**

80.2.1 A switch shall be subjected to 50 operations of making and breaking the locked rotor current of a fully charged battery operated tool.

### **80.3 Endurance**

80.3.1 A switch shall be subjected to 6000 cycles of operation making and breaking the normal no load current encountered in the fully charged battery-operated tool.

## APPENDIX A

### Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

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Attachment Plugs and Receptacles – UL 498  
Cord Sets and Power-Supply Cords – UL 817  
Flexible Cord and Fixture Wire – UL 62  
Fuseholders – UL 512  
Fuses for Supplementary Overcurrent Protection – UL 198G  
Fuses, Plug – UL 198F  
Lampholders, Edison-Base – UL 496  
Motors, Electric – UL 1004  
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94  
Polymeric Materials – Long Term Property Evaluations – UL 746B  
Polymeric Materials – Short Term Property Evaluations – UL 746A  
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C  
Power Units, Class 2 – UL 1310  
Power Units Other Than Class 2 – UL 1012  
Printed-Wiring Boards – UL 796  
Switches, Special-Use – UL 1054  
Systems of Insulating Materials – General – UL 1446  
Tape – Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510  
Thermal Cutoffs for Use in Electrical Appliances and Components – UL 1020  
Tubing, Extruded Insulating – UL 224  
Wires and Cables, Rubber-Insulated – UL 44  
Wires and Cables, Thermoplastic-Insulated – UL 83

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## **CRG 45 CANADIAN REQUIREMENTS COMPARISON GUIDE**

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### **UL AND CANADIAN STANDARDS FOR PORTABLE ELECTRIC TOOLS**

Product Category: Portable Electric Tools  
UL Category Control Number: XKFR

UL Standard:

Standard for Portable Electric Tools  
UL 45  
Eighth Edition

Canadian Standard:

Portable Electric Tools  
CAN/CSA-C22.2 No. 71.1  
Second Edition

This Canadian Requirement Comparison Guide is only intended to identify Canadian requirements that must be applied in addition to the requirements in the UL Standard to obtain a C-UL Mark. The guide is not intended to replace a through review and comparison of the requirements applicable to the product category as contained in the applicable UL and Canadian Standards. Where requirements are not specifically addressed, compliance with the requirements in the UL Standard satisfy the requirements in the Canadian Standard.

The actual requirements applied for a C-UL product investigation may differ from those identified in this guide based on the specific features, characteristics, components, materials, or systems used in the product.

CRG: 45

Issue No.: 1

Issue Date: May 6, 1997

Revisions of this guide will be made by issuing revised or additional pages bearing their date of issue. A Canadian Requirement Comparison Guide is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revision pages for the Guide.

The following outlines the requirements contained in CSA C22.2 No. 71.1 that are in addition to the requirements in UL 45 that must be met in order for a product to bear the appropriate UL Marking. UL provides a certification program for products that meet the Canadian requirements. The C-UL Mark is the manufacturers assurance that products as evaluated by UL, continue to comply with the appropriate Canadian requirements.

Requirements Topics	CSA Clause	Comparison
<b>CONSTRUCTION</b>		
Components	4.1.1	Look for CSA Certified or c-UL Listed components. If the components are not there, the applicable CSA standard shall be used.
Openings In Enclosures	4.2.2.1, Figure 1	The length and depth of enclosure openings is to be evaluated with the probe illustrated in Figure 1.
Accessibility to Moving Parts of Circular Saws	4.3.2.6, Figure 5	The probe shall not touch the circular saw blade.
Guards	4.3.1.2	All tools employing guards shall require the use of a tool to remove the guard.
Power Supply Cord Length	4.5.2.1	The power supply cord shall be 1.8 m or more or, for a cord terminating in a locking type attachment plug, less than or equal to 460 mm.
Outdoor Use Power Supply Cords	4.5.2.6	The power supply cord for tools intended to be used outdoors shall be of a type suitable for outdoor use.
Thickness of Insulating Material	4.8.3	Internal wiring shall be suitable for the application with respect to temperature, voltage, exposure to oil or grease, and other conditions.
Maximum Operating Voltage	Table 5	The maximum operating voltage for tools covered under CSA C22.2 No. 71.1 is 375 V.
<b>PERFORMANCE</b>		
Temperature Test	6.4.4	The Temperature Test is to be conducted at the extreme operating voltages of the supply system.
Temperature Test	6.4.7	A tool that is normally operated in both directions is to be temperature tested in both the forward and reverse direction.
Input Test and Temperature Test for Grinders	6.3.6.1	A grinder is to be loaded with the tool grinding steel or with the manufacturer's recommended accessory producing the highest load. This affects the temperature test.
Starting Current	6.5	Three consecutive starts of the tool are to occur at either room temperature or normal operating temperature, whichever results in the higher input current.

## Table Continued

Requirements Topics	CSA Clause	Comparison
Leakage Current Test	6.6.4, 6.6.5	All tools are cycled on/off, at extreme voltages, rotated every four hours in three different positions, for a total of 48 hours. The tool is then subjected to a 50% dielectric strength test and leakage current test following humidity conditioning.
Dielectric Strength	6.7	The dielectric test voltage is twice rated voltage plus 1000 V.
Strain Relief	6.9	A torque is to be applied between the cord and enclosure for 1 minute, followed by a steady pull on the power supply cord in any direction a total of 10 times.
Cord Flexing	6.10.3	Following the cord flex cycling, the cord is to carry twice its rated ampacity for 2 minutes. During that 2 minutes, the temperature of the cord shall not exceed the temperature rating of the insulation.
Physical Abuse	6.11.1	Three impacts are to be performed on the same sample.
Brush Cap Impact	6.11.3	A single 1.4J impact is to be introduced to the brush cap.
Switch Impact	6.11.4	Before and after oven conditioning, switches and controls are to be subjected to 3 impacts with a 1.4J force.
Switch Performance	6.12	In addition to meeting CSA C22.2 No. 55 or 111, a switch shall also pass 50 locked rotor cycles and 25 cycle endurance tests for ac and dc acceptance.
Oven Conditionings	6.13	The oven conditioning is to be conducted at a minimum of 90°C.
Abnormal Operation	6.16.1, 7.6.4.3	An abnormal operation evaluation is required on both grounded and double insulated tools.
Dielectric Strength	7.6.1, Table 9	The tool is to withstand the potentials defined in Table 9.



**Table Continued**

<b>Requirements Topics</b>	<b>CSA Clause</b>	<b>Comparison</b>
MARKINGS		
Markings	5.5	A tool with male pins or blades shall be marked to indicate the correct extension cord type and ampacity.
French Markings	5 (5.7 – 5.10)	Warning markings are to be in French and English.
No-Load Speed Marking	5.1	All tools having a rotary output shaft shall have the maximum no-load speed clearly marked.
Marking for DI Tools	7.5.2	A double-insulated tool that is likely to cut into a wall shall be marked to warn the user that the tool could become live.

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Subjects 45 (745)

12 Laboratory Drive  
Research Triangle Park, NC 27709  
October 13, 1997

**TO: Industry Advisory Conference of UL for Portable Electric Tools,  
Consumer Advisory Council of Underwriters Laboratories Inc.,  
Casualty Council of Underwriters Laboratories Inc.,  
Electrical Council of Underwriters Laboratories Inc.,  
Subscribers to UL's Standards Service for  
Portable Electric Tools**

**SUBJECT: Announcement of Significant Interpretations for Portable Electric Tools**

UL announces significant interpretations for UL 45 and UL 745, the Standards for Portable Electric Tools. A significant interpretation is a clarification that better defines a requirement for future applications. A significant interpretation can also be a decision to apply or not to apply a requirement that will result in an impact to existing Listed, Recognized, or Classified products or that will have an impact on future submittals. Attached as Appendix A are details concerning the significant interpretations.

This bulletin should be kept with your copy of the Standard.

Questions regarding interpretation of requirements should be directed to the responsible UL Staff. Please see Appendix B of this bulletin regarding designated responsibility for the subject product categories.

UNDERWRITERS LABORATORIES INC.

REVIEWED BY:

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45ANN97.001

APPENDIX A**1. WALL SAWS****BACKGROUND**

Wall saws are tools that are designed to cut a slot or channel in a concrete wall or floor. These saws are usually not provided with guarding for the blade since the cutting blade is a diamond wheel and the lower portion of the blade is not exposed during the cutting operation. The tools are also designed to make plunge cuts into the concrete surface. The concern raised was whether the exposed blade located below the bottom of the shoe was required to be guarded.

**DECISION**

A guard is not required for this type of saw if the following conditions are met:

- 1) the saw must have two distinct movements to activate the switch,
- 2) the coast down time must be reasonable (similar to the maximum coast time for other saws), and
- 3) the manual must state that the saw is not to be used as a circular saw.

This significant interpretation will have no impact on currently Listed products.

**2. CIRCULAR SAW PROBE****BACKGROUND**

Clause 18.101 of UL 745-1 delineates the guarding required to minimize the risk of accidental access to a rotating blade or knife. Paragraph 2 of this clause indicates that the periphery of the blade or knife shall be effectively guarded from the rear and sides by a fixed guard, and access to the front shall be limited as defined by the application of a cylindrical probe, 13 mm in diameter and 50 mm long.

**DECISION**

Clause 18.101.1 of UL 745-1 is a clarification of clause 18.101. The probe is intended to remain parallel to the platen at all times and is to be maintained at a uniform height above the platen. A uniform practice is required to obtain reproducible results.

This significant interpretation will have no impact on currently Listed products.

**3. APPLICATION OF 6 mm BALL****BACKGROUND**

Presently, clause 8.1 of UL 745-1 requires that a 6 mm ball be placed at all ventilation openings with the exception of openings adjacent to the fan. Each of the other probes specify a force to be used, but in the case of the 6 mm ball, no force is given.

**DECISION**

No force is to be applied when testing ventilation openings with the 6 mm ball. The tool is not required to be placed on the ball as means to force the ball into the openings; nor is the tool to be activated in an effort to create a suction that might draw the ball into the openings.

European testing agencies do not use force when testing the ventilation openings with the 6 mm ball. To maintain consistency with the European agencies, UL will follow the same guideline.

This significant interpretation will have no impact on currently Listed products.

#### **4. AIR GAP BETWEEN LIVE PARTS AND ENCLOSURES**

##### **BACKGROUND**

Tool constructions in UL 45 require a minimum air gap of 0.8 mm between live parts and the plastic enclosure. Reinforced insulation is only allowed to be used when it is not possible to accommodate the use of basic and supplementary insulation.

The requirement in clause 20.8 of UL 745-1 implies that it is acceptable for the enclosure to serve as reinforced insulation if it is manifestly impossible to provide separate basic and supplemental insulation. However, it has been the practice of certain European labs to allow live parts to contact a single layer of enclosure material serving as reinforced insulation provided the material will meet construction and end-product testing for reinforced insulation.

##### **DECISION**

Live parts are allowed to contact the enclosure provided that the minimum thickness and performance test requirements for reinforced insulation are met. To maintain consistency with European labs and agencies, UL will follow the same guideline.

This significant interpretation will have no impact on currently Listed products.

#### **5. TRANSPORTABLE TOOL CORD FLEX TEST**

##### **BACKGROUND**

Clause 23 of UL 745-1 provides requirements for supply connections and external flexible cables and cords. Clauses 23.6 and 23.7 of UL 745-1 require flexibility testing for cords on all tools.

##### **DECISION**

While transportable magnetic drill presses and diamond core drills are subjected to portable tool requirements of UL 745-1, they will not be subjected to a cord flex test. UL 745-2-31 and UL 745-2-32 are to be revised to state that clause 23 of part 1 is not applicable.

This significant interpretation will have no impact on currently Listed products. This test is not conducted in UL 45.

#### **6. REMOVABLE GRINDER GUARDS**

##### **BACKGROUND**

A client has designed a grinding wheel that does not require the use of tools for removal. The guard is removed by depressing a lever and rotating the guard 180° before the guard can be removed.

However, clause 18.1, paragraph 2 of UL 745-1 states: "Protective enclosures, guards, and the like shall have adequate mechanical strength. They shall not be removable without the aid of a tool, unless their removal is necessary in normal use as specified in the relevant Part 2".

**DECISION**

The user must make a conscious effort to remove the guard. In this case, the guard is removed by depressing a lever and rotating the guard 180°. The guard must pass all construction requirements and required tests.

A review may be necessary to determine if this construction was previously rejected under requirements of the First Edition of UL 745-1.

APPENDIX B

## DESIGNATED RESPONSIBILITY FOR UL

## XKFR, XJYW, PORTABLE ELECTRIC TOOLS

The individuals shown in the following table are involved with the investigation of products covered under the subject categories. The Primary Designated Engineer (**shown in UPPERCASE letters**) coordinates the establishment and uniform interpretation of UL requirements applicable to the product categories. The Designated Engineers (**shown in lowercase letters**) work with the Primary Designated Engineer to interpret requirements and maintain standards.

Should you have questions regarding the requirements that affect your product, you are encouraged to contact the individual at the office to which you normally submit your products.

The Industry Advisory Conference (IAC) Chairman for the subject categories is Gary Schrempp at UL's Research Triangle Park office. The IAC Chairman oversees the significant interpretations made by the Primary Designated Engineer and arbitrates any differences regarding interpretation of UL requirements.

CCN	Office/Subsidiary	Responsible Engineer	Extension
XKFR XJYW	Camas	Mark Steinke	55614
	Melville	John Stimitz	22214
	Northbrook	Paul Wordlaw	42995
	RTP	MICHAEL BELCHER	11649
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