

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.

The revisions dated January 5, 2000 were issued for editorial corrections. These corrections include any combination of the following: Updated Foreword (item D); Updated Scope; title changes to UL 489 and/or UL 1950; Withdrawn standards, UL 519 and UL 547, being replaced by UL 2111; Removal of the "94" flammability classification. These revisions may also include other miscellaneous editorial corrections.

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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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CRG 45 CANADIAN REQUIREMENTS COMPARISON GUIDE

UL AND CANADIAN STANDARDS FOR PORTABLE ELECTRIC TOOLS	CRG1
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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:

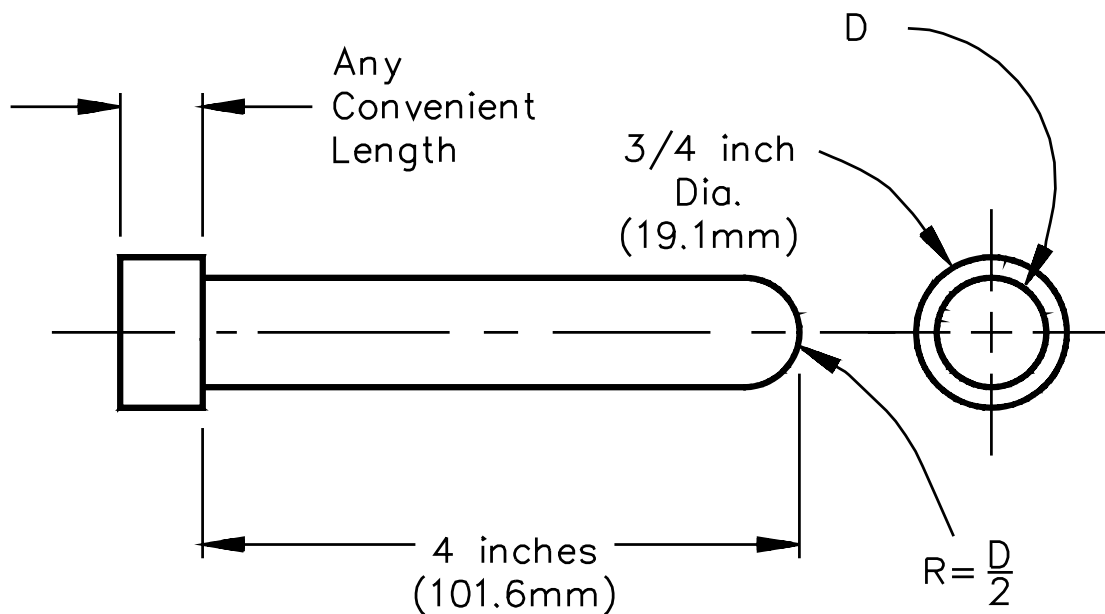
- a) Mechanical strength.
- b) Resistance to impact.
- c) Moisture-absorptive properties.
- d) Combustibility.
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of intended use and reasonably foreseeable abuse.
- f) Resistance to arcing.

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

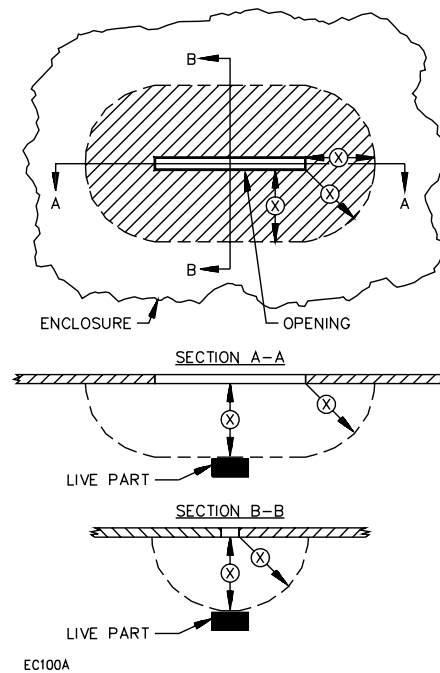
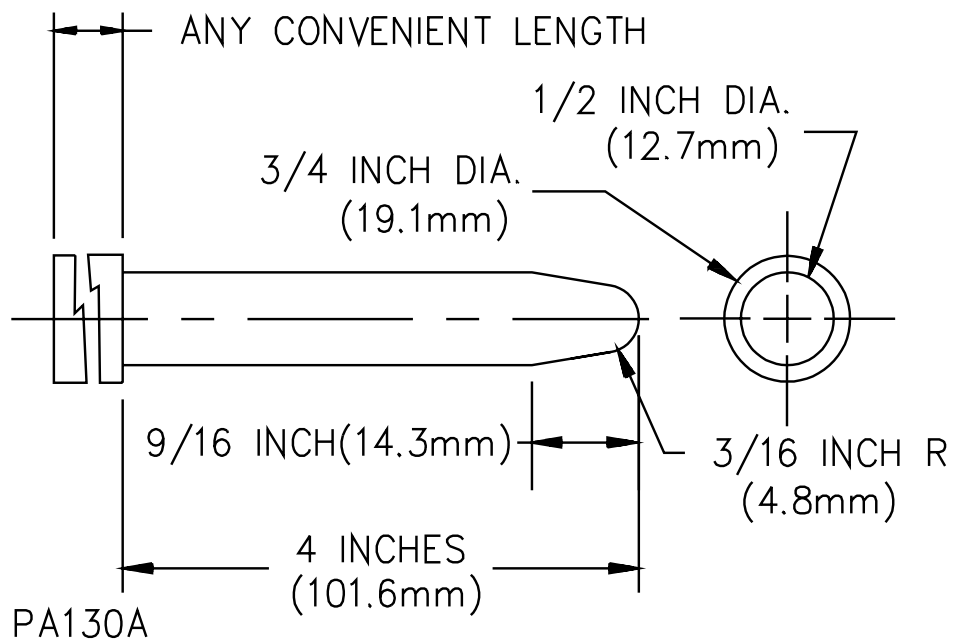


Figure 6.3
Probe for uninsulated live part



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.

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Table 9.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Wire intended to be grounded ^a	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
^a 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 mm²) 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 mm²) 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 ^a	(0.76)	No ^a	—	
Cross-linked synthetic polymer	0.015	(0.38)	No	—	
^a 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 ^c		Motor diameter more than 7 inches (178 mm) ^c	
	Over surface	Through air	Over surface	Through air
0 – 125	3/32 (2.4)	3/32 (2.4)	1/4 ^{a,b} (6.4)	1/8 ^{a,b} (3.2)
126 – 250	3/32 (2.4)	3/32 (2.4)	1/4 ^{a,b} (6.4)	1/4 ^{a,b} (6.4)
251 – 600	1/2 (12.7)	3/8 ^b (9.5)	1/2 ^b (12.7)	3/8 ^b (9.5)

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

^b 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.

^c 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.

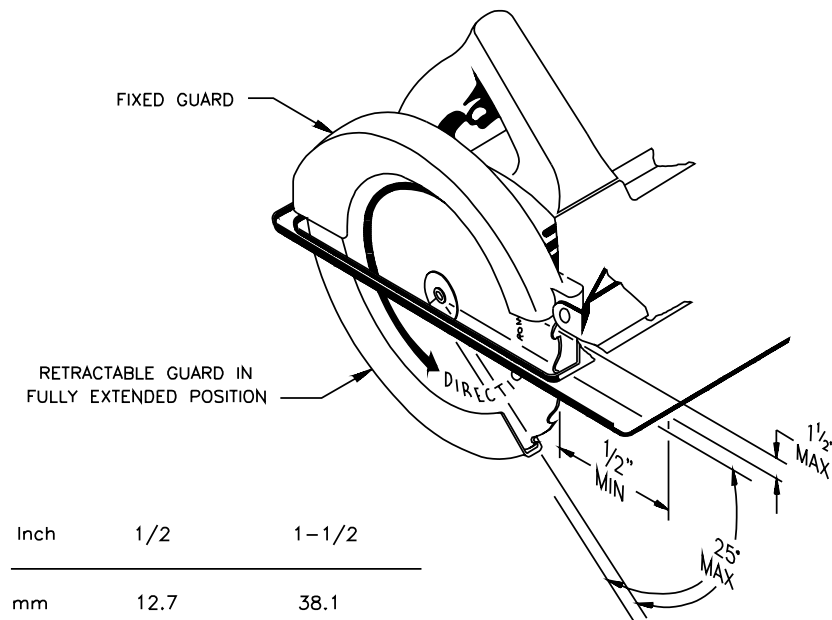
27.1.2 A circular saw shall be provided with a guard that:

- 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.

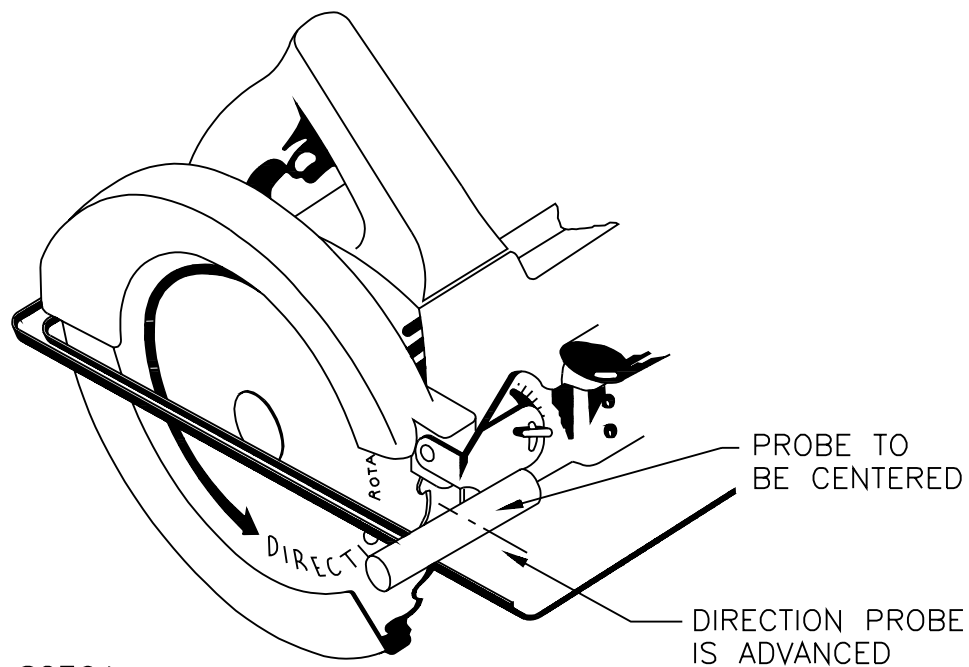
- c) Extends at least to the root of the teeth; and
- d) Provides protection such that a 1/2-inch (12.7-mm) diameter rod, 2 inches (50.8 mm) long, will not touch the blade teeth when advanced toward the blade from the front of the saw, perpendicular to the blade, parallel to the table and above the table. 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



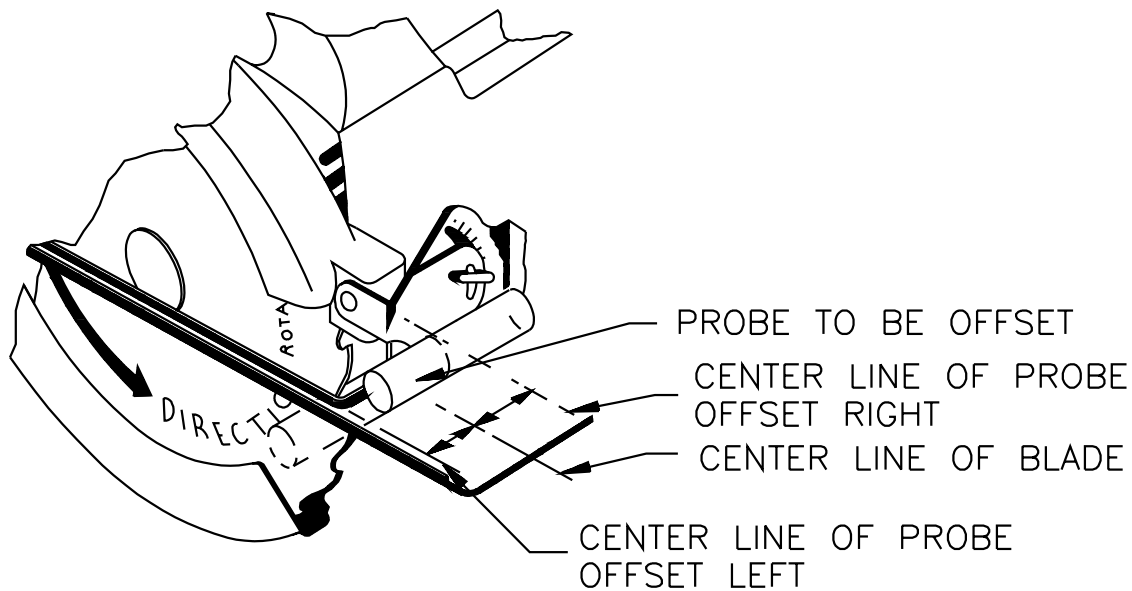
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Figure 27.2
Guard illustrating test probe centered



S2764

Figure 27.3
Guard illustrating probe offset



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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 ^a	B ^a	A ^a	B ^a	A ^a	B ^a	A ^a	B ^a
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 ^a 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)

^a 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 ^a	B ^a	A ^a	B ^a	A ^a	B ^a		
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)		
9,500 (47.5)	2 (50.8)	1/16 (1.6)	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)	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)	—	—		

^a 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^a

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)

^a See Figure 27.6.

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

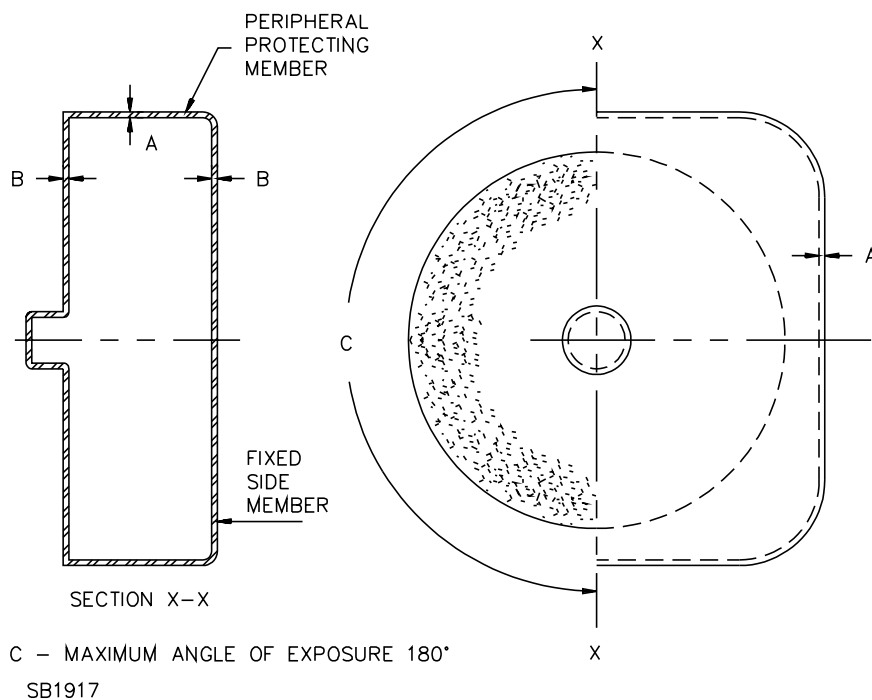


Figure 27.5
Typical drawn-steel guard for type 1 straight wheels not more than 10 inches in diameter

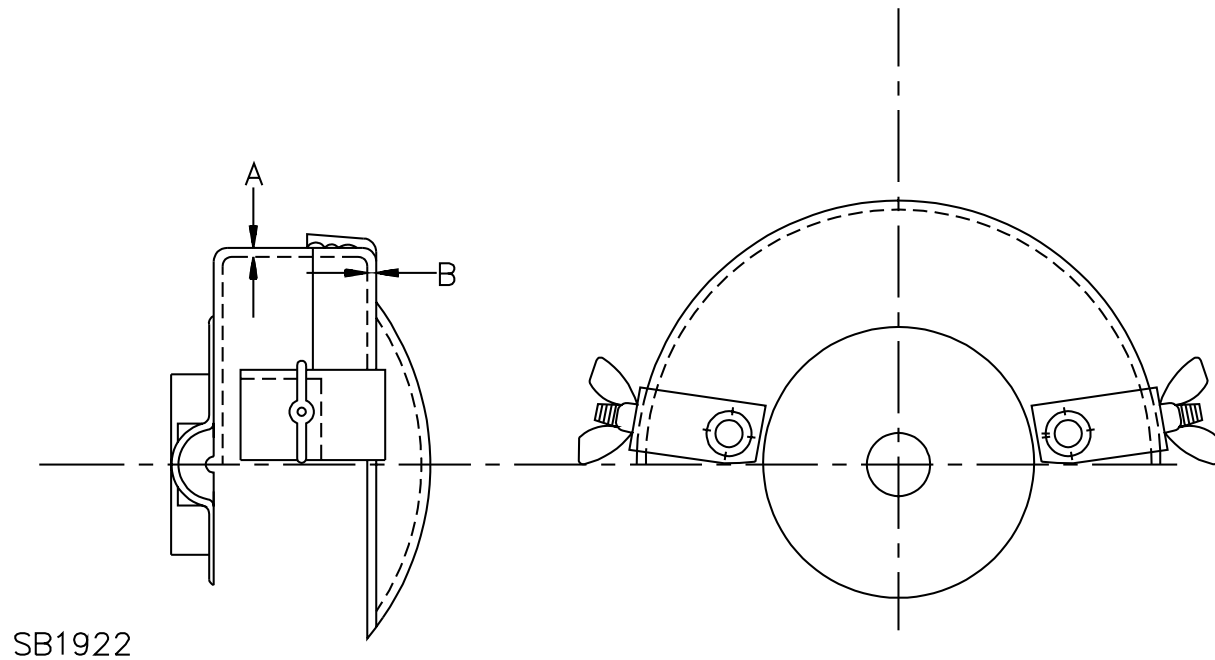
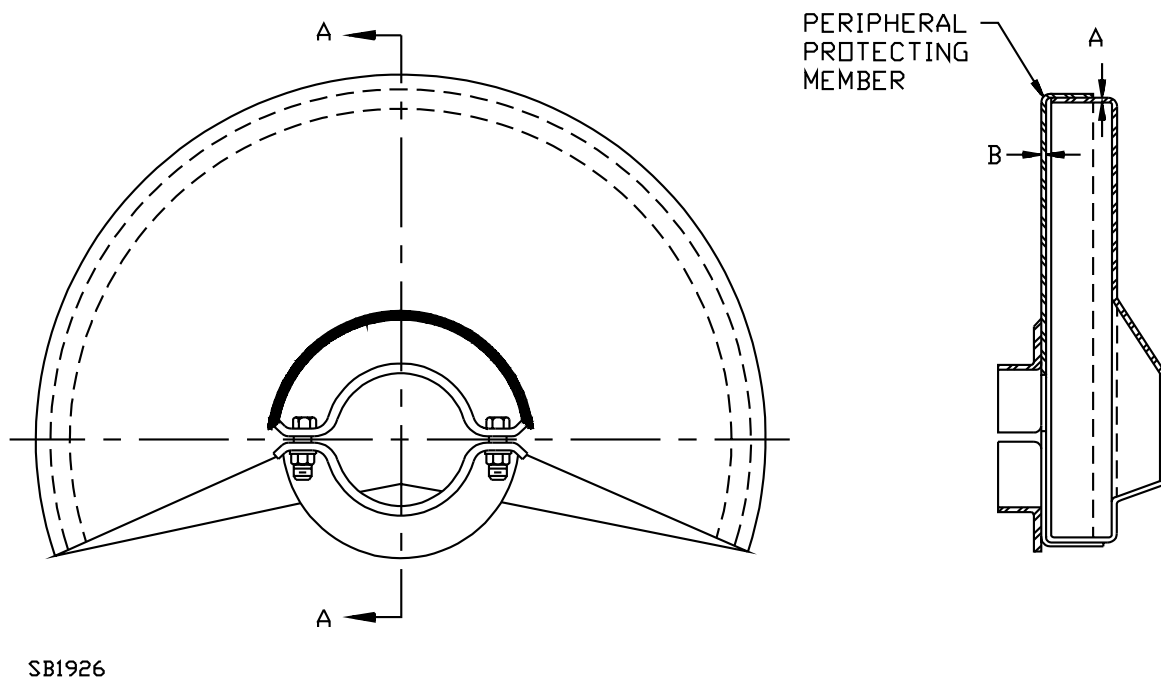


Figure 27.6
Typical guard for cutting-off wheels



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.

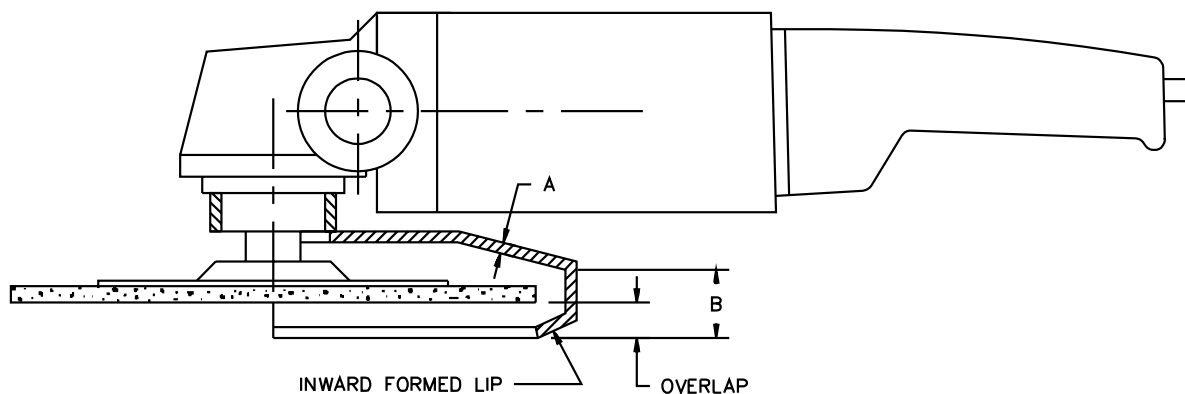
Table 27.4
Drawn-steel guard for types 27 and 28 thin abrasive wheel

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 ^a	B ^a
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)

^a See Figure 27.7.

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

Figure 27.7 revised August 7, 1998



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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.

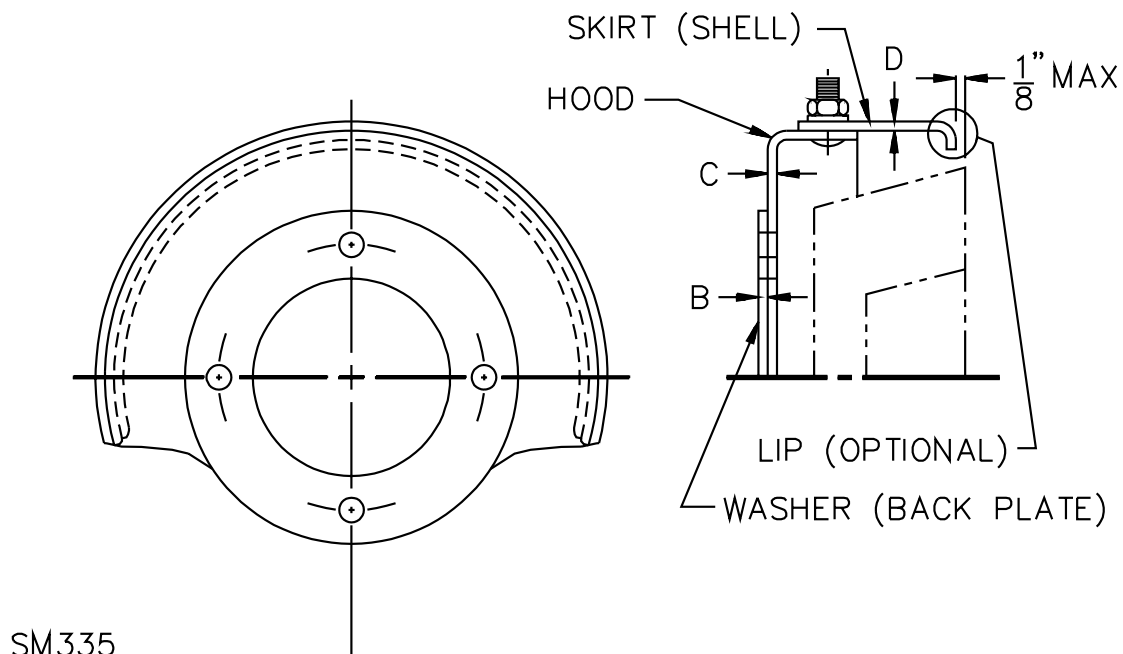
Table 27.5
Material thickness for drawn steel cup type wheel guards^a

Wheel Diameter, Inches (mm)	B Washer Back Plate Thickness,		C Hood,		D Skirt	
	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)

^a 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



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.

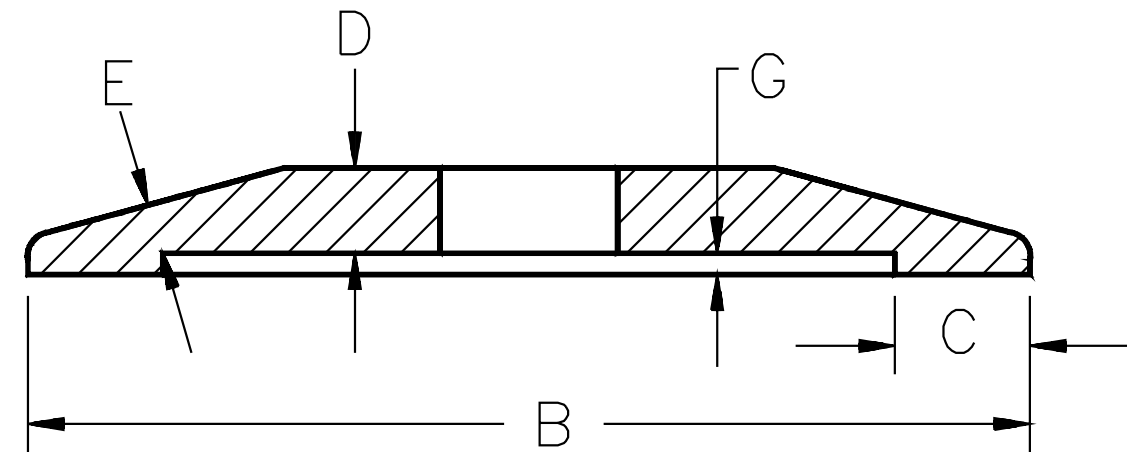
27.3.21 A Type 27 wheel 5 inches (127 mm) or smaller, shall be mounted as indicated in 27.3.18 or 27.3.20.

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^a

Figure 27.9 revised August 7, 1998



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^a See Table 27.6 for dimensions

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