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March 20, 1996

Revision pages for

Standard for

Portable Electric Tools

UL 45, Seventh Edition

Attached to this transmittal notice is a revision of the Seventh edition of UL 45.

A CHANGE ON A PAGE DATED MARCH 20, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THIS REVISION IS BEING ISSUED TO REVISE THE STANDARD TO REPLACE TYPE W-A WITH TYPE W CORDS FOR OUTDOOR USE. SUBITEM 1 OF ITEM E OF PARAGRAPH 54.5 IS ONLY EFFECTIVE UNTIL JULY 2, 1998.

THIS REVISION IS ALSO BEING ISSUED TO PUBLISH THE REQUIREMENTS THAT MUST BE APPLIED IN ORDER TO OBTAIN A c-UL MARK (CANADIAN REQUIREMENTS COMPARISON GUIDE — CRG (45)). THE CRG IS NOW IN EFFECT.

The new requirements are substantially in accordance with UL's bulletin on this subject dated March 6, 1996. The bulletin is now obsolete and may be discarded.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 45-1990.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the Department of Defense approved text of UL 45.

Revised and/or additional pages may be issued from time to time.

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With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

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Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated October 1, 1991. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

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The Department of Defense (DoD) has approved the Seventh edition of UL 45 on March 11, 1991. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the DoD approved text.

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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 or 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 differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, 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.

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	

^a 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.

Immersion Tests

53.3 Six samples of the test panels are to be placed in a controlled atmosphere maintained at $23.0 \pm 2.0^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) with a 50 ± 5 percent relative humidity for 24 hours. Three samples are then to be immersed in water and three samples immersed in No. 3 oil as specified in Tests for Rubber Property — Effect of Liquids ANSI/ASTM D 471 at a temperature of $21.0 \pm 2.0^\circ\text{C}$ ($69.8 \pm 3.6^\circ\text{F}$) for 48 hours in each case.

Standard Atmosphere Test

53.4 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 $23.0 \pm 2.0^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) with a 50 ± 5 percent relative humidity.

53A Test for Permanence of Cord Tag

General

53A.1 To determine compliance with paragraph 52.8A, representative samples that have been subjected to the tests described in paragraphs 53A.3 — 53A.6 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.

Added paragraph 53A.1 effective June 1, 1998

Test Conditions

53A.2 For each type of conditioning specified in paragraphs 53A.3 — 53A.5, 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.

Added paragraph 53A.2 effective June 1, 1998

53A.3 Three samples are to be tested as received.

Added paragraph 53A.3 effective June 1, 1998

53A.4 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 ± 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.

Added paragraph 53A.4 effective June 1, 1998

53A.5 Three samples are to be tested within 1 minute after exposure for 72 hours to a humidity of 85 ± 5 percent at $32 \pm 2^\circ\text{C}$ ($89.6 \pm 3.6^\circ\text{F}$).

Added paragraph 53A.5 effective June 1, 1998

Test Method

53A.6 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 item D of paragraph 53A.1, manipulation is permissible, such as straightening of the tag by hand. To determine compliance with item E of paragraph 53A.1, 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.

Added paragraph 53A.6 effective June 1, 1998

INSTRUCTIONS

54. Instruction Manual

54.1 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 (1) the dimensions and material of the work piece, and (2) 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 paragraph 55.4.

54.2 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.

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

54.4 Paragraph 54.4 deleted October 2, 1991

Figures 54.1 — 54.9 Figures 54.1 — 54.9 deleted October 2, 1991

54.5 The instruction manual for a circular saw shall include, in addition to those items that apply to circular saws in paragraphs 54.1 — 54.3, 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 54.10).

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. Instructions for use of an extension cord, including the instructions in (3) — (5) and either (1) or (2):

1. A statement, if the cord is intended to be used outdoors, indicating that the cord shall be marked with the suffix W-A following the cord type designation, for example — SJTW-A, to indicate it is acceptable for outdoor use.

2. A statement, if the cord is intended to be used outdoors, indicating that the cord shall be marked with the suffix W following the cord type designation, for example — SJTW, to indicate it is acceptable for outdoor use.

3. A statement indicating the proper size extension cords to be used with the tool — that is, wire size for various lengths of cord.

4. A statement that instructs the user to use an extension cord heavy enough to carry the current the tool will draw and that an undersize cord will cause a drop in line voltage resulting in loss of power and overheating.

5. A statement that the user should make sure the extension cord is in good condition before using.

F. 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: Items E and F do not apply to battery-operated portable tools.

*Paragraph 54.5(E)(2) acceptable alternative to
paragraph 54.5(E)(1) until paragraph 54.5(E)(2)
supersedes paragraph 54.5(E)(1) effective July 2, 1998*

54.6 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.

Added paragraph 54.6 effective June 1, 1995

CANADIAN REQUIREMENTS COMPARISON GUIDE

CRG 45

**UL AND CANADIAN
STANDARDS FOR**

PORTABLE ELECTRIC TOOLS



Documents
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Product Category: Portable Electric Tools

UL Category Control Number: XKFR

UL Standard: Standard for Portable Electric Tools
UL 45
Seventh 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 thorough 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: March 20, 1996

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.

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Requirements Topics	CSA Clause	Comparison
CONSTRUCTION		
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.
PERFORMANCE		
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.

Requirements Topics	CSA Clause	Comparison
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.
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.

Requirements Topics	CSA Clause	Comparison
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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THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT EXCEPT FOR PARAGRAPHS 27.67, 27.67A, 35.1A, 35.3 — 35.7, 45A.1, 52.8A, 58.11A — 58.11C, TABLE 35.1, AND SECTION 53A, WHICH BECOME EFFECTIVE JUNE 1, 1998 AS INDICATED IN THE SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL JUNE 1, 1998, DO NOT DISCARD THE PREVIOUS PAGES CONTAINING THE REQUIREMENTS SPECIFIED ABOVE UNTIL THIS FUTURE EFFECTIVE DATE.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this standard unless the applicant specifically requests that the product be judged under the current requirements. However, should the applicant elect this option, it should be noted that compliance with all the requirements in this standard will be required as a condition of continued Listing and Follow-Up Services after the effective date and understanding of this should be signified in writing.

The new and revised requirements are substantially in accordance with UL's bulletins on this subject dated July 25, 1995 and September 12, 1995. The requirements for motor speed controls proposed in the July 25, 1995 bulletin are not being adopted with these revisions. These bulletins are now obsolete and may be discarded.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 45-1990.

(Continued)

December 19, 1995 — UL 45

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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 differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, 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.

7.7 Compliance with the requirement in paragraph 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 paragraph 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 paragraph 41.1. If the pressure pad is exposed to grease, it shall also be tested in accordance with paragraph 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 paragraph 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 paragraph 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

Cords and Plugs

9.1 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.

9.2 Except as noted in paragraph 9.4, the flexible cord on a hand circular saw shall be at least 6 feet (1.8 m) long.

9.3 Except as noted in paragraph 9.4, the flexible cord on all other tools shall be at least 5 feet (1.5 m) long.

Paragraph 9.3 revised October 2, 1991

9.4 A tool may be provided with less than 5 feet (1.5 m) of permanently attached flexible cord (see paragraph 9.6) or with a motor attachment plug:

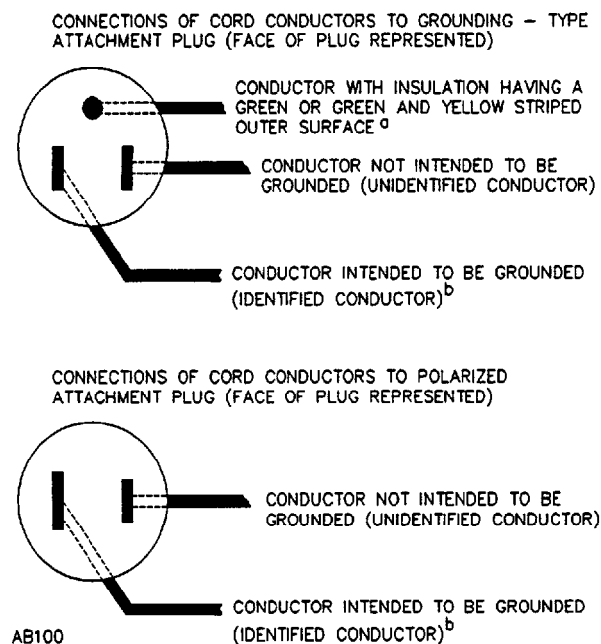
A. If the manufacturer makes an acceptable extension cord available, and if a statement indicating the availability of such extension cord is marked on the tool or is included in the instruction book or the like regularly furnished with the tool; or

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.

9.4A 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 paragraph 9.1.

Paragraph 9.4A effective June 1, 1995

FIGURE 9.1
CONNECTION TO ATTACHMENT PLUG



^aThe blade to which the green conductor is connected may have a U-shaped or circular cross section.

^bSignifies a conductor identified in accordance with Table 9.1.

Figure 9.1 effective June 1, 1995

9.5 Paragraph 9.5 deleted October 2, 1991

9.6 The power supply cord mentioned in paragraph 9.4 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.

Paragraph 9.6 revised October 2, 1991

9.7 A three-to-two wire grounding-type adapter shall not be provided with a tool employing a short cord as described in paragraph 9.4 unless an acceptable 3-wire grounding-type extension cord set is also provided with the tools.

Paragraph 9.7 revised October 2, 1991

9.8 Except as noted in paragraphs 9.10, 9.11, and 9.12, the flexible cord shall be hard-service cord, such as Type SJ, or extra-hard-service cord, such as Type S.

Paragraph 9.8 revised October 2, 1991

9.9 Paragraph 9.9 deleted October 2, 1991

9.10 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.

9.11 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.

9.12 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.

9.13 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.

9.14 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 — 1993, not less than the current rating of the tool.

Paragraph 9.14 revised December 19, 1995

9.15 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 paragraph 52.5.

9.16 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.

9.22 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.

Bushings

9.23 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.

9.24 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.

9.25 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.

9.26 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.

9.27 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 paragraph 9.28), 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.

9.28 A bushing of any of the materials mentioned in paragraph 9.27 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 paragraph 9.23.

9.29 If a bushing of one of the materials mentioned in paragraph 9.27 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.

9.30 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 (1) if permitted in accordance with Section 3, or (2) within a motor or associated governor; but 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 paragraph 11.1 is considered to exist if, when considered as though it were film-coated wire, the wiring would be acceptable according to paragraph 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 (1) the temperature and voltage to which the wire is likely to be subjected, (2) exposure to oil, grease, or other substances likely to have a deleterious effect, and (3) 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.

Paragraph 11.4 revised December 19, 1995

11.5 **Paragraph 11.5 deleted December 19, 1995**

11.6 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).

11.7 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.

11.8 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 paragraph 11.1 shall be provided with a bushing and strain relief in accordance with paragraphs 9.18—9.30 and Section 39 unless the construction is such that the cord will be protected from stress and motion.

TABLE 11.1

CHARACTERISTICS OF INTERNAL WIRING

Insulation	Nominal Wall Thickness of Insulation, Inch (mm)	Braid or Jacket Required	Nominal Thickness of Braid or Jacket, Inch (mm)
Thermoplastic or neoprene	0.030 ^a (0.76)	No ^a	—
Cross-linked synthetic polymer	0.015 (0.38)	No	—

^aThe 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.

Table 11.1 revised December 19, 1995

18. Spacings

18.1 Except as noted in paragraph 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.

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—1993, 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.

Paragraph 18.3 revised December 19, 1995

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.

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.

18.6 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 paragraph 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 paragraph 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 paragraph 18.7.

Paragraph 18.6 revised December 19, 1995

18.7 For the purpose of determining suitability of spacings in accordance with the exception to paragraph 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.

Paragraph 18.7 added December 19, 1995

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 item C of paragraph 19.2 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 item B of paragraph 19.2 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 paragraph 52.25. 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.

Paragraph 20.1 revised April 15, 1994

20.1A 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 paragraph 20.1.

Paragraph 20.1A added April 15, 1994

20.2 All auxiliary type handles on the tools mentioned in paragraphs 20.1 and 20.1A 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.

Paragraph 20.2 revised April 15, 1994

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 paragraph 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 (1) the degree of exposure, (2) the sharpness of the moving part, (3) the likelihood of unintentional contact therewith, (4) the speed of the moving part, and (5) 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).

Paragraph 25.4 revised October 2, 1991

25.5 The unobstructed distance from the opening to the moving part mentioned in paragraph 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).

Paragraph 25.5 revised October 26, 1992

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 paragraphs 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 paragraphs 26.7—26.9A.

Paragraph 26.6 revised October 2, 1991

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. *Reserved.*
- C. A percussion tool without positive accessory holding means.
- D. 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.

Paragraph 26.7 revised December 19, 1995

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.

Paragraph 26.8 revised December 19, 1995

26.8A For a drill or a hammer drill, the lock-on device mentioned in paragraph 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.

Added paragraph 26.8A effective June 1, 1995

26.8B Compliance with the requirement in paragraph 26.8A 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.

Added paragraph 26.8B effective June 1, 1995

26.9 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.

26.9A 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.

Paragraph 26.9A added October 2, 1991

26.10 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.

Chain Saws *Heading "Chain Saws" deleted
October 2, 1991*

27.11 — 27.50 *Paragraphs 27.11 — 27.50
deleted October 2, 1991*

Tables 27.1 — 27.3 *Tables 27.1 — 27.3 deleted
October 2, 1991*

Figures 27.4 — 27.8 *Figures 27.4 — 27.8 deleted
October 2, 1991*

Reciprocating Saws

27.51 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.

27.52 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.

Grinders

27.53 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.

Paragraph 27.53 revised April 15, 1994

27.54 A grinder, other than as mentioned in paragraph 27.57, 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.

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

27.56 The guard and mounting hardware mentioned in paragraph 27.54 shall not be shipped unassembled from the tool.

Exception No. 1: A guard as described in paragraph 27.66 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 paragraph 52.29.

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 paragraphs 52.29 and 52.30,

B. The carton or cartons containing the guard and mounting hardware are marked in accordance with paragraph 52.31, and

C. Proper assembly can be readily accomplished without risk of injury and clear, detailed assembly instructions are provided and packaged with the tool.

Paragraph 27.56 revised December 19, 1995

27.57 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 item B of paragraph 52.28,

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 item D of paragraph 52.28,

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 item E of paragraph 52.28, 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.

27.58 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.

27.59 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.

27.60 Except as noted in paragraph 27.67, a guard as mentioned in paragraph 27.58 shall be of a material and shall comply with the dimensions given in Table 27.4, 27.5, or 27.6. See Figures 27.9, 27.10, or 27.11, whichever is applicable.

27.61 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.

27.62 Except as noted in paragraph 27.67, a drawn-steel guard for a Type 27 and 28 thin abrasive wheel for surface grinding shall comply with Table 27.7. See Figure 27.12.

27.63 Except as noted in paragraph 27.67, a grinder provided with a cup wheel shall be provided with a fixed guard complying with Table 27.8. See Figure 27.13.

27.64 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 paragraph 27.65 and Figure 27.13. The guard shall cover the wheel for at least 180 degrees toward the operator.

27.65 If it is necessary to determine whether a cup-wheel guard complies with paragraph 27.64, 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.

27.66 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.

27.67 A guard that employs materials or dimensions that do not comply with the requirements in paragraphs 27.60, 27.62, or 27.63 is acceptable if it complies with the requirements of the Grinder Wheel Guard Test in Section 45A and with paragraph 27.67A.

Revised paragraph 27.67 effective June 1, 1998

27.67A A polymeric guard for a grinder shall additionally be classed 94V-2 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Added paragraph 27.67A effective June 1, 1998

27.68 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.

TABLE 27.4
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 speci- fications 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 27.9. Note: Minimum Tensile Strengths per ASTM.

TABLE 29.1 (Cont'd)

LOADS FOR TESTS

Tool	Test Procedure	General or Special Use
7. Hammer Rotary	Hammering mode: The test is to be conducted in the same manner as for a hammer. 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 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	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: A. Operation at no load until constant temperatures are attained. 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. C. Operation at no load until temperatures again become constant. D. Uninterrupted impacting for one minute against the nut described above without reversal of rotation. Temperatures are to be measured near the conclusion of steps B and D.	Special
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

(Continued)

TABLE 29.1 (Cont'd)

LOADS FOR TESTS

Tool	Test Procedure	General or Special Use
12A. 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.	
13. Polisher	The test is to be conducted with the tool polishing, without wax or abrasive, a smooth surface of asbestos cement composition board.	General
14. 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
15. 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
15A. 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
16. 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
17. 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

(Continued)

TABLE 29.1 (Cont'd)

LOADS FOR TESTS

Tool	Test Procedure	General or Special Use										
18. Sander (vibrator- powered)	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: 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. B. Any other sander is to be operated sanding continuously until temperatures become constant.	Special										
19. Deleted												
20. Saw, circular hand	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. A horizontal cutting force shall be applied to the tool as follows: <table><tr><th colspan="2">Horizontal</th></tr><tr><th>Blade diameter, inches (mm)</th><th>Cutting Force, pounds (N)</th></tr><tr><td>Less than 6.5 (165)</td><td>5 (22)</td></tr><tr><td>6.5—9.25 (165—235)</td><td>8 (35)</td></tr><tr><td>Greater than 9.25 (235)</td><td>15 (66)</td></tr></table>	Horizontal		Blade diameter, inches (mm)	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
Horizontal												
Blade diameter, inches (mm)	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)											

(Continued)

TABLE 29.1 (Cont'd)

LOADS FOR TESTS

Tool	Test Procedure	General or Special Use
21. Saw, reciprocating	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. The temperature test is to consist of operation until constant temperatures are reached, employing a duty cycle of: A. Five minutes of sawing the plywood described above, followed by B. One minute idling. 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: 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. 2. Any other saw is to be operated sawing continuously until temperatures become constant.	Special
21A. 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
22. 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

(Continued)

TABLE 29.1 (Cont'd)

LOADS FOR TESTS

Tool	Test Procedure	General or Special Use
23. Shears	The test is to be conducted in the same manner as those of a nibbler	Special
24. 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.	Special
25. 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
26. 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.	Special

Table 29.1 revised December 19, 1995

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 paragraphs 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 paragraphs 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 items 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 μ 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- μ 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.

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:

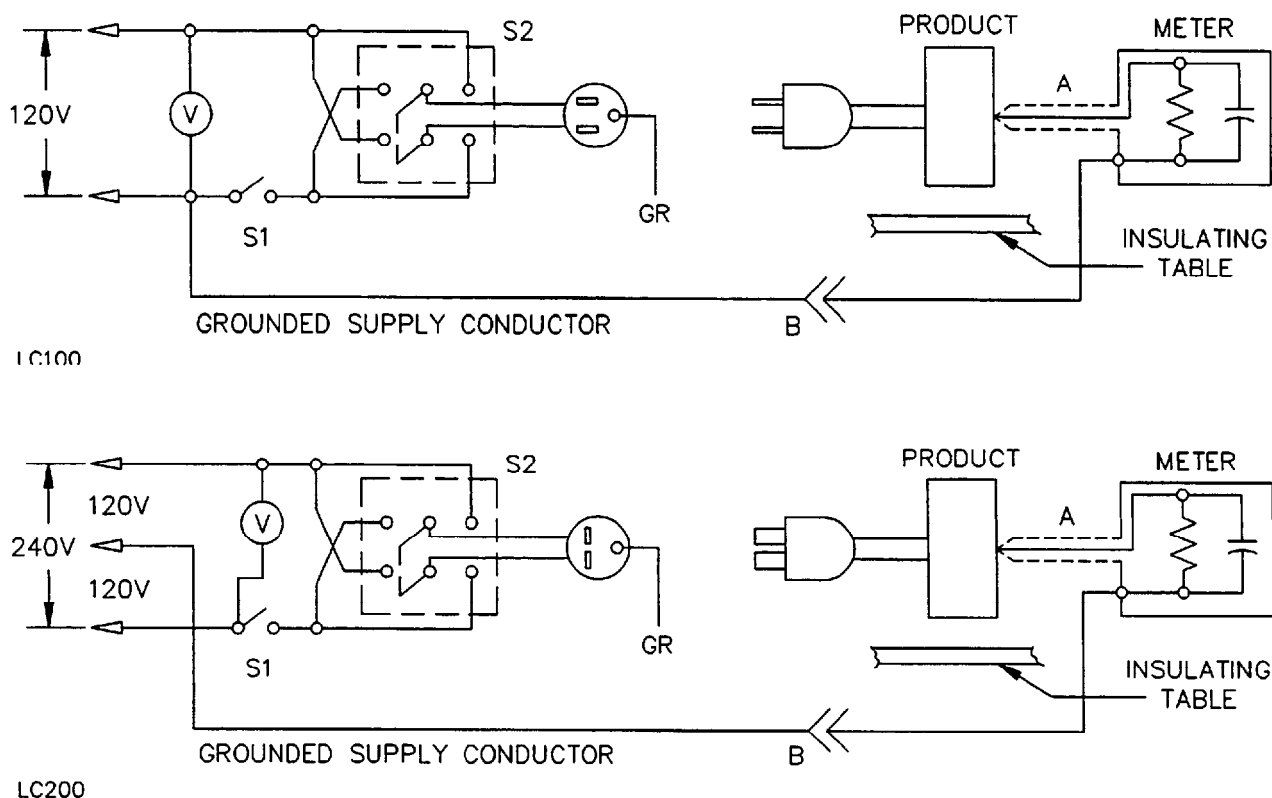
A. With switch S1 open, the tool is to be connected to the measuring circuit. Leakage current is to be measured using both positions of S2, and with the tool switching devices in all their normal operating positions.

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.

FIGURE 30.1

LEAKAGE-CURRENT MEASUREMENT CIRCUITS



A: PROBE WITH SHIELDED LEAD.

B: SEPARATED AND USED AS CLIP WHEN MEASURING CURRENTS FROM ONE PART OF DEVICE TO ANOTHER

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—1993, the tool may be connected.

Paragraph 31.1 revised December 19, 1995

31.2 In a test to determine whether a tool complies with the requirement in paragraph 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 paragraph 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 paragraph 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.

Revised paragraph 32.1 effective June 1, 1995

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 (1) speeds, (2) drill bits, saw blade, or other accessory to be acceptable for use with the tool, and (3) work stock, such as steel, wood, concrete, and the like.

32.2A 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.

Paragraph 32.2A added October 26, 1992

32.3 The means for controlling the speed mentioned in paragraphs 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.

32.4 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.

TABLE 33.1

MAXIMUM TEMPERATURE RISES (Cont'd)

^aSee paragraph 33.13.

^bRubber-insulated conductors within a motor having Class A insulation systems, rubber-insulated leads, and a rubber-insulated flexiled 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 paragraph 33.17.

^cThe limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been found to have heat-resistant properties.

^dA 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.

^eFor 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).

^fSee note ^c to Table 18.1.

^gThese temperatures do not apply to the cutting tool.

^hThese temperatures do not apply to a hammer, including the rotary type.

Table 33.1 revise June 22, 1993

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 paragraph 29.1 and Table 29.1 at the maximum-speed setting, except as indicated in paragraph 33.8. The test is then to be repeated at lower speeds, and the requirements in paragraph 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 (1) the blade, chisel, or other accessory acceptable for use with the tool, and (2) the work stock, such as steel, wood, concrete, and the like.

Paragraph 33.6 revised December 19, 1995

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 paragraph 33.1.

33.8 With reference to paragraph 33.5 and the maximum-speed test mentioned in paragraph 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 paragraph 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 paragraph 33.10.

Exception: The requirement in paragraph 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 paragraph 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 paragraph 33.9, it is to be operated at the voltage and frequency indicated in paragraphs 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 paragraph 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 6 and 13 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_1 is the room temperature in degrees C at the beginning of the test, t_2 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 mm²).

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 mm²) 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.

Paragraph 33.19 revised October 2, 1991

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 paragraph 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 paragraphs 34.1—34.3, the test potential is to be applied as described in paragraph 34.6 by means of test equipment having the characteristics outlined in paragraph 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 (1) 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, (2) 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 item A of paragraph 18.6, shall withstand the potential specified in paragraphs 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 paragraph 35.2 or 35.3, whichever is applicable, a tool as mentioned in paragraphs 35.2 and 35.3:

A. Rated for a nominal 120 V or 240 V supply, shall comply with the requirements in paragraph 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 item 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.

35.1A After the dielectric evaluation required by paragraph 35.1, a tool that is likely or intended to be used with liquid shall be subjected to the test in paragraphs 35.4 — 35.6. 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 paragraphs 35.4 — 35.6.

Added paragraph 35.1A effective June 1, 1998

35.1B After being subjected to the conditioning described in paragraph 35.7, 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 paragraph 35.7, 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.

Added paragraph 35.1B effective June 1, 1998

35.2 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.

35.3 A concrete vibrator of a type other than that described in paragraph 35.2 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 paragraph 35.1 is to be conducted immediately upon completion of the exposure, and is to be repeated one-half hour later.

Revised paragraph 35.3 effective June 1, 1998

35.4 Prior to the test of paragraph 35.5, 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 $70 \pm 2^\circ\text{C}$ ($158 \pm 3.6^\circ\text{F}$) 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 paragraph 35.5. The glands and other sealing means are to be tightened to a value as indicated in Table 35.1.

Added paragraph 35.4 effective June 1, 1998