UL 987

STANDARD FOR SAFETY

Stationary and Fixed Electric Tools

UL Standard for Safety for Stationary and Fixed Electric Tools, UL 987

Eighth Edition, Dated October 19, 2011

Summary of Topics

This reaffirmation of ANSI/UL 987 dated April 9, 2025 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated February 14, 2025.

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Standard for Stationary and Fixed Electric Tools

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The Department of Defense (DoD) has adopted UL 987 on May 20, 1976. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover cord-connected or permanently-connected stationary and light industrial electric tools for use in accordance with the National Electrical Code, ANSI/NFPA 70 and provided with a means for:

a) Grounding the tool on a branch circuit rated not more than 600 V and employing no universal motor rated more than 250 V; or

b) Providing double insulation for a tool on a branch circuit involving a potential of not more than 150 V to ground.

1.2 These requirements also cover accessories and attachments for use with tools included in 1.1 if the accessories or attachments are:

a) Identified by catalog number or equivalent product designation in the instruction manual for the tool; or

b) Packed with the tool.

Specific requirements are outlined in Sections 85 – 88.

1.3 These requirements do not cover any of the following:

a) Portable tools;

b) Automated machine tools intended for production line use;

c) Garage equipment with the exception of bench type brake lathes;

d) Painting equipment; or

e) Other equipment covered by individual requirements.

1.4 A stationary or fixed electric tool intended to be remotely or automatically controlled, or a permanently connected tool intended for continuous duty are judged on the basis of compliance with the requirements in this standard, insofar as they are applicable, and further examination and test to determine whether the tool is acceptable for the purpose.

1.5 These requirements do not cover accessories or attachments that:

a) Are not packed with the tool; or

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

Accessories or attachments mentioned in mini-catalogs or flyers may or may not be provided with the tool.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Undated References

3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

4 Glossary

4.1 In the following text, a requirement that applies only to a specific class or classes of stationary, fixed, and light industrial electric tools is so identified by a specific reference in the requirement to the class or classes of equipment involved. Absence of such specific reference or use of the term tool indicates that the requirement applies to all of the classes of equipment covered by this standard unless the context indicates otherwise.

4.2 For the purpose of this standard, the following definitions apply.

4.3 ACCESSORY – A device that is attached only to the spindle of the tool. Accessories include carbide tipped saw blades, wire brushes, and shaper cutters.

4.4 APPLIANCE COUPLER – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug).

4.5 APPLIANCE INLET (Motor Attachment Plug) – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector.

4.6 APPLIANCE (FLATIRON) PLUG – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

4.7 ATTACHMENT – A device attached to the housing or other component of the tool that may or may not attach to the spindle. Attachments include tables to convert bench mounted tools to floor mounted tools, and devices that facilitate the use of tools such as a saw dust collection device.

4.8 COMPONENT – A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to the purpose. When incorporated in an appliance, equipment otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

4.9 CORD CONNECTOR – A female contact device wired on flexible cord for use as an extension from an outlet to make a detachable electrical connection to an attachment plug or, as an appliance coupler, to an equipment inlet.

4.10 CONTROL, AUTOMATIC ACTION – A control in which at least one aspect is non-manual.

4.11 CONTROL, AUXILIARY – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency control not relied upon to reduce the risk of fire, electric shock, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

4.12 CONTROL, MANUAL – A device that requires direct human interaction to activate or rest the control.

4.13 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a

thermal cutout/limiter or another layer of protection would reduce the risk of fire, electric shock, or injury to persons, is considered an operating control. Operating controls are also referred to as "regulating controls".

4.14 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of fire, electric shock, or injury to persons during normal and reasonably anticipated abnormal operation of the appliance whereby during the evaluation of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as "limiting controls" and "safety controls".

4.15 CONTROL, TYPE 1 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence has not been declared and tested under this standard.

4.16 CONTROL, TYPE 2 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence have been declared and tested under this standard.

4.17 STATIONARY TOOL – Electric motor-operated or magnetically-driven machine so designed that the motor and the machine from an assembly which does not require support by hand and the material on which the machine performs the work is brought to the machine.

4.18 TOOL – A stationary or light industrial tool as specified in 1.1.

4.19 TRANSPORTABLE TOOL – A stationary tool that is cord connected and is easily transported to the work site by one person, simple devices to facilitate transportation may be incorporated, e.g. handles, wheels and the like.

CONSTRUCTION

5 General

5.1 A tool shall employ materials throughout that are acceptable for the use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

5.2 A motor for a tool provided with a means for grounding may be shipped detached from the tool if both the motor and the tool comply with the applicable requirements in 8.5, 10.5, 10.6, 13.1.10, 15.18, 15.19, 16.1 – 16.4, 79.6, 80.9, 80.10, 83.1.4, and 83.1.5.

5.3 The motor of a double insulated tool shall be shipped attached to the tool.

6 Components

6.1 General

6.1.1 A component of a product covered by this standard shall:

a) Comply with the requirements for that component as indicated in 6.2 – 6.22;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability;

d) Additionally comply with the applicable requirements in this end product standard; and

e) Not contain mercury.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product;

b) Is superseded by a requirement in this standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

Exception No. 2: A component that complies with a UL component standard other than those specified in 6.2 – 6.22 is acceptable if:

a) The component also complies with the applicable component standard specified in 6.2 – 6.22; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, ANSI/NFPA 70, where applicable;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

3) Any use limitations of the other component UL standards are identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and that complies with the relevant component standard may assume user expertise not common in household applications.

6.1.2 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

6.1.3 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements in the applicable UL standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component UL standard(s) need not be applied.

6.1.4 A component not anticipated by the requirements in this end product standard, not specifically covered by the component standards in 6.2 – 6.22, and that involves a risk of fire, electric shock, or injury to persons, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 6.1.1 (b) – (d).

6.1.5 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is applicable where that standard anticipates normal and abnormal use conditions consistent with the application of this end product standard.

6.2 Attachment plugs, receptacles, connectors, and terminals

6.2.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 6.2.8.

Exception No. 1: Attachment plugs and appliance couplers integral to cord sets or power supply cords that are investigated in accordance with the requirements in the Standard for Cord Sets and Power Supply Cords, UL 817 are not required to comply with UL 498.

Exception No. 2: A fabricated pin terminal assembly(ies) need not comply with UL 498 if it complies with Live Parts, Section 14, Insulating Material, Section 17, and Spacings, Section 23, of this end product standard.

6.2.2 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with UL 310.

6.2.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977. See 6.2.8.

6.2.4 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

6.2.5 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

6.2.6 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459. See 6.2.9.

6.2.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

6.2.8 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

Exception: A fabricated part performing the function of a terminal block need not comply with UL 1059 if the part complies with the requirements in Live Parts, Section 14, Insulating Material, Section 17, and Spacings, Section 23, of this end product standard. This exception does not apply to protective conductor terminal blocks.

6.2.9 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, an appliance coupler that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

6.3 Batteries

6.3.1 Rechargeable lithium ion (Li-ion) cells shall comply with the requirements for secondary lithium cells Specified in the Standard for Lithium Batteries, UL 1642.

6.4 Boxes and raceways

6.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3, Wiring Methods and Materials, of the National Electrical Code, ANSI/NFPA 70 and that comply with the relevant UL standard (such as the Standard for Metallic Outlet Boxes, UL 514A, the Standard for Nonmetallic Outlet Boxes, Flush-Devices Boxes and Covers, UL 514C, the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D) and 6.1 are considered to comply with the requirements in this end product standard.

6.5 Capacitors and filters

6.5.1 The component requirements for a capacitor are not specified. A capacitor that complies with the Standard for Capacitors, UL 810, is considered to comply with the requirements in 22.1.

6.5.2 Electromagnetic interference filters with integral enclosures that comply with the Standard for Electromagnetic Interference Filters, UL 1283, are considered to comply with the requirements in 22.1.

6.6 Controls

6.6.1 General

6.6.1.1 Auxiliary controls shall be evaluated using the applicable requirements in this end product standard and the requirements in the Controls – End Product Test Parameters, Section 34.

6.6.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and if applicable, the requirements in Controls – End Product Test Parameters, Section 34, unless otherwise specified in this end product standard.

6.6.1.3 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of fire, electric shock, or injury to persons, such as a speed control unexpectedly changing its output, shall comply with one or both of the following standards:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, and the Standard for Software in Programmable Components, UL 1998; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

6.6.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and if applicable, the parameters in Controls – End Product Test Parameters, Section 34, unless otherwise specified in this end product standard.

6.6.1.5 Solid-state protective controls that do not rely upon software as a protective component shall comply with one or both of the following standards:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1, except for the Controls Using Software requirements.

6.6.1.6 Protective controls that rely upon software as a protective component shall comply with one or both of the following standards:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

6.6.1.7 An electronic, non-protective control that is simple in design need only be subjected to the applicable requirements in this end-product standard. A control that does not include an integrated circuit or microprocessor, but does consist of a discrete switching device, capacitors, transistors, or resistors is considered simple in design. See Abnormal Operation Tests, Section 64.

6.6.2 Electromechanical and electronic controls

6.6.2.1 A control, other than as specified in 6.6.2 – 6.6.7, shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873; or

c) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

6.6.3 Liquid level controls

6.6.3.1 A liquid level control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508; or

d) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1, and;

1) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water Level Controls of the Float Type for Household and Similar Applications, UL 60730-2-16; or

2) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water and Air Flow Sensing Controls, Including Mechanical Requirements, UL 60730-2-18.

6.6.4 Motor and speed controls

6.6.4.1 A control used to start, stop, regulate or control the speed of a motor shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508;

d) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1; or

e) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

6.6.5 Pressure controls

6.6.5.1 A pressure control shall comply with one of the following:

a) The Standard for Temperature-Indicating and -Regulating, UL 873;

b) The Standard for Industrial Control Equipment, UL 508; or

c) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

6.6.6 Temperature controls

6.6.6.1 A temperature control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508; or

d) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

6.6.6.2 A temperature positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with the Standard for Thermistor-Type Devices, UL 1434.

6.6.6.3 A thermal cutoff shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

6.6.7 Timer controls

6.6.7.1 A timer control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

6.7 Cords, cables, and internal wiring

6.7.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

6.7.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to comply with this requirement when pre-assembled in a cord set or power supply cord that complies with the Standard for Cord Sets and Power Supply Cords, UL 817.

6.7.3 Internal wiring composed of insulated conductors shall comply with the Standard for Appliance Wiring Material, UL 758.

Exception No. 1: Insulated conductors need not comply with UL 758 if they comply with one of the following:

a) The Standard for Thermoset-Insulated Wires and Cables, UL 44;

b) The Standard for Thermoplastic-Insulated Wires and Cables, UL 83;

c) The Standard for Fixture Wire, UL 66; or

d) The applicable UL standard(s) for other insulated conductor types specified in Chapter 3, Wiring Methods and Materials, of the National Electrical Code, ANSI/NFPA 70.

Exception No. 2: Insulated conductors for specialty applications (e.g. data processing or communications) and located in a low-voltage circuit not involving the risk of fire, electric shock or injury to persons need not comply with UL 758.

6.8 Cord reels

6.8.1 A cord reel shall comply with special use cord reel requirements in the Standard for Cord Reels, UL 355.

6.9 Film-coated wire (magnet wire)

6.9.1 The component requirements for film coated wire and Class 105 (A) insulation systems are not specified.

6.9.2 Film coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

6.10 Ground-fault, arc-fault, and leakage current detectors/interrupters

6.10.1 Ground-fault circuit-interrupters (GFCI) for protection against electrical shock shall comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943. The following statement, or equivalent, shall be included as a marking near the GFCI, or as an instruction in the manual: "Press the TEST button (then RESET button) every month to assure proper operation."

6.10.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B.

6.10.3 With respect to 6.11.2, an ALCI is not considered an acceptable substitute for a GFCI when the National Electrical Code, ANSI/NFPA 70 requires a GFCI.

6.10.4 Equipment ground-fault protective devices shall comply with the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053, and the applicable requirements in the Standard for Ground-Fault Circuit-Interrupters, UL 943.

6.10.5 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

6.10.6 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

6.11 Insulation systems

6.11.1 Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446.

6.11.2 All insulation systems employing integral ground insulation shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

6.12 Light sources and associated components

6.12.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

Exception: Lampholders forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

6.12.2 Lighting ballasts shall comply with one of the following:

a) The Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) The Standard for High-Intensity Discharge Lamp Ballasts, UL 1029.

Exception No. 1: Ballasts forming part of a luminaire that complies with an applicable UL luminaire standard are considered to comply with this requirement.

Exception No. 2: Ballasts for other light sources shall comply with the applicable UL standard(s).

6.12.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with an applicable UL luminaire standard are considered to comply with this requirement.

Exception No. 2: Individual LED light sources mounted on printed wiring boards and intended for indicating purposes need not comply with UL 8750, but shall comply with the applicable requirements in this end product standard.

6.13 Marking and labeling systems

6.13.1 A marking and labeling system shall comply with the Standard for Marking and Labeling Systems, UL 969. Requirements include standard atmosphere, oil, and oven conditioning.

Exception: A label on a tool that is only intended to be used for wood-working and that is not shipped with an oil coating is not required to be evaluated for oil.

6.14 Motors and motor overload protection

6.14.1 General

6.14.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in 6.14.2 or 6.14.3. This includes fractional HP motors rated up to 1 HP (typically NEMA frame sizes 42, 48, or 56), and integral HP motors rated 1 HP and greater (typically NEMA frame sizes 140 – 449T).

6.14.1.2 Component type motors shall comply with the requirements specified in 6.14.2 or 6.14.3.

6.14.1.3 Motors located in a low voltage circuit are evaluated for the risk of fire, electric shock, or injury to persons in accordance with the applicable requirements in this end product standard.

6.14.1.4 Low voltage component fans that comply with the Standard for Electric Fans, UL 507, are considered to comply with the requirements for Motors, Section 18.

6.14.2 General-purpose type motors

6.14.2.1 A general-purpose type motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

6.14.3 Component type motors

6.14.3.1 Component type motors shall comply with either 6.14.3.2 or 6.14.3.3.

6.14.3.2 The motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 except as noted in Table 6.1.

Table 6.1
Superseded requirements

UL 1004-1 Exempted Requirement	Superseded by UL 987 Requirements
Current and Horsepower Relation, Section 6	Paragraph 56.3
Cord-Connected Motors, Section 15	Section 13.1
Factory Wiring Terminals and Leads, Section 17	Section 15
Electrical Insulation, Section 22	Section 17
Non-Metallic Functional Parts, Section 28	Sections 7, 17, 18
Solid-State Controls, 7.2	Section 6.6
Non-metallic enclosure thermal aging, 9.1.4	Section 7.2
Motor enclosure, 9.2 – 9.4	Section 7
Grounding, Sections 10 and 11	Section 24
Ventilation Openings, Section 12: only applicable where the openings are on surfaces considered to be the appliance enclosure.	Sections 8 and 9
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 13	Sections 8 and 9
Protection Against Corrosion, Section 14	Section 11

Table 6.1 Continued on Next Page

Table 6.1 Continued

UL 1004-1 Exempted Requirement	Superseded by UL 987 Requirements
Available fault current ratings for motor start and running capacitors, Paragraph 26.6: not applicable for cord and plug connected appliances.	Section 22
Switch, Section 27 is not applicable to centrifugal starting switches	Section 19
With the exception of Sections 35 and 40 (Resilient Elastomer Mounting and Electrolytic Capacitor Tests, respectively), the performance tests in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 are not applicable	All applicable performance tests
Only the following marking requirements specified in 43.1 of UL 1004-1 are applicable: manufacturer's name or identification; rated voltage; rated frequency; number of phases if greater than 1; and multi-speed motors, other than a shaded-pole or a permanent-split-capacitor motor, shall be marked with the amperes and horsepower at each speed	Paragraph 80.1

6.14.3.3 The motor shall comply with the applicable component requirements for Components, Section 6, the following construction requirements, and the applicable performance requirements (when tested in conjunction with the end product), of this end product standard:

a) Protection Against Corrosion, Section 11;

b) Wiring Compartments, Section 12.2;

c) Internal Wiring, Section 15;

d) Insulating Material, Section 17;

e) Motors, Section 18;

f) Capacitors, Section 22;

g) Spacings, Section 23; and

h) Grounding, Section 24.

6.14.4 Motor overload protection

6.14.4.1 Thermal protection devices integral with the motor shall comply with one of the following:

a) The Standard for Overheating Protection for Motors, UL 2111;

b) The Standard for Thermally Protected Motors, UL 1004-3; or

c) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2 Particular Requirements for Thermal Motor Protectors, UL 60730-2-2; in conjunction with the Standard for Thermally Protected Motors,UL 1004-3 (to evaluate the motor-protector combination).

6.14.4.2 Impedance protection shall comply with the Standard for Impedance Protected Motors, UL 1004-2.

6.14.4.3 Electronic protection integral to the motor shall comply with the Standard for Electronically Protected Motors, UL 1004-7.

6.14.4.4 Except as indicated in 6.14.4.3, electronically protected motor circuits shall comply with one of the following. See Motor and Speed Controls, Section 6.6.4, for basic control requirements.

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the standard for tests for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1;

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; If software is relied upon to perform a safety function, it shall be considered software Class B; or

c) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy, UL 61800-5-1.

Exception: Compliance with the above standards is not required for an electronically protected motor circuit if there is no risk of risk of fire, electric shock, or injury to persons during abnormal testing with the motor electronic circuit rendered ineffective; compliance with the applicable requirements in this end product standard is then required.

6.15 Overcurrent protection

6.15.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

6.15.2 Fuseholders shall comply with Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9).

6.15.3 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with UL 489.

6.15.4 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

6.15.5 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

6.15.6 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

6.16 Polymeric materials and enclosures

6.16.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.16.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

6.17 Power supplies

6.17.1 A Class 2 power supply shall comply the Standard for Class 2 Power Units, UL 1310.

6.17.2 A non-Class 2 power supply shall comply with the Standard for Power Units Other Than Class 2, UL 1012.

6.18 Printed wiring boards

6.18.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed Wiring Boards, UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in UL 796 if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

6.18.2 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support of live parts requirements.

6.18.3 Unless otherwise specified, a printed-wiring board shall have a minimum flame classification of V-2.

Exception: A printed-wiring board located in a secondary circuit that complies with the requirements for Class 2 or limited voltage/current circuits have a minimum flame Class of HB.

6.19 Semiconductors and small electrical and electronic components

6.19.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard of Safety for Electrically Isolated Semiconductor Devices, UL 1557.

6.19.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with the Standard for Safety for Optical Isolators, UL 1577.

6.19.3 Except as otherwise specified in this standard, component requirements are not specified for small electrical parts on printed wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

6.19.4 Where an electronic component is determined to be a critical component during the Abnormal Operation Test, Section 64 in this standard, the circuit shall comply with one or both of the following standards. See Protective Controls (Limiting Controls), Section 34.4 for the test parameters to be used.

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, including its Follow-Up Program; and as applicable, the Standard for Software in Programmable Components, UL 1998 for controls that rely upon software as a protective component; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

6.19.5 A critical component is a component that performs one or more safety-related functions whose failure results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end-product application.

6.19.6 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with the Failure-Mode and Effect Analysis (FMEA) requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

6.19.7 Portions of a circuit comprised of a microcontroller or other programmable device that performs a back-up, limiting, or other safety function intended to reduce the risk of fire, electric shock, or injury to persons shall comply with the Controls Using Software requirements in the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1, Annex H.

6.20 Supplemental insulation, insulating bushings, and assembly aids

6.20.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to comply with a performance requirement of this standard. In such cases, the insulation or device shall comply with the following applicable standards:

a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441; or

c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

6.20.2 Wire positioning devices required to comply with the requirements in this end product standard shall comply with the Standard for Positioning Devices, UL 1565.

6.20.3 Insulating bushings shall comply with the Standard for Insulating Bushings, UL 635 and be suitable for the application with respect to the hole size and shape, maximum use temperature and wire size or type. To determine if the hole size and shape is suitable for the bushing, the applicable test(s) specified in this standard (e.g. Strain Relief Test, Section 59, Push-Back Relief Test, Section 60, Thermal Stability Test, Section 70.10) shall be conducted.

6.21 Switches

6.21.1 Switches shall comply with one of the following, as applicable:

a) The Standard for Special-Use Switches, UL 1054;

b) The Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;

c) The Standard for General-Use Snap Switches, UL 20; or

d) The Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A.

Exception: Switching devices that comply with the applicable UL standards for specialty applications (e.g. transfer switch equipment), industrial use (e.g. contactors, relays, auxiliary devices), or are integral to another component (e.g. switched lampholder) need not comply with this requirement.

6.21.2 Clock-operated switches, and time switches, including timers, shall comply with one of the following:

a) The Standard for Clock-Operated Switches, UL 917; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

6.21.3 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, that functions as a protective control, shall comply with the requirements for a protective control. See 6.6.1.3.

6.22 Transformers

6.22.1 General-purpose transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

Exception: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component complies with the intent of this requirement.

6.22.2 Class 2 and Class 3 transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

Exception: Transformers located in a low voltage circuit, and that do not involve a risk of fire, electric shock or injury to persons need not comply with this requirement.

7 Frame and Enclosure

7.1 General

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

7.2 Enclosures of metallic materials

7.2.1 Cast-metal portions of an enclosure shall not be thinner than the minimum acceptable values specified in Table 7.1.

Table 7.1
Minimum acceptable thickness of a cast metal enclosure

Metal	Flat surfaces		Curved, ribbed, or otherwise reinforced surfaces, and surfaces having a size or shape providing the required mechanical strength,	
	Inch	(mm)	Inch	(mm)
Die-cast metal	5/64	(2.0)	3/64	(1.2)
Cast malleable iron	3/32	(2.4)	1/16	(1.6)
Other cast metal	1/8	(3.2)	3/32	(2.4)

7.2.2 Among the factors to be considered when judging an enclosure of sheet metal shall be the size, shape, and thickness of the metal all with respect to the application and intended use of the tool.

7.2.3 Among the factors to be considered when judging an enclosure of magnesium shall be the combustibility and resistance to arcing of the metal.

7.2.4 Sheet metal to which a wiring system is intended to be connected in the field shall have a thickness not less than the minimum acceptable value specified in Table 7.2.

Table 7.2
Minimum acceptable thickness of a sheet metal surface to which a wiring system is intended to be connected in the field

Metal	Surfaces to which a wiring system is intended to be connected in the field	
	Inch	(mm)
Uncoated sheet steel	0.032	(0.81)
Galvanized sheet steel	0.034	(0.86)
Sheet aluminum	0.045	(1.14)
Sheet copper or brass	0.045	(1.14)

7.3 Enclosures of polymeric materials

7.3.1 Polymeric material used for the enclosure of a cord-connected tool that requires operator attendance while work is being done shall comply with the requirements in 7.3.3 and 67.1 and with the requirements for Polymeric Materials, Section 69 or 70, whichever is applicable.

7.3.2 Polymeric material used for the enclosure of a tool that is intended for permanent connection to the power supply or a tool that may be operated unattended shall comply with:

a) The requirement in 7.3.3 and 67.1 and with the requirements for Polymeric Materials, Section 69 or 70, whichever is applicable; and

b) Any additional examination and test needed to evaluate the material for use in the application.

7.3.3 A polymeric material used for the enclosure of a tool shall be resistant to thermal degradation at the maximum temperature to which it is exposed during its normal use.

7.3.4 With reference to 7.3.3, a polymeric material is considered to be resistant to thermal degradation at the temperatures to which it will be exposed if:

a) The material has a temperature index, based on historical data or a long-term thermal aging program, more than the maximum temperature to which it is exposed during its normal use;

b) The maximum temperature to which the material is exposed during normal use does not exceed 65°C (149°F); or

c) The maximum temperature to which the material is exposed during normal use does not exceed 95°C (203°F), and the material complies with the requirement for Tests of Polymeric Enclosures Following Oven Conditioning, Section 68.

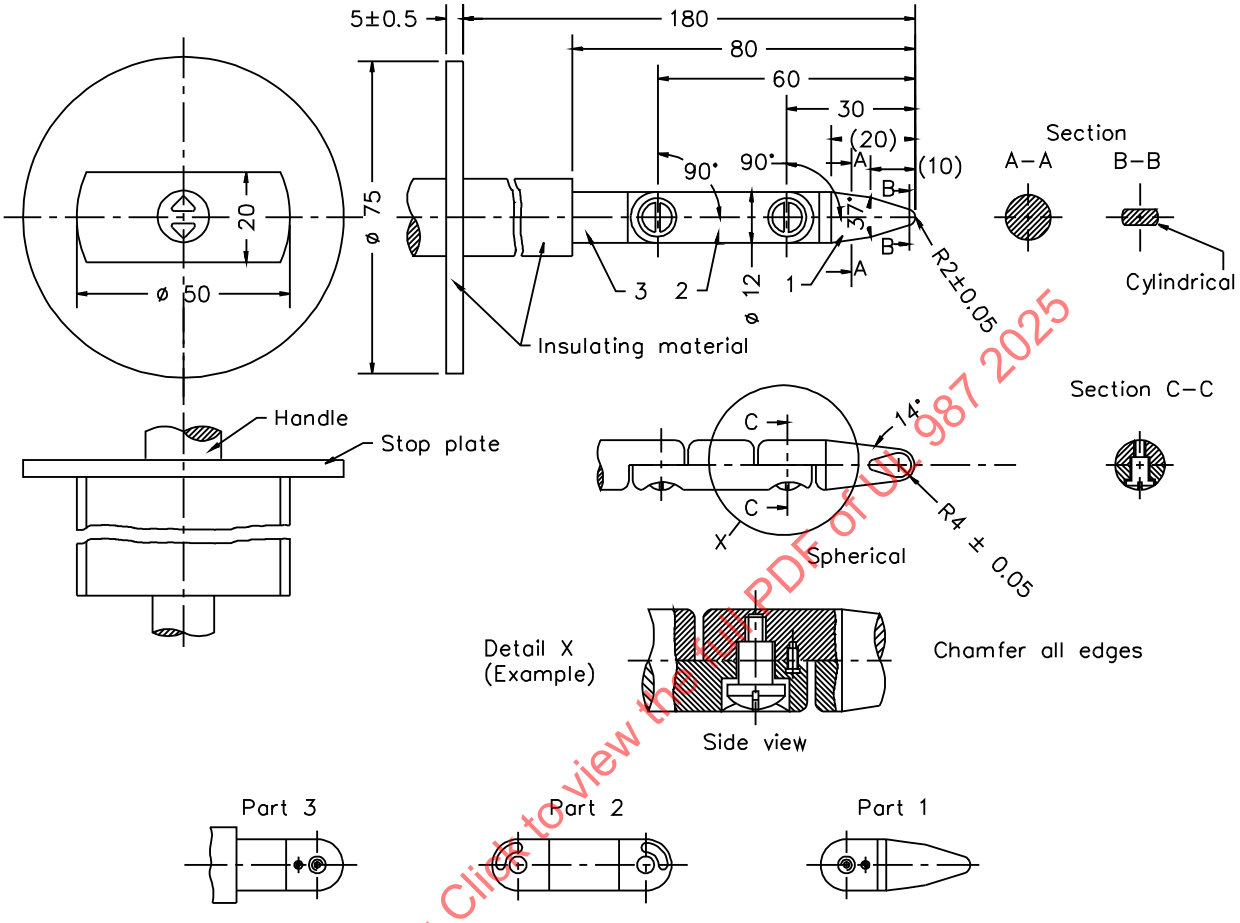
8 Accessibility of Live Parts

8.1 An electrical part of a tool shall be located or enclosed so that the likelihood of unintentional contact with an uninsulated live part will be reduced. Insulated brush caps do not require additional enclosure.

8.2 With reference to the requirement in 8.1, the enclosure of a tool shall have no openings, other than those required for normal use of the tool, which will permit the finger probe, illustrated in Figure 8.1, to contact any uninsulated live part or film-coated wire when applied in any direction.

Figure 8.1

IEC articulate probe



Linear dimensions in millimeters

Tolerances on dimensions without specific tolerance:

on angles: +0', -10'

on linear dimensions:

up to 25 mm: +0 mm, -0.05 over 25 mm: ±0.2 mm

Material of finger: for example heat-treated steel

Both joints of this finger may be bent through an angle of 90°, with a 0 to +10° tolerance, but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a 90° bending angle with a 0 to +10° tolerance.

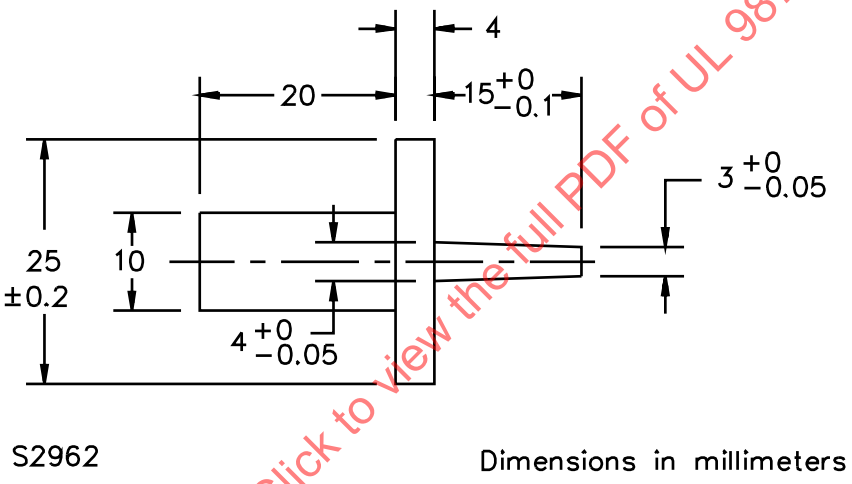
8.3 In a double-insulated tool, a test pin as illustrated in Figure 8.2, when inserted point first into an opening in an enclosure housing, shall not contact any parts separated from live parts by basic insulation only.

8.4 During the examination of a tool in connection with the requirement in 8.2 and 8.3, a part of the outer enclosure that is intended to be removed without the use of a tool by the user – to permit the attachment of an accessory, to allow access to means for making an operating adjustment, or for a similar reason – is to be disregarded; that is, such a part is not considered to reduce the risk of electric shock.

8.5 If removal of a guard or a cover is necessary for mounting a motor shipped detached from a tool, the guard or cover shall be constructed so that it cannot be replaced improperly.

Figure 8.2

Test pin



9 Exclusion of Foreign Matter

9.1 The enclosure of a tool, a control unit, or an auxiliary component, such as a rheostat or a rectifier, that is not integral with the tool shall exclude foreign matter, including abrasive or electrically conductive particles, that is likely to be present during operation and that may:

a) Adversely affect electrical insulation – for example, by build-up of a leakage path over an insulating surface; or

b) Otherwise result in a risk of fire or electric shock.

9.2 All uninsulated live parts and film-coated wire in a grinder shall be completely enclosed.

Exception: The following are acceptable for a grinder with provision for grounding:

a) An opening in a horizontal bottom surface of a bench grinder;

b) An opening in a vertical skirt of a bench grinder entirely below an opening specified in (a) above;

c) An opening in a vertical skirt of a bench grinder below an opening in a curved bottom surface; and

d) An opening in the enclosure of a grinder other than a bench grinder if protection equivalent to that for a bench grinder is provided.

10 Mechanical Assembly

10.1 A tool assembled by the manufacturer or in accordance with the manufacturer's specifications, shall not be adversely affected by the vibration during its intended operation.

10.2 A brush cap shall be tightly threaded or otherwise designed and secured to reduce the likelihood of unexpected loosening.

10.3 A switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or a similar component shall be mounted securely, and shall be prevented from turning or shifting. See 10.4.

Exception No. 1: The requirement that a switch be deterred from turning or shifting may be waived if all four of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch.

b) Means for mounting the switch make it unlikely that operation of the switch will loosen it.

c) The spacings are not reduced below the minimum acceptable values if the switch rotates.

d) Normal operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be deterred from turning if rotation cannot reduce spacings below the minimum acceptable values.

10.4 The means for preventing the turning mentioned in 10.3 is to consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as means to deter turning of a small stem-mounted switch or other device having a single-hole mounting means.

10.5 If a motor shipped detached from a tool is intended to be installed in the field according to the instructions provided with the tool, proper alignment shall be provided for by location and size of the mounting hardware. If a motor is intended to be used on a belt-driven tool, the necessary pulleys for field installation shall be provided with the tool. See 83.1.4.

10.6 With reference to the requirement in 10.5, adjustment means may be provided to allow for belt tensioning and alignment.

11 Protection Against Corrosion

11.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means if the corrosion of such parts would be likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: A surface of sheet steel or a cast-iron part in an enclosure if the oxidation of the iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable need not comply with this requirement. The thickness of the metal and the temperature are also factors.

Exception No. 2: Bearings, laminations, and minor parts of iron or steel, such as washers, screws, and the like, need not comply with this requirement.

12 Power Supply Connections– Permanently Connected Tools

12.1 General

12.1.1 A tool intended for permanent connection to the power-supply circuit shall have provision for the connection of a wiring system.

12.2 Wiring compartments

12.2.1 The location of a wiring compartment in which connections to the supply circuit are intended to be made shall be such that these connections can be readily inspected after the tool is installed as intended.

12.2.2 A wiring compartment intended for connection of a wiring system shall be attached to the tool so as to be prevented from turning with respect thereto.

12.2.3 A wiring compartment and any other space intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or the like, that could damage the conductor insulation.

12.3 Wiring terminals and leads

12.3.1 A field-wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire is provided as part of the tool and a pressure wire connector, a soldered loop, a crimped eyelet, or other means of making the connection is factory-assembled to the wire.

12.3.2 A permanently connected tool shall be provided with field-wiring terminals for the connection of conductors having an ampacity suitable for the tool, or it shall be provided with field-connection leads for such connection.

12.3.3 A field-wiring terminal shall be provided with a pressure wire connector, firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a field-wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

12.3.4 A wire-binding screw shall not be smaller than No. 10 (5.3 mm^2).

Exception: A No. 8 screw may be used at a field-wiring terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

12.3.5 A field-wiring terminal shall be prevented from turning.

12.3.6 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.05 in (1.27 mm) thick. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

Exception: A plate equal to or greater than 0.03 in (0.76 mm) thick may be used if the tapped threads have acceptable mechanical strength.

12.3.7 Upturned lugs or a cupped washer shall be capable of retaining a conductor corresponding in size to that mentioned in 12.3.2 under the head of the screw or washer.

12.3.8 The free length of a field-connection lead inside an outlet box or a wiring compartment shall be 6 in (152 mm) or more.

12.4 Grounded power-supply conductor

12.4.1 A permanently connected tool rated 125 V or 125/250 V, 3-wire, or less employing a lampholder of the Edison screw-shell type, a single-pole switch, or a single-pole overcurrent-protective device other than an automatic control without a marked off position shall have one field-wiring terminal or field-connection lead that is identified for the connection of the grounded conductor of the supply circuit. The terminal or lead intended to be grounded shall be electrically connected to screw shells of lampholders and not to a switch or overcurrent-protective device of the single-pole type, other than an automatic control without a marked off position.

Exception: A double insulated tool complying with the requirements in Sections 89 – 93 need not comply with this requirement.

12.4.2 A field-wiring terminal intended for connection of a grounded supply conductor shall:

a) Be made of or plated with metal substantially white in color and be readily distinguishable from the other terminals; or

b) Be clearly identified in some other manner, such as on a wiring diagram permanently attached to the tool.

12.4.3 A lead intended for field-connection of a grounded supply conductor shall be finished to show a white or grey color, and shall be readily distinguishable from the other lead or leads.

12.5 Equipment-grounding conductor

12.5.1 A field-wiring terminal or field-connection lead for an equipment-grounding conductor shall be provided.

Exception: A double insulated tool complying with the requirements in Sections 89 – 93 need not comply with this requirement.

12.5.2 The surface of a lead intended for field-connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

12.5.3 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G," "GR," "GND," "Ground," "Grounding," with the symbol ⏚, or the like, or by a marking on a wiring diagram provided on the tool. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during normal servicing of the tool.

13 Power Supply Connections – Cord-Connected Tools

13.1 Cords and plugs

13.1.1 A cord-connected tool shall be provided with 6 – 10 ft (1.8 – 3.0 m) of flexible cord, permanently attached to the tool, and with an attachment plug, which may be of the locking type, for connection to the supply circuit.

Exception: A tool may be provided with less than 6 ft (1.83 m) of permanently attached flexible cord or with a motor-attachment plug if the manufacturer:

a) Makes an acceptable extension cord available and the tool complies with the requirements in 80.16; or

b) Furnishes an acceptable detachable cord set, 6 ft (1.83 m) or more in length, with the tool.

13.1.2 The permanently attached flexible cord mentioned in the Exception to 13.1.1 shall be of such length that it is not likely to be damaged or impaired by a cutting edge, a blade, a belt, or a rotating part. The cord shall not be more than 18 in (460 mm) long.

13.1.3 The length of the cord is to be measured from where it enters the tool to the face of the attachment plug.

13.1.4 The flexible cord shall be Type S, SE, SJ, SJE, SJO, SJT, SJTO, SO, SP-3, SPE-3, SPT-3, ST, or STO.

13.1.5 A permanently attached flexible power-supply cord or a detached cord set provided with a tile saw shall be the outdoor use type, either junior hard-service cord (such as Type SJ) or hard-service cord (such as Type S), identified by W suffix type designation on the cord (for example, SJW).

13.1.6 Flexible supply cords used with panel saws shall be rated for extra hard service conditions. Interconnecting cords shall be at least one of the types specified in 13.1.4.

13.1.7 If a component having a separate supply cord is provided as part of a tool, the cord for the component being used in conjunction with the tool shall be one of the types specified in 13.1.4.

13.1.8 Supply connections for tools incorporating more than one electrical supply connection shall have the connections grouped and marked as specified in 81.1.8.

13.1.9 The flexible cord shall be rated for a voltage not less than the rated voltage of the tool and shall have an ampacity not less than the current rating of the tool.

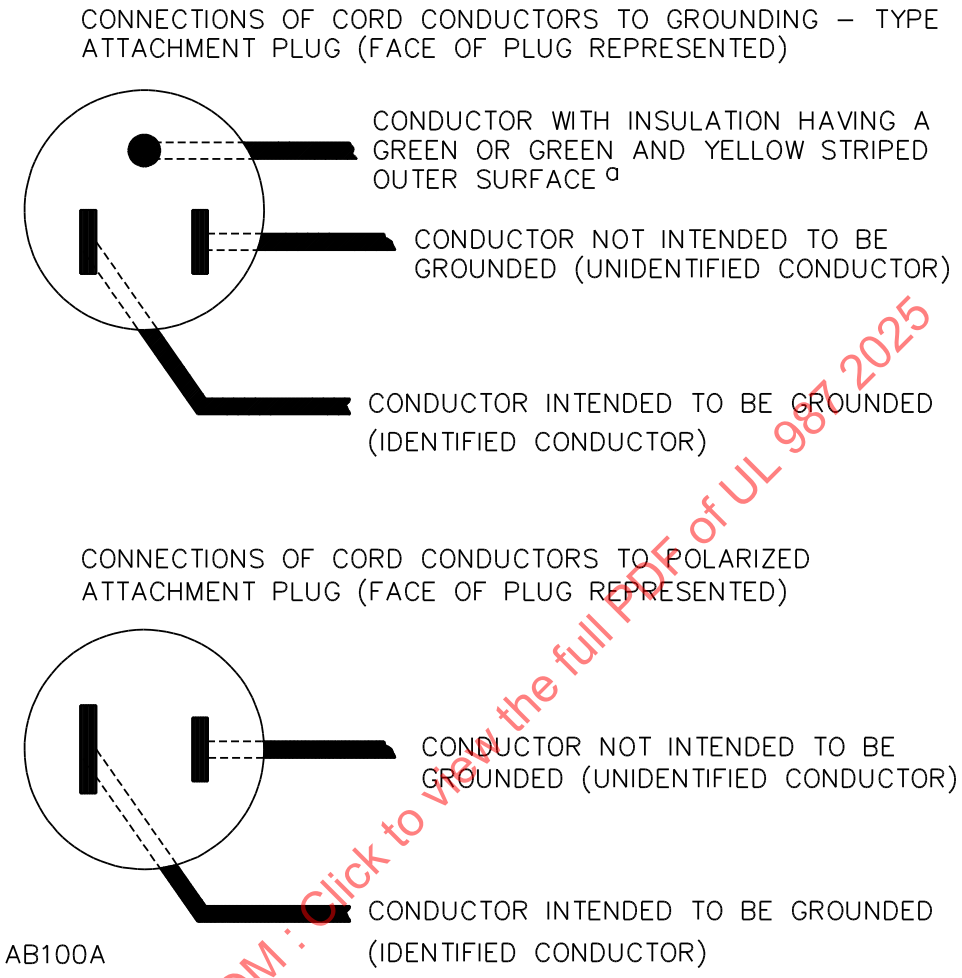
13.1.10 The attachment plug of a tool and the cord of a motor shipped detached from a tool shall be rated not less than the rated current and the rated voltage of the tool. If a tool has provision for being adapted for use on two or more different values of voltage by field alteration of internal connections, the attachment plug and any receptacle provided on the tool for the connection of the motor shall be rated not less than the voltage and current for which the tool or motor is connected when shipped from the factory. See 80.6.

13.1.11 If a tool incorporates a disconnecting means, such as a cord connector in the power-supply cord, the arrangement shall be such that no live part will be exposed under any normal condition.

13.1.12 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 13.1. See 13.1.

Figure 13.1

Connection to attachment plug



[a] The blade to which the green conductor is connected may have a U-shaped or circular cross section.

13.1.13 The equipment-grounding conductor of a flexible cord:

a) Shall be provided with insulation having an outer surface that is green with or without one or more yellow stripes;

b) Shall be connected to the grounding member of an attachment plug of the grounding type; and

c) Shall be conductively connected to:

1) All exposed dead metal parts of the tool that may become energized; and

2) All dead metal parts within the enclosure that are exposed to contact during any user servicing operation and that may become energized. User servicing as mentioned in this item and in 24.5 is considered to include operations, such as changing a blade on a radial-arm saw, adjusting a belt on a drill press, and the like.

d) The conductor shall be secured by a closed loop connector, connector with upturned ends, or equivalent means. Lock washers or equivalent means shall be utilized to hold the conductor in place. Thread-on devices shall not be used in the ground conductor.

13.1.14 A tool shall not be provided with a motor supply cord where the connection to a supply source will directly turn on the motor (i.e. without the operation of a motor controller, switch or other device for starting and stopping the motor), the operation of which could result in a risk of injury to persons.

13.2 Strain relief

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

13.2.2 Means shall be provided to prevent the supply cord or interconnecting cable from being pushed into the enclosure of a tool through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or interconnecting cable to mechanical damage;

b) Exposing the supply cord or interconnecting cable to a temperature higher than that for which it is rated;

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord or interconnecting cable shall be tested in accordance with Section 60, Push Back Relief Test.

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

13.2.4 The strain-relief means provided on a flexible cord shall comply with the requirements in Strain Relief Test, Section 59.

13.2.5 The strain relief provided on a supply cord shall be independent of any rubber or thermoplastic cord guard unless the guard is molded on the cord or has been investigated and found to be acceptable for the application.

13.2.6 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, the edges of the opening shall be smoothly rounded. If it is not obvious that the edges of such an opening are smoothly rounded, the tool shall comply with the requirements in 61.1.

14 Live Parts

14.1 Metal employed for a current-carrying part shall be silver, copper, copper alloy, or other metal that has been investigated and found to be acceptable for the application.

14.2 Ordinary iron or steel, if provided with a corrosion-resistant coating, may be used for a current-carrying part:

a) If permitted in accordance with 6.1; or

b) Within a motor or associated governor.

The use of ordinary iron or steel, even if plated, for current-carrying parts elsewhere in a tool is not acceptable.

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

14.4 Friction between surfaces is not acceptable as a means to prevent turning or shifting of an uninsulated live part, but a properly applied lock washer may be used.

15 Internal Wiring

15.1 The wiring and connections between parts of a tool shall be protected or enclosed.

Exception: Flexible cord as specified in 13.1.4 and used for external interconnection between components where flexibility is essential need not be protected or enclosed; however, Type SP and SPT cord shall not be used if it will be subjected to extreme flexing, such as the cord supplying the motor of a radial-arm saw.

15.2 Internal wiring exposed through an opening in the enclosure of a tool is considered to be protected as required by 15.1 if, when judged as though it were film-coated wire, the wiring complies with the conditions specified in 8.2. Internal wiring not so protected shall be secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

15.3 Among the factors to be considered when judging internal wiring shall be:

a) The temperature and voltage to which the wiring may be subjected;

b) Exposure to oil, grease, or other substances that may have a deleterious effect; and

c) Other conditions of service to which it may be subjected.

15.4 Thermoplastic-insulated wire and neoprene-insulated wire employed for internal wiring shall be standard building wire or appliance wiring material. The thickness of insulation shall be 0.030 in (0.76 mm) or more.

Exception: The nominal thickness of the insulation may be less than 0.030 in, but shall not be less than 1/64 in (0.4 mm) if the wire is also provided with a braid not less than 1/64 in thick.

15.5 Rubber-insulated wire employed for internal wiring shall be provided with a braid, and the wall thickness of the insulation shall not be less than 1/32 in (0.8 mm).

Exception: A braid need not be provided for appliance-wiring material having heat-resistant rubber insulation, of other than a silicone type, 3/64 in (1.2 mm) or more thick.

15.6 Appliance-wiring material having cross-linked synthetic polymer, polytetrafluorethylene, or fluorinated ethylene propylene insulation 0.015 in (0.38 mm) or more thick is acceptable for internal wiring.

15.7 Insulating tubing employed in place of wire insulation shall be suitable for the application and shall have a wall thickness not less than 1/32 in (0.8 mm).

15.8 Wiring shall be protected from sharp edges, including screw threads, burrs, moving parts, and other agencies that may abrade the insulation on a conductor. See 61.3 and 61.4.

15.9 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 a smooth, rounded surface upon which the wires may bear, to prevent abrasion of the insulation. See 61.3 and 61.4. If a flexible cord is used for external interconnection as mentioned in 15.1, the construction shall comply with the requirements in 13.2.1 – 13.2.6 and the Strain Relief Test, Section 59, unless the cord will be protected from stress and motion.

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

15.11 All splices and connections shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in a risk of fire or electric shock.

15.12 In a tool in which excessive vibration is likely to occur, the requirement in 15.11 necessitates the use of lock washers or other means to prevent wire-binding screws and nuts from becoming loosened.

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

15.14 A wire-binding screw shall thread into metal.

15.15 A splice shall be provided with insulation equivalent to that on the wires involved if permanence of spacings between the splice and other metal parts may not be maintained.

15.16 The thickness of insulation on a splice shall be 1/32 in (0.8 mm) or more. In determining whether splice insulation consisting of coated-fabric, thermoplastic, or other tubing is acceptable, consideration shall be given to such factors as its dielectric properties, heat- and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable. An insulated splicing device is acceptable within the limits of its voltage and temperature range.

15.17 Stranded internal wiring shall be connected at a wire-binding screw so that loose strands of wire will not reduce spacings below the values identified in Spacings, Section 23. This may be accomplished by use of pressure wire connectors, crimped eyelets, soldering all strands of the wire together, or equivalent means.

15.18 A quick connect, an eyelet, a wire connector, or other means that does not require positioning to prevent reduction of spacings below the minimum acceptable values shall be provided to make necessary electrical connections, such as to:

a) Electrically connect a motor shipped detached from the tool;

b) Reconnect a multiple-voltage motor for a different voltage;

c) Reconnect a motor shipped detached from a tool, which can rotate in either direction, for rotation in the opposite direction; or

d) Reposition a switch mounted integrally with a motor shipped detached from a tool to comply with the requirement in 38.5.

15.19 Internal wiring shall not be disturbed in mounting a motor shipped detached from the tool.

15.20 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

15.21 With reference to 15.20, a wire binding screw or a pressure wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and the like.

15.22 A tool which employs a splicing device (wire nut) of the thread-on or setscrew type (other than in terminal blocks) shall be additionally secured by wrapping the wires and the connector with friction tape or by other equivalent means. Thread-on devices shall not be used to connect a ground lead.

Exception No. 1: This requirement does not apply to double-insulated tools.

Exception No. 2: Tape need not be additionally applied to machine-applied wire nuts, or to wire nuts located in a confined area where the wire nut is not capable of backing off.

16 Interconnecting Cords

16.1 Other than as mentioned in 16.4, a motor intended to be installed in the field shall be provided with a length of flexible cord and an attachment plug for connection to a supply receptacle installed as a part of the tool.

16.2 Flexible cord as mentioned in 16.1 shall be one of the types specified in 13.1.4; however, Type SP or SPT cord shall not be used if it will be subjected to extreme flexing, such as the cord supplying the motor of a radial-arm saw. For a grounded tool, the flexible cord shall include an equipment-grounding conductor, and this conductor shall be bonded to all dead metal enclosures of electrical parts of a motor assembly and shall connect through the receptacle to the grounding system of the tool.

16.3 Other than mentioned in this paragraph, the length of flexible cord shall not be excessive and the cord shall be routed directly from the motor to the receptacle. Routing hardware may be provided if a longer length is required and it becomes necessary to secure the cord to prevent possible damage in using or moving the tool.

16.4 A motor shipped detached from a tool may be provided with a 6 – 10-ft (1.83 – 3.05-m) cord terminating in an attachment plug for connection to the power supply if, when the motor is installed in accordance with the manufacturer's instructions, the tool complies with the requirements in this standard.

17 Insulating Material

17.1 Material for mounting an uninsulated live part shall be phenolic composition, cold-molded composition, or other material that has been investigated and found acceptable for the application.

17.2 Vulcanized fiber may be used for an insulating bushing, a washer, a separator, a brush-holder liner, and a barrier, but not as the sole support for an uninsulated live part where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock. Thermoplastic material may be employed for the sole support of an uninsulated live part only if it has been investigated and found to have mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric strength, resistance to arc tracking, and other properties needed for the application.

17.3 A molded part shall be constructed so that it will have the mechanical strength and rigidity needed to withstand stresses of normal use. A brush cap shall be protected, by recessing or other means, from mechanical damage that may occur during normal use unless it has the strength necessary to withstand the abuses to which it is likely to be subjected.

18 Motors

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

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

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

a) An accessible dead metal part from becoming energized; and

b) A live part from becoming accessible.

18.4 A motor that is shipped detached from a tool and intended for installation in the tool by the user shall be investigated with the tool.

19 Switches and Controls

19.1 A switch or other control device shall have a voltage rating and an ampacity not less than the corresponding values of the load that it controls.

19.2 A motor controller – a switch or other device for starting and stopping the motor – shall be provided on a tool. The motor controller may be on a motor shipped detached from a tool.

Exception: A motor controller need not be provided on a permanently connected tool if all three of the following conditions are met:

a) The instruction manual specifies the correct motor controller for use with a particular motor, and the motor controller is available from the manufacturer;

b) The instruction manual contains instructions for mounting the motor controller in accordance with 33.3 – 33.6; and

c) The motor controller is provided with a locking means that complies with the requirements in 33.7 and 33.8.

19.3 A single-pole switch employed in a tool having a nominal rating of 125 V or less shall be connected in the conductor not intended to be grounded. A double-pole switch shall be employed in a tool having a nominal rating more than 125 V.

Exception: A single-pole switch may be employed in a tool having a nominal rating more than 125 V if it switches the control circuit of a motor controller. The motor controller shall open all ungrounded supply conductors.

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

19.5 *Deleted*

20 Lampholders

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

20.2 An Edison-base lampholder employed in a tool having a nominal rating more than 125 V shall be connected on the load side of the on-off switch of the tool.

20.3 An Edison-base lampholder employed in a double-insulated tool shall be connected such that the screw shell is connected to the neutral side of the line.

21 Overcurrent-Protective Devices

21.1 An overcurrent- or thermal-protective device shall be suitable for the application, considering the rating of the branch circuit to which the tool will be properly connected.

21.2 A thermal- or overcurrent-protective device shall not open during normal use of the tool.

21.3 If the handle of a circuit breaker is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

22 Capacitors

22.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line – such as a capacitor for radio-interference elimination or power-factor correction – shall be housed within an enclosure or container that will protect the plates against mechanical damage, and that will prevent the emission of flame or molten material resulting from breakdown of the capacitor. The construction shall comply with one of the following:

a) The capacitor container or enclosure shall be of sheet steel not less than 0.02 in (0.51 mm) thick or shall be constructed to afford equivalent protection;

b) A capacitor having a sheet-steel container or enclosure thinner than 0.02 in or of other suitable material shall be mounted in an enclosure that houses other parts of the appliance and that is acceptable for the enclosure of live parts;

c) The individual container or enclosure of an electrolytic capacitor with means for venting shall be such as to provide protection against mechanical damage only, and no minimum enclosure thickness is specified; or

d) The individual container or enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 in (1.6 mm) wide between the capacitor enclosure and

the motor shall comply with the requirements in 63.1, and no minimum enclosure thickness is specified.

23 Spacings

23.1 The following spacing shall not be less than the minimum acceptable value specified in Table 23.1 (see 12.3.1):

a) Between field-wiring terminals of opposite polarity; and

b) Between a field-wiring terminal and a dead metal part or an uninsulated live part not always of the same polarity.

Exception: Spacings complying with 23.3 need not comply with this requirement.

Table 23.1
Minimum acceptable spacings at field-wiring terminals

Potential involved, volts	Minimum spacing, Inch (mm)[a]					
	Between field-wiring terminals of opposite polarity, through air or over surface		Between a field-wiring terminal and a dead metal part or an uninsulated live part not always of the same polarity			
			Over surface		Through air	
250 or less	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
More than 250	1/2	(12.7)	1/2	(12.7)	3/8	(9.5)

[a] Applies to the sum of the spacings involved where an isolated dead metal part is interposed.

23.2 At other than field-wiring terminals, the following spacings shall not be less than the minimum acceptable value specified in Table 23.2:

a) Between uninsulated parts of opposite polarity; and

b) Between an uninsulated live part and a dead metal part.

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 below the minimum acceptable value. See 23.6 and Figure 23.1.

Exception: Spacings complying with 23.3 need not comply with this requirement.

Table 23.2
Minimum acceptable spacings at other than field-wiring terminals

Potential involved, volts	Minimum spacing, Inch (mm)							
	Tool employing a motor having a diameter of 7 in (178 mm) or less[a]				Tool employing a motor having a diameter more than 7 in (178 mm) through 11 in (279 mm)[a]			
	Over surface		Through air		Over surface		Through air	
0 – 125	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)[b]	1/8	(3.2)[b]
126 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)[b]	1/4	(6.4)[b]

Table 23.2 Continued on Next Page

Table 23.2 Continued

Potential involved, volts	Minimum spacing, Inch (mm)							
	Tool employing a motor having a diameter of 7 in (178 mm) or less[a]				Tool employing a motor having a diameter more than 7 in (178 mm) through 11 in (279 mm)[a]			
	Over surface		Through air		Over surface		Through air	
251 – 600	1/2	(12.7)[b]	3/8	(9.5)[b]	1/2	(12.7)[b]	3/8	(9.5)[b]

[a] This is the diameter, measured in the plane of a lamination, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and the like, used solely for motor mounting, cooling, assembly, or connection.

[b] A spacing of not less than 3/32 in (2.4 mm), over surface and through air, is acceptable between film-coated wire, rigidly supported and held in place on a coil, and dead metal parts.

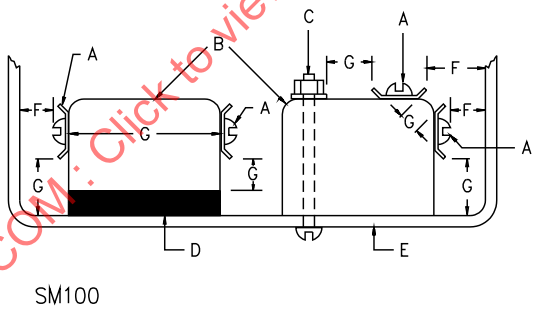
23.3 The minimum acceptable spacings specified in Table 23.1 and Table 23.2 do not apply to the inherent spacings of a component of a tool, such as a snap switch; such spacings shall be judged on the basis of the requirements for the component. See Figure 23.1.

23.4 The spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

23.5 In applying Table 23.2 to a tool employing two or more motors of different sizes, the spacings shall be judged on the basis of the size of the largest motor in the tool.

Figure 23.1

Component spacings



A. Uninsulated live parts of a component.

B. Insulating material of a component.

C. Mounting screw of a component.

D. Dead metal part of a component.

E. Dead metal part of the product.

F. Spacings to which the requirements of this standard apply unless specifically noted otherwise.

G. Spacings to which the requirements of the component standard apply.

23.6 At a terminal screw and a stud to which connection is made in the field by a wire connector, eyelet, and the like, as described in 12.3.1, and at support springs of brushes, the spacings shall not be less than the values specified in Table 23.2 when such a connector, eyelet, and the like, is in the position that results in minimum spacings between parts of opposite polarity and to dead metal.

23.7 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 in (0.8 mm) thick, and shall be located or of such material so that it will not be adversely affected by arcing.

Exception: Vulcanized fiber equal to or greater than 1/64 in (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.

23.8 Film-coated wire is regarded as an uninsulated live part when spacings are being considered.

23.9 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 that complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; and

1) Are applied at no less than the required thickness; and

2) Comply with the Dielectric Voltage Withstand Test, Section 56.6;

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

1) Have a minimum spacing of not less than 1/32 in; and

2) Comply with the Dielectric Voltage Withstand Test, Section 56.6;

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 the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, in accordance with 23.10.

23.10 For the purpose of determining suitability of spacings in accordance with the exception to 23.9, 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 in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the conformal coatings shall be used in accordance with its ratings, and applied in accordance with the coating manufacturer's instructions.

24 Grounding

24.1 The power-supply cord of a tool that is not double insulated shall include an equipment-grounding conductor. A tool operating at potentials of not more than 150 V to ground may be provided with a system of double insulation complying with the requirements for Double-Insulated Tools, Sections 89 – 93, in lieu of grounding.

24.2 The grounding member of the attachment plug mentioned in 13.1.13(b) shall be fixed in position with respect to the plug.

24.3 With reference to the requirements in 13.1.3(c), the connection shall be made by a screw or other means not likely to be removed during any servicing not involving the power-supply cord. Solder alone shall not be used for making this connection. A sheet metal screw shall not be used for the connection of a grounding conductor to an enclosure.

24.4 The screw mentioned in 24.3 shall be of corrosion-resistant metal or shall be protected against corrosion. A lock washer or other means shall be employed to prevent the screw from being loosened by vibration. This screw shall have a slotted, hexagonal, green-colored head.

Exception: Screws that are clearly marked or are inaccessible need not have a slotted, hexagonal, green-colored head.

24.5 In a permanently connected tool, all exposed dead metal parts that may become energized, and all dead metal parts within the enclosure that are exposed to contact during any user servicing operation and that may become energized shall be conductively connected to:

a) The point of the enclosure at which the supply circuit is intended to be connected; and

b) The equipment-grounding field-wiring terminal or field-connection lead.

24.6 With reference to the requirements in 13.1.13 and 24.5, the following dead metal parts are not considered likely to become energized:

a) A small metal part, such as an adhesive-attached foil marking, a screw, a handle, and the like, that is:

1) On the exterior of the enclosure and separated from all electrical components by grounded metal; or

2) Electrically isolated from all electrical components.

b) A panel or a cover that is isolated from all electrical components by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material not less than 1/32 in (0.8 mm) thick and reliably secured in place.

c) A panel or a cover that does not enclose an uninsulated live part and is electrically isolated from other electrical components.

d) A core and an assembly screw of a relay, a solenoid, and the like.

24.7 Unless the dead metal parts described in 13.1.13 and 24.5 are bonded together by mechanical fasteners, a individual bonding conductor or strap shall be used for this purpose.

24.8 The bonding conductor shall be silver, copper, copper alloy, or other metal that has been investigated and found to be acceptable for use as an electrical conductor, and shall be protected against corrosion unless inherently resistant thereto. An individual bonding conductor or strap shall be installed so that it is unlikely to be damaged.

24.9 Bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection, brazing, or welding. A bonding connection shall reliably penetrate a nonconductive coating, such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material unless the construction has been shown to be acceptable by an investigation that includes tests, such as overload, short-circuit, and aging.

24.10 The size of an individual conductor or strap employed to bond an electrical enclosure or motor frame shall not be less than the applicable size indicated in Table 250-95 of the National Electrical Code, ANSI/NFPA 70. The applicable size is to be determined by the rating of the branch-circuit overcurrent device to which the tool is intended to be connected.

Exception No. 1: A smaller conductor may be used provided it complies with the Bonding Overload Test, Section 65.

Exception No. 2: A bonding conductor to a motor need not be larger than the motor-circuit conductors.

24.11 If more than one rating of a branch-circuit overcurrent device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor.

24.12 With reference to the requirement in 24.11, if a motor may be individually protected by a branch-circuit overcurrent device smaller than the overcurrent devices protecting the overall equipment, the size of a bonding conductor for that motor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the motor.

24.13 The grounding means of a resilient mount of a motor, including a series motor, shall comply with the requirements for those features in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

25 Lasers

25.1 A laser used to indicate a cutting line or the like, shall comply with the Code of Federal Regulations (CFR), Title 21, Part 1040.

25.2 With reference to 25.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of the laser product and the Class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's Center for Devices and Radiological Health (CDRH) product report;

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

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

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

e) Verifying that the manufacture's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

PROTECTION AGAINST INJURY TO PERSONS

ALL TOOLS

26 General

26.1 Sections 26 – 50 contain requirements for tools covered by this standard the operation of which may involve a risk of injury to persons.

26.2 During examination of a tool with respect to a risk of injury to persons, the general requirements for materials, enclosure, guards, and the like, shall be applied, along with specific requirements for that tool. The requirements in Sections 27 – 50 apply to tools of common constructions; specific features of tools that are not contemplated herein will be considered. A specific requirement pertaining to a particular tool takes precedence over a corresponding requirement specified in the general section.

26.3 The material of an enclosure, a frame, a guard, or the like, breakage or deterioration of which may result in a risk of injury to persons, shall have such properties as to meet the demand of expected conditions of normal use.

27 Attachments and Accessories

27.1 Operation of a tool with an accessory or an attachment (see 1.2, 1.5, 4.3 and 4.7) shall not result in a risk of injury to persons. See Sections 84 – 88 for specific requirements for accessories and attachments. The tool with the accessory or attachment installed shall comply with the applicable requirements in Sections 28 – 46.

28 Temperatures

28.1 When tested as described in 28.2, a temperature on a surface of a tool that may be contacted by the user, other than the cutting tool, shall not be more than the maximum acceptable value specified in Table 28.1.

Table 28.1
Maximum acceptable surface temperature

Location	Composition of surface			
	Metal		Nonmetallic	
	°C	°F	°C	°F
Handle, lever, or knob likely to be grasped	50	122	60	140
Accessible surface in a work area	60	140	85	185
Surface subject to casual contact	70	158	95	203

28.2 With reference to 28.1, surface temperatures of a bench grinder, or a radial-arm saw are to be measured after 30 minutes of operation as described in Table 54.1, with the tool at room temperature at the beginning of the test. Surface temperatures of all other tools are to be measured during the normal temperature test. For all tools, if the test is conducted at a room temperature other than 25°C (77°F), the results are to be corrected to that temperature.

28.3 A lamp shall be provided with a shade or be recessed within the tool enclosure.

29 Rotating Members

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

29.2 A removable rotating part not intended to be removed by the user shall be:

a) Secured as described in 29.1; or

b) Secured by a keyed nut, a jam nut, a nut locked in place with a pin, or other positive means.

29.3 The outboard edges of all pulleys and sheaves shall be free of projections, sharp edges, and burrs.

30 Enclosures and Guards

30.1 A belt, pulley, gear, shaft, or other moving part likely to present a risk of injury to persons shall be guarded so as to reduce the likelihood of such injury.

Exception: A part that is necessarily exposed during normal operation and maintenance of a tool need not comply.

30.2 Among the factors to be considered in judging the acceptability of a moving part shall be:

a) The degree of exposure;

b) The sharpness of the moving part;

c) The likelihood of unintentional contact therewith;

d) The speed of the moving part; and

e) The likelihood that fingers, arms, feet, or clothing would be endangered by the moving part.

These factors shall be considered with respect to normal operation of the tool, setting of any adjustment, and replacement of any tool.

30.3 Some guards provided over moving parts are required to be of the self-restoring type – for example, a guard on a saw and a guard on a jointer. Other features of a guard that shall be considered include:

a) Removability of the guard without the use of a tool;

b) Removability for servicing and the need for replacement;

c) Strength and rigidity;

d) Completeness; and

e) Creation of a risk of injury to persons, such as pinch points, material hang-ups or jams, restricted vision, or other conditions adversely affecting the ease of operation; and the necessity for additional handling because of increased need for servicing – such as cleaning, unjamming, and the like.

30.4 An opening in a guard or an enclosure around a moving part capable of causing injury – for example, a cutting tool, a fan, a pulley, a gear, a chain, or the like – shall:

a) Have a minor dimension not more than 6 in (152 mm); and

b) Not be closer to the moving part than the distance specified in Table 30.1.

Exception No. 1: An opening for the cutting edge of a tool need not comply.

Exception No. 2: An opening in a grinder as specified in the Exception to 38.6; and in 40.4 – 40.6 need not comply.

30.5 A probe based on the dimensions specified in Table 30.1 may be used to determine whether an opening complies with the requirement in 30.4(b).

Table 30.1
Distance to a moving part

Minor dimension of opening		Minimum straight-line distance from opening to moving part	
inches	(mm)	inches	(mm)[a,b]
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114.0)
1	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
	c	30	(762.0)

[a] A fan blade is considered to be guarded if it cannot be contacted with the probe illustrated in Figure 8.1.

[b]Between 1/4 and 2-1/8 in (6.4 and 54 mm), interpolation is to be used to determine a value between values specified in the table.

[c]More than 2-1/8 in (54 mm), but not more than 6 in (152.0 mm).

30.6 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to cause a risk of injury to persons in normal use and maintenance of a tool.

30.7 The enclosure or guard around a rotating member shall be sufficiently complete from the standpoint of number and size of openings provided; and shall have the strength and resistance to puncture necessary to contain and deflect a part that, because of breakage or other reason, may become loose or separate from the rotating member.

Exception: An opening for the cutting edge of a tool need not comply.

30.8 Compliance with the requirements in 30.7 may be determined by:

a) Calculation in accordance with 30.9;

b) Evaluation of the manufacturer's design data;

c) Performance tests; or

d) Other equivalent means.

30.9 A guard or enclosure is considered to comply with the requirements in 30.7 if its minimum thickness is greater than the value calculated by the following formula using data supplied by the manufacturer:

$$t = \sqrt{\frac{Wv^2}{2gY_s Pb}}$$

in which:

t is the thickness of the guard or enclosure in inches (mm);

W is the weight of the heaviest loose part that may separate from a rotating part in pounds (N);

v is the speed of the loose part in in/second (mm/s);

g is the acceleration due to gravity in in/second/second (mm/s/s);

Y_s is the shear strength at yield point of the material of the guard or enclosure in lb/in^2(MPa);

P is the smallest perimeter of the loose part in in (mm); and

b is the pure shear of the material of the guard or enclosure in percentage.

30.10 If a guard is intended to be removed, it shall be readily removable and replaceable.

30.11 A guard that must be removed to permit a speed change, lubrication, or a similar adjustment or operation shall be hinged or equivalently attached; and when opened, shall remain in the open position.

30.12 A guard required by this standard shall be provided as a part of a tool.

30.13 If removal of a guard or a cover is necessary for mounting a motor shipped detached from a tool, the guard or cover shall be constructed so that it cannot be replaced improperly.

31 Stability

31.1 A tool shall be provided with bolt holes or other means for securing it to the supporting structure.

Exception No. 1: A tool powered by a vibrator or a motor developing less than 1/10 hp (74.6 W output) and containing explicit instructions in the instruction manual as to how to prevent the tool from tipping, sliding, or walking on the supporting surface, if there is any tendency to do so.

Exception No. 2: A tile saw that complies with the requirements in 31.2 – 31.5 is not required to comply with this requirement.

31.2 Casters or wheels that support a tool shall be retractable or of a locking design; or other means shall be provided to prevent unexpected movement of the tool during operation.

31.3 A tool tested as described in 31.4 shall return to its normal at-rest position on a level surface when tipped through an angle of 7° from the horizontal.

Exception: A tool that is provided with instructions to the user to fasten the tool to the bench top or floor prior to installation need not comply with this requirement.

31.4 The test mentioned in 31.3 is to be conducted with the tool mounted in accordance with the manufacturer's instructions and under the normal operating condition most likely to cause tip-over. The tool is to be tipped in the direction of least stability.

31.5 A tool mounted in accordance with the manufacturer's instructions shall not overturn when any doors, empty drawers, movable tables, or other appurtenances are placed in any position to which they are capable of being moved without the use of a hand tool. The tool need not be capable of normal operation when components are positioned for this test.

32 Mechanical Assembly

32.1 A tool shall operate smoothly without vibration, chatter, or deflection of a support member or a worktable that could result in a risk of injury to persons.

32.2 The requirement in 32.1 applies throughout the speed range of a tool, at full or partial capacity – size of workpiece, and the like – and while performing any of the functions of which it is capable.

32.3 A movable or adjustable component, such as a table, shall be secured so that, even if it should become loosened, it will not fall or otherwise present a risk of injury to persons.

33 Switches and Controls

33.1 A device that automatically starts a tool – a timer, an automatically reset overload-protective device, or the like – shall not be employed if automatic starting of the tool will result in a risk of injury to persons.

33.2 An on-off switch shall be capable of being turned off by the operator with a single straight-line motion.

Exception: A switch that cannot result in a risk of injury to persons if unintentionally operated need not comply.

33.3 A switch or motor controller shall be:

a) Readily accessible from the position normally assumed by the operator while using the tool;

b) Located or guarded so that unintentional movement to the on position is unlikely – see 33.4; and

Exception: A switch that cannot result in a risk of injury to persons if unintentionally operated need not be guarded.

c) For a magnetic motor controller, mounted so that unintentional actuation is unlikely.

33.4 With reference to 33.3(b), a switch that is located or guarded so that it is not capable of being turned on by being struck with the palm of the hand is acceptable.

33.5 A push-pull switch shall be turned off by an inward push. Other than a switch with two on positions, a switch – such as a toggle switch, a slide switch, or the like – shall be located so that it will be turned off by:

a) A vertical downward movement;

b) A right-to-left movement; or

c) A rearward movement.

33.6 A multiple-function tool shall be designed to prevent unexpected operation of any part that may involve a risk of injury to persons. Protection against unexpected operation of the switch controlling one function shall not be defeated by the controls of another function.

33.7 A tool shall be provided with a means for locking the motor-control switch in the off position. See 83.1.8.

Exception No. 1: A rebar cutter/bender, grinder or brake lathe that is not intended to be used in an area accessible to children is not required to be provided with the lockout if the tool is marked in accordance with 81.1.7.

Exception No. 2: A tool that does not involve a risk of injury to persons as determined by inspection is not required to have a locking mechanism.

Exception No. 3: A permanently-connected tool or a three-phase tool is not required to be provided with the lockout when the instruction manual provided with the tool instructs the installer to follow local regulations and National Electrical Code, ANSI/NFPA 70 installation requirements.

33.8 A guard or lockout mechanism constructed of polymeric material used to meet the requirements of 33.3(b) or 33.7 shall have the strength to withstand a 5 ft-lb (6.8 N·m) impact before and after seven hours of oven conditioning at 70°C (158°F), without increasing the risk of electric shock or the risk of injury to the user.

33.9 A lock-actuating means shall be removable.

33.10 *Deleted*

33.11 A handle, a lever, a knob, or other control shall be located so that it is not necessary to traverse an area that may involve a risk of injury to persons when reaching for it. Such an area adjacent to the control shall be guarded or located so that it cannot be entered unintentionally.

34 Controls – End Product Test Parameters

34.1 General

34.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements in the applicable control standard as determined in Controls, Section 6.6.

34.1.2 Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

34.2 Auxiliary controls

34.2.1 Auxiliary controls shall not introduce a risk of risk of fire, electric shock, or injury to persons.

34.2.2 Auxiliary controls shall comply with the requirements in this end product standard.

Exception: An auxiliary control that complies with a component standard(s) specified in Temperature Controls, Section 6.6 is considered to comply with this requirement.

34.3 Operating Controls (regulating controls)

34.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;

c) Installation class 2 in accordance with the Standard for Electromagnetic Compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test, IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 34.1;

e) For the applicable Material Group, see Table 34.2; and

f) For the applicable Pollution Degree, see Table 34.3.

34.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;

c) For the applicable overvoltage category, see Table 34.1;

d) For the applicable material group, see Table 34.2; and

e) For the applicable pollution degree, see Table 34.3.

Table 34.1
Overvoltage categories

Appliance	Overvoltage Category
Control located in low-voltage circuit	I
Portable and stationary cord-connected	II
Intended for fixed wiring connection	III
NOTE – Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would increase the risk of fire or electric shock.	

Table 34.2
Material group

CTI PLC value of insulating materials	Material group
CTI ≥ 600 (PLC = 0)	I
400 ≤ CTI < 600 (PLC = 1)	II
175 ≤ CTI < 400 (PLC = 2 or 3)	IIIa
100 ≤ CTI < 175 (PLC = 4)	IIIb
NOTE – PLC stands for Performance Level Category, and CTI stands for Comparative Tracking Index as specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.	

Table 34.3
Pollution degrees

Appliance Control Microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated control without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in household or commercial clean environments achieve this degree.	2
Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected. Typically controls located near and may be adversely affected by motors with graphite or graphite composite brushes, or outdoor use appliances achieve this degree.	3

34.4 Protective controls (limiting controls)

34.4.1 An electronic control that performs a protective function shall comply with the requirements in Temperature Controls, Section 6.6 while tested using the parameters in this section. Examples of protective controls include:

a) A control used to sense abnormal temperatures of components within the appliance;

b) An interlock function to de-energize a motor;

c) Temperature protection of the motor due to locked rotor, running overload, or loss of phase; or

d) Other function intended to reduce the risk of fire, electric shock, or injury to persons.

34.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1:

a) Failure-Mode and Effect Analysis (FMEA) or equivalent risk analysis method;

b) Power supply voltage dips, variation and interruptions within a temperature range of 50 °F (10° C) and the maximum ambient temperature determined by conducting the Temperature Test, Section 55;

c) Surge immunity test – installation class 3 shall be used;

d) Electrical fast transient/burst test, a test level 3 shall be used;

e) Electrostatic Discharge Test;

f) Radio-frequency electromagnetic field immunity:

1) Immunity to conducted disturbances, when applicable, test level 3 shall be used; and

2) Immunity to radiated electromagnetic fields, field strength of 3 V/m shall be used;

g) Thermal Cycling Test shall be conducted on protective devices intended for other than outdoor use at ambient temperatures of 32.0 ±3.6°F (0 ±2°C) and 104 ±3.6°F (40.0 ±2°C). For protective devices intended for outdoor use, the test shall be conducted at ambient temperatures of -31.0 ±3.6°F (-35.0 ±2°C) and 104 ±3.6°F(40.0 ±2°C). If the maximum ambient temperature of the control is determined to exceed the specified upper limit of the ambient temperature by conducting the Temperature Test, Section 55, this higher ambient temperature shall be used. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test, Section 55; and

i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class B.

34.4.3 The test parameters and conditions used in the investigation of the circuit covered by 6.6.1.4 shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance complies with the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication.

b) A field strength of 3 V per meter is to be used for the Radiated EMI Test.

c) The Composite Operational and Cycling Test is to be conducted for 14 days at temperature extremes of 0°C (32°F) and 70°C (158°F).

d) The Exposure Class as defined under Humidity Classes for the products intended end use is to be used for the Humidity Test.

e) A vibration level of 5 g is to be used for the Vibration Test.

f) The computational investigation is not applicable to tools covered by this end product.

g) When the Demonstrated Method is conducted, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances or 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 77°F (25°C) use ambient.

h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 140°F (60°C), or 18°F (10°C) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use.

i) For the Electrical Fast Transient Burst Test, test level 1 is to be used;

j) Conduct a failure-mode and effect analysis (FMEA); and

k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

34.4.4 Unless otherwise specified in this standard, protective controls shall be evaluated for 100,000 cycles for Type 2 devices and 6,000 cycles for Type 1 devices with rated current.

34.5 Controls using a temperature sensing device

34.5.1 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control, shall be tested using the following number of cycles when testing a sensing device in accordance with the Endurance Test as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 or the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1:

a) For a device employed as a operating device – 6000 cycles;

b) For a device employed as a protective device – 100,000 cycles; and

c) For a device employed as a combination operating and protective device – 100,000 cycles.

35 Tables

35.1 The table of a tool, including a table insert shall:

a) Be smooth;

b) Resist scratching to the degree that free movement of the workpiece would be impeded; and

c) Not cause glare.

Exception: A tile saw is not required to comply with Item (c).

36 Miter Grooves

36.1 A miter slot or groove shall be of uniform depth. The top of a miter gauge bar shall not extend more than 0.005 in (0.13 mm) above the top surface of the table. The table or miter gauge bar, or both, shall be chamfered or equivalently finished so that the bar will not hang up at the table edge during use.

SPECIFIC TOOLS

37 Drill Presses

37.1 Drill presses covered by these requirements are drilling machines of the floor- or bench-type. These requirements cover drill presses intended primarily for use in hole drilling, but adaptable through use of various cutters or bits or accessories to perform other operations, such as shaping, mortising, plug cutting, sanding, routing, and other vertical-spindle operations.

37.2 These requirements are not intended to cover:

a) A portable drill fastened to a column-and-level arrangement; or

b) A very small drill press, such as a watchmaker's drill press.

37.3 The hollow shaft containing the bearing and the spindle – quill – shall be such that it cannot be unintentionally removed from the head. In addition to tightening, there shall be provision to prevent the stop-rod collar from being driven off the quill through continued use.

37.4 There shall be provision to prevent unexpected removal and opening or complete unwinding of the return spring. Tightening or tensioning of the return spring shall be by an adjusting means the operation of which will not result in a risk of injury to persons.

37.5 To prevent unexpected disengagement from the spindle, the chuck shall be firmly fastened to the spindle by a No. 33 nonreleasing chuck taper, a threaded collar, a similar fastening device, or a combination of devices.

37.6 Provision shall be made for mandatory removal or self-ejection of the chuck key before the drill press can be turned on.

37.7 Collars that mount around the column or other means shall be provided to prevent unintentional lowering or dropping of either the head or the table on a floor-model tool or the head on a bench tool.

37.8 Unless it is designed for coolant recovery, a table shall be provided with clamping ledges, table slots, table holes, or similar features for conveniently fastening or holding the workpiece.

37.9 Means shall be provided for securely fastening an optional vise, jig, or other workholding device to the drill-press column or table.

37.10 A hold-down, a chisel holder, a guard, a fence, and a mounting bracket shall fit properly on the drill press or attachment assembly.

37.11 An optional cutting tool that may be provided shall comply with the following:

a) Mortising-chisel bits, mortising chisels and bushings, and adapters shall work smoothly together in the drill press assembly.

b) An abrasive sleeve or sheath shall mount firmly and securely to the assembly.

37.12 The shank of an accessory intended to be gripped in a chuck shall be sufficiently long to be clamped firmly in the chuck or other holding device.

38 Bench and Pedestal Type Grinders

38.1 These requirements cover bench grinders and pedestal grinders.

38.2 A grinder shall be nonreversible, with clockwise rotation as viewed from the outside of the left-hand wheel.

38.3 A grinder shall be constructed so that an oversize grinding wheel (that is larger in diameter than the maximum diameter grinding wheel specified by the manufacturer for use with the grinder) cannot be used with the grinder.

38.4 A grinder shall be provided with a wheel guard to reduce the risk of injury to persons in the event of wheel breakage.

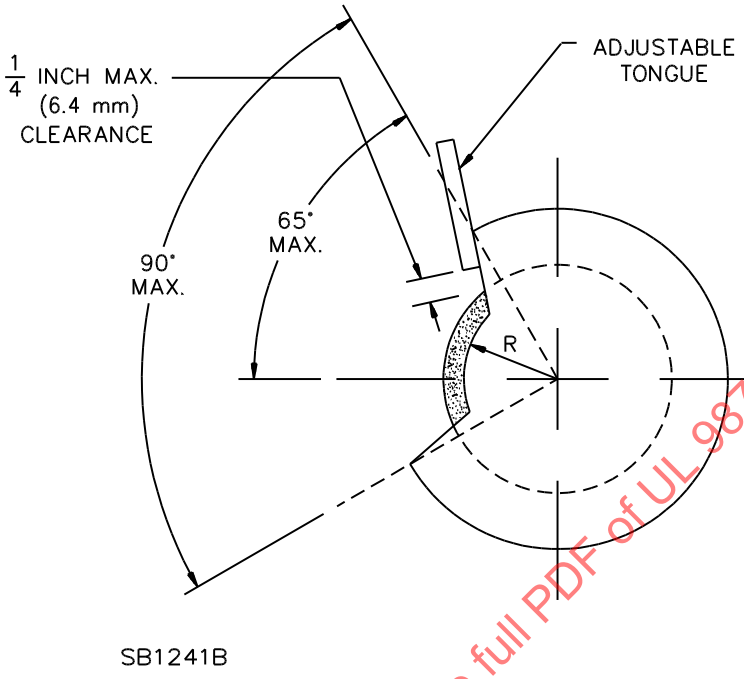
38.5 In judging the acceptability of a guard, consideration shall be given to the direction of rotation of the grinding wheel, the type of wheel, and the position and location of the operator during the various operations.

38.6 A grinder with which grinding may be performed on the periphery of the grinding wheel above the horizontal plane through the spindle shall be provided with a hood guard that does not expose the periphery and side of the wheel for more than 90°, with no more than 65° above the horizontal plane through the spindle. See Figure 38.1.

Exception: The guard may have an opening for discharging debris from the grinding operation provided the size of the opening or its orientation with respect to the grinding wheel, or both, are such that injury to persons from flying pieces of the grinding wheel or debris is not likely to occur.

Figure 38.1

Guard with maximum clearance shown



The radius (R) shall not be less than one-half the flange diameter specified in Table 38.4.

38.7 The angles of exposure specified in 38.6 and illustrated in Figure 38.1 shall be measured with the vertexes at the center of the spindle and:

a) For the 90° angle, with the sides extending through the ends of the peripheral protective member exclusive of a projecting adjustable tongue or the like.

b) For the 65° angle, with one side in the horizontal plane through the axis of the spindle and the other side extending through the upper end of the peripheral protective member exclusive of a projecting adjustable tongue.

38.8 With reference to 38.6 and 38.7, the opening in the guard shall be entirely within the 90° angle.

Exception: The opening may be outside of the 90° angle provided the size of the opening or its orientation with respect to the grinding wheel, or both, are such that injury to persons from flying pieces of the grinding wheel or debris is not likely to occur.

38.9 The peripheral protective member of a hood guard, as described in 38.6 – 38.8 and illustrated in Figure 38.1, shall be adjustable, or the guard shall be provided with an adjustable tongue so that a maximum clearance of 1/4 in (6.4 mm) can be maintained between the grinding wheel and the end of the peripheral member or the adjustable tongue as the diameter of the wheel decreases up to 3/4 in (19.1 mm) with use.

Exception: For a grinder intended for use with grinding wheels not more than 5 in (127 mm) in diameter, operating at peripheral speeds not more than 5000 surface ft/min (1520 sm/min), and having a rated output not more than 1/10 hp (74.6W), the 1/4 in (6.4 mm) clearance applies only to the largest diameter wheel intended for use with the grinder; and the peripheral member need not be adjustable nor be provided with an adjustable tongue.

38.10 A guard shall be constructed so that removal of the peripheral protecting member is not necessary for replacement of the grinding wheel.

38.11 The peripheral and side protective members of a guard for a grinding wheel shall comply with 38.12 or shall be of material as specified in Table 38.1 and Table 38.2.

Exception: The members of a guard may be of other material or thinner provided that when tested as described in 38.13:

a) There is no breakage of the guard; or

b) The guard remains structurally intact and capable of performing the intended guarding function.

38.12 A polymeric guard for a grinder shall be classed V-2 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The guard shall also be tested in accordance with 38.13, and at the completion of the test, shall:

a) Not break; and

b) Remain structurally intact and capable of performing its intended guarding function.

Table 38.1
Minimum thickness of peripheral and side protective members of a grinding wheel guard other than a drawn steel guard, inch (mm)[a]

Material employed in guard	Minimum tensile strength, PSI (MPa)		Maximum speed SFPM (SMPM)		Diameter of grinding wheel, Inch (mm)							
					More than 3 (76.2) but not more than 6 (152)				More than 6 (152) but not more than 10 (254)			
					A[b]		B[b]		A[b]		B[b]	
Cast iron	20,000	(138)	8,000	(2440)	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)	5/16	(7.9)
Malleable iron	50,000	(345)	9,000	(2740)	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)	5/16	(7.9)
Steel castings	60,000	(414)	16,000	(4880)	1/4	(6.4)	1/4	(6.4)	5/16	(7.9)	5/16	(7.9)
Structural steel	60,000	(414)	16,000	(4880)	1/8	(3.2)	1/16	(1.6)	5/16	(7.9)	1/4	(6.4)

[a] These values apply only to a guard intended for use with grinding wheels not more than 2 in (50.8 mm) wide. A guard intended for use with grinding wheels more than 2 in wide are to be given consideration.

[b] "A" is the thickness of the peripheral protective member, and "B" is the thickness of the side members.

Table 38.2
Nominal thickness in inches of peripheral and side protective members of a drawn grinding wheel guard of hot rolled steel having a minimum tensile strength of 60,000 lbs/in^2 (414 MPa)

Maximum speed of wheel SFPM (SMPM)		Maximum thickness of wheel in		Diameter of grinding wheel, Inch (mm)					
				More than 3 (76.2) but not more than 6 (152)		More than 5 (127), but not more than 8 (203)		More than 8 (203), but not more than 10 (254)	
		Inches	(mm)[a]	A[b]	B[b]	A[b]	B[b]	A[b]	B[b]
5,000	(1520)	2	(50.8)	–	–	3/32	1/16	3/32	1/16
9,500	(2900)	2	(50.8)	1/16	1/16	3/32	1/16	–	–

Table 38.2 Continued on Next Page

Table 38.2 Continued

Maximum speed of wheel SFPM (SMPM)		Maximum thickness of wheel in		Diameter of grinding wheel, Inch (mm)					
				More than 3 (76.2) but not more than 6 (152)		More than 5 (127), but not more than 8 (203)		More than 8 (203), but not more than 10 (254)	
		Inches	(mm)[a]	A[b]	B[b]	A[b]	B[b]	A[b]	B[b]
12,500	(3810)	2	(50.8)	3/32	1/16	3/32	3/32	–	–
17,000	(5180)	1	(25.4)	3/32	1/16	1/8	3/32	–	–

[a] A guard intended for use with grinding wheels more than 2 in (50.8 mm) wide are to be given consideration.

[b] "A" is the thickness of the peripheral protective member, and "B" is the thickness of the side members.

38.13 For the test mentioned in 38.12 and in the Exception to 38.11, a grinding wheel having the maximum diameter and thickness recommended by the manufacturer is to be assembled to the spindle. The grinder is then to be operated at maximum no-load speed, and the grinding wheel is to be caused to break while running.

38.14 A grinder shall be provided with an eye shield employing clear, nonshattering material and mounted so that loosening of the grinding wheel guard is not necessary for adjustment of the shield. The eye shield of a grinder intended for use with grinding wheels more than 5 in (127 mm) in diameter shall be such that the eye shield can be moved out of place for grinding large objects.

38.15 A work rest shall be provided for support of the workpiece. The work rest shall be rigid and readily adjustable so that a clearance of 1/8 in (3.2 mm) or less can be maintained between the work rest and the grinding wheel as the diameter of the wheel decreases up to 3/4 in (19.1 mm) with use.

38.16 For a grinder intended for use with grinding wheels 2 in (50.8 mm) thick or less, the minimum diameter of a spindle at the point the grinding wheel is intended to be mounted shall be as specified in Table 38.3, or a grinder as mentioned in 38.17 shall comply with the requirements in 38.17. For a grinder intended for use with grinding wheels more than 2 in thick, a spindle shall be investigated to determine whether it is suitable for the intended application.

Table 38.3
Minimum diameter of spindle where the grinding wheel is intended to be mounted

Diameter of wheel,		Thickness of wheel, Inch (mm)															
		1/4 (6.4) or less		1/8	(9.5)	1/2	(12.7)	5/8	(15.9)	3/4	(19.1)	1	(25.4)	1-1/4 (31.8) and 1-1/2	(38.1)	2	(50.8)
Inches	(mm)																
2	(50.8)	1/8	(3.2)	3/16	(4.8)	3/16	(4.8)	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)
3	(76.2)	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)
4	(102)	5/16	(7.9)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)
5	(127)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)
6	(152)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	5/8	(15.9)
7	(178)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	5/8	(15.9)	5/8	(15.9)

Table 38.3 Continued on Next Page

Table 38.3 Continued

Diameter of wheel,		Thickness of wheel, Inch (mm)															
Inches	(mm)	1/4 (6.4) or less		1/8	(9.5)	1/2	(12.7)	5/8	(15.9)	3/4	(19.1)	1	(25.4)	1-1/4 (31.8) and 1-1/2	(38.1)	2	(50.8)
8	(203)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	3/4	(19.1)
9	(229)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	3/4	(19.1)	3/4	(19.1)
10	(254)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	5/8	(15.9)	3/4	(19.1)	3/4	(19.1)	3/4	(19.1)	3/4	(19.1)

38.17 A grinder employing a shaded pole motor and intended for use with a grinding wheel 5 in (127 mm) or less in diameter and 1/2 in (12.7 mm) or less thick may have a spindle diameter of 3/8 in (9.5 mm) provided the final runout does not exceed the initial runout by more than 0.005 in (0.13 mm) when the grinder is evaluated in accordance with the following:

a) The total runout of the spindle at the midpoint of the wheel seat is to be measured.

b) The test described in 38.29 is to be conducted.

c) The ball-impact test described in 58.2 is to be conducted on the periphery of a simulated grinding wheel made of steel. The simulated wheel is to be mounted on the grinder. This test is to be conducted in such a manner that any runout caused will be additive to that measured as specified in 38.17(a) and to that resulting from the test specified in 38.17(b).

d) The simulated steel grinding wheel is to be replaced with a grinding wheel intended for use with the grinder. With the grinder running at no-load speed, the grinder is to be stalled as quickly as possible by jamming a rough-surfaced 15°- steel wedge between the wheel and the lower guard.

e) The resulting final runout of the spindle is to be measured at the midpoint of the wheel nut.

38.18 If the means for mounting a grinding wheel consists of a threaded spindle, a nut and flanges, for all grinding wheels intended for use with the grinder, the spindle shall:

a) Be of sufficient length to fully engage the threads of the spindle nut;

b) Be of such diameter that the grinding wheel or a bushing intended for use with the grinder will fit freely on it; and

c) Be threaded:

1) In a direction such that removal of the spindle nut will be in the same direction as normal rotation of the grinder when in use; and

2) For a length sufficient to extend at least through the outer flange but not more than half-way through the hole in the grinding wheel.

38.19 The length of a bushing as mentioned in 38.18(b) shall not exceed the thickness of the grinding wheel with which it is intended to be used.

38.20 A grinder shall be provided with two flanges of equal diameter for mounting a grinding wheel. The flange shall be at least one-fourth the diameter of the grinding wheel.

38.21 A flange shall be of cold-rolled steel, cast iron, or equivalent material. Flanges for a given wheel shall be the same diameter. A flange shall be free of sharp edges and burrs.

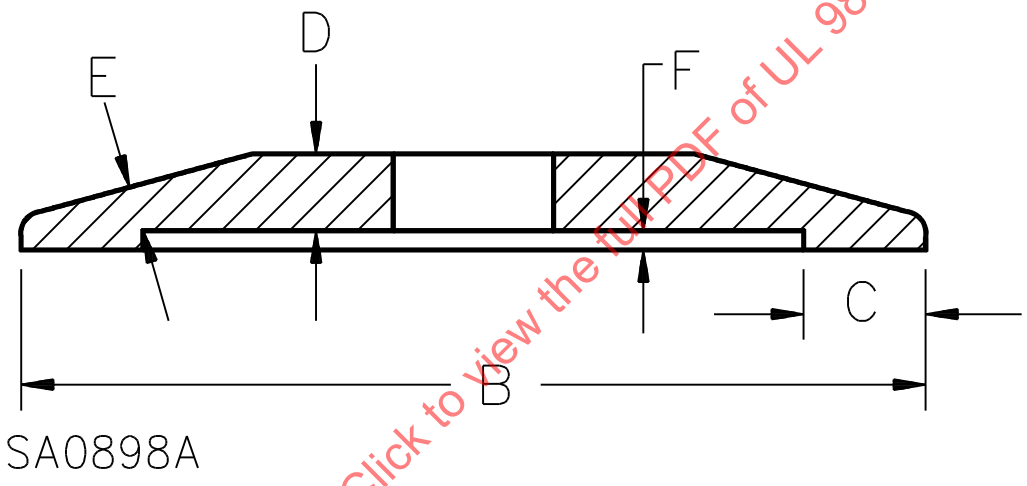
38.22 A straight relieved flange other than as mentioned in 38.23 shall have the configuration illustrated in Figure 38.2 and the dimensions specified in Table 38.4. The recess adjacent to the bearing surface shall not be less than 1/16 in (1.6 mm) (item F in Figure 38.2).

Exception No. 1: A flange intended for use with a grinding wheel having a diameter less than 2 in (50.8 mm) need not be recessed adjacent to the bearing surface provided the bearing surface is flat and true.

Exception No. 2: A flange complying with 38.24 need not comply with this requirement.

Figure 38.2

Straight relieved flange other than as illustrated in Figure 38.3



38.23 A stamped or formed straight relieved flange and a sintered steel flange shall have the configuration illustrated in Figure 38.3 and the dimensions specified in Table 38.5.

Exception: A flange complying with 38.24 need not comply with this requirement.

38.24 Flange designs differing in thickness from those mentioned in 38.22 and 38.23 are acceptable if, when investigated as described in 38.25, a 0.002-in (0.005-mm) feeler gauge cannot be inserted between the bearing area of the flange and a steel wheel.

Figure 38.3

Stamped or formed straight relieved flange and sintered steel flange

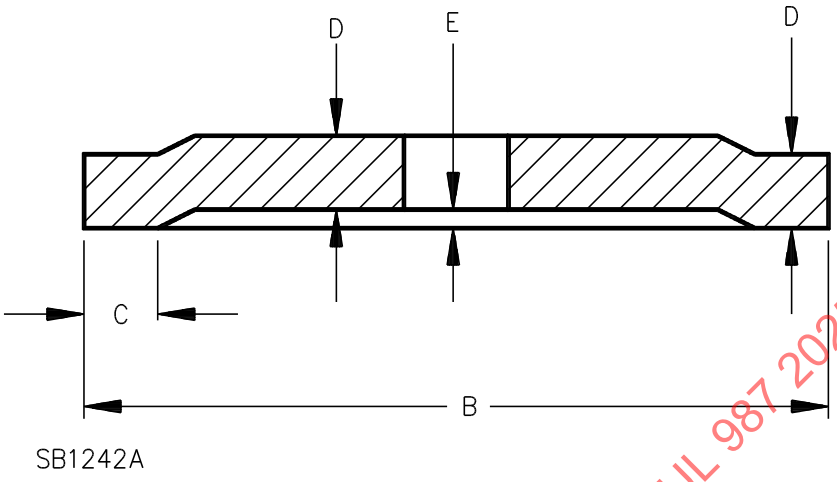


Table 38.4
Dimensions for straight relieved flanges other than as mentioned in Table 38.5

A		B		C Radial width of bearing surface				D		E	
				inch		(mm)					
Diameter of grinding wheel		Minimum outside diameter of flange		Minimum		Maximum		Minimum thickness of flange at bore,		Minimum thickness of flange at edge of recess	
inch	(mm)	inch	(mm)					inch	(mm)	inch	(mm)
1	(25.4)	3/8	(9.5)	1/16	(1.6)	1/8	(3.2)	1/16	(1.6)	1/16	(1.6)
2	(50.8)	11/16	(17.5)	1/8	(3.2)	3/16	(4.8)	1/8	(3.2)	3/32	(2.4)
3	(76.2)	1	(25.4)	1/8	(3.2)	3/16	(4.8)	3/16	(4.8)	3/32	(2.4)
4	(102)	1-3/8	(34.9)	1/8	(3.2)	3/16	(4.8)	3/16	(4.8)	1/8	(3.2)
5	(127)	1-11/16	(42.9)	3/16	(4.8)	1/4	(6.4)	1/4	(6.4)	1/8	(3.2)
6	(152)	2	(50.8)	1/4	(6.4)	1/2	(12.7)	3/8	(9.5)	3/16	(4.8)
7	(178)	2-3/8	(60.3)	1/4	(6.4)	1/2	(12.7)	3/8	(9.5)	3/16	(4.8)
8	(203)	2-11/16	(68.3)	1/4	(6.4)	1/2	(12.7)	3/8	(9.5)	3/16	(4.8)
10	(254)	3-3/8	(85.7)	5/16	(7.9)	5/8	(15.9)	3/8	(9.5)	1/4	(6.4)

Table 38.5
Dimensions for stamped or formed straight relieved flanges and sintered steel flange inches (mm)

A		B		C				D		E	
				Radial width of bearing surface							
Diameter of grinding wheel		Minimum outside diameter of flange		Minimum		Maximum		Minimum thickness of flange		Minimum recess	
4	(102)	1-3/8	(34.9)	1/8	(3.2)	3/16	(4.8)	1/16	(1.6)	1/32	(0.8)
4-1/2	(114)	1-1/2	(38.1)	3/16	(4.8)	1/4	(6.4)	1/16	(1.6)	1/32	(0.8)
5	(127)	1-11/16	(42.9)	3/16	(4.8)	1/4	(6.4)	1/16	(1.6)	1/32	(0.8)
6	(152)	2	(50.8)	1/4	(6.4)	1/2	(12.7)	3/32	(2.4)	1/32	(0.8)
7	(178)	2-3/8	(60.3)	1/4	(6.4)	1/2	(12.7)	1/8	(3.2)	1/16	(1.6)
8	(203)	2-11/16	(68.3)	1/4	(6.4)	1/2	(12.7)	1/8	(3.2)	1/16	(1.6)
10	(254)	3-3/8	(85.7)	5/16	(7.9)	5/8	(15.9)	1/8	(3.2)	1/16	(1.6)

38.25 With reference to 38.24, a flat steel wheel having a diameter at least 2 in (50.8 mm) more than that of the flanges being investigated is to be mounted on the spindle between the flanges. The mounting nut is to be tightened in accordance with Table 38.6. Blotters or other compressible materials are not to be employed between the steel wheel and the flanges. The feeler gauge is to be applied between each flange and the steel wheel at all locations on the periphery of each flange. The flange is acceptable if the feeler gauge cannot be inserted.

Table 38.6
Tightening torque for spindle nut

Diameter of grinding wheel		Torque in	
inches	(mm)[a]	pound-feet	(N·m)
4-1/2	(114)	4-1/2	(6.1)
5	(127)	4-1/2	(6.1)
6	(152)	8	(10.8)
7	(178)	10	(13.6)
8	(203)	10	(13.6)
10	(254)	12	(16.3)

[a] For a grinding wheel not covered by this table, the spindle nut is to be tightened in accordance with the recommendation of the manufacturer but not less than the value specified in the table for the next smaller size grinding wheel.

38.26 A blotter or a flange facing of compressible material shall be affixed to each side of a grinding wheel, and shall cover the entire area of intended contact between wheel and flange. A highly compressible material, such as blotting paper, shall not be more than 0.025 in (0.64 mm) thick. A less compressible material may be thicker.

38.27 A grinding wheel of unusual design or contour shall be given consideration to determine whether its mounting is acceptable.

38.28 A grinder intended for use with grinding wheels 4 in (102 mm) or more in diameter shall not crack, break, or release any part when tested as described in 38.29.

38.29 A simulated grinding wheel having a diameter equal to that of a wheel intended for use with the grinder is to be mounted on the spindle. The grinder is then to be operated at the no-load speed for 250,000 revolutions. The simulated wheel may consist of a circular steel plate. The simulated wheel is to be out of balance, by the addition or removal of material:

a) For wheels 6 in (152 mm) or more in diameter, by 2 oz-in (14 N·mm); and

b) For wheels less than 6 in in diameter, by $d^2/18$ oz-in ($d^2/2.55$ N·mm), where d is the diameter of the wheel in inches (mm).

38.30 A grinding wheel provided with the tool shall be constructed of such material and in such manner as to comply with the requirements in 86.3.1 and 86.3.2.

39 Jointers

39.1 These requirements cover jointers having horizontal cutter heads.

39.2 Where provision for rabbeting operations is provided as a part of the jointer design, the following requirements shall be met:

a) The rabbeting operations allowed shall be effectively guarded;

b) The jointer swing guard shall not be removable without the use of a tool or tools;

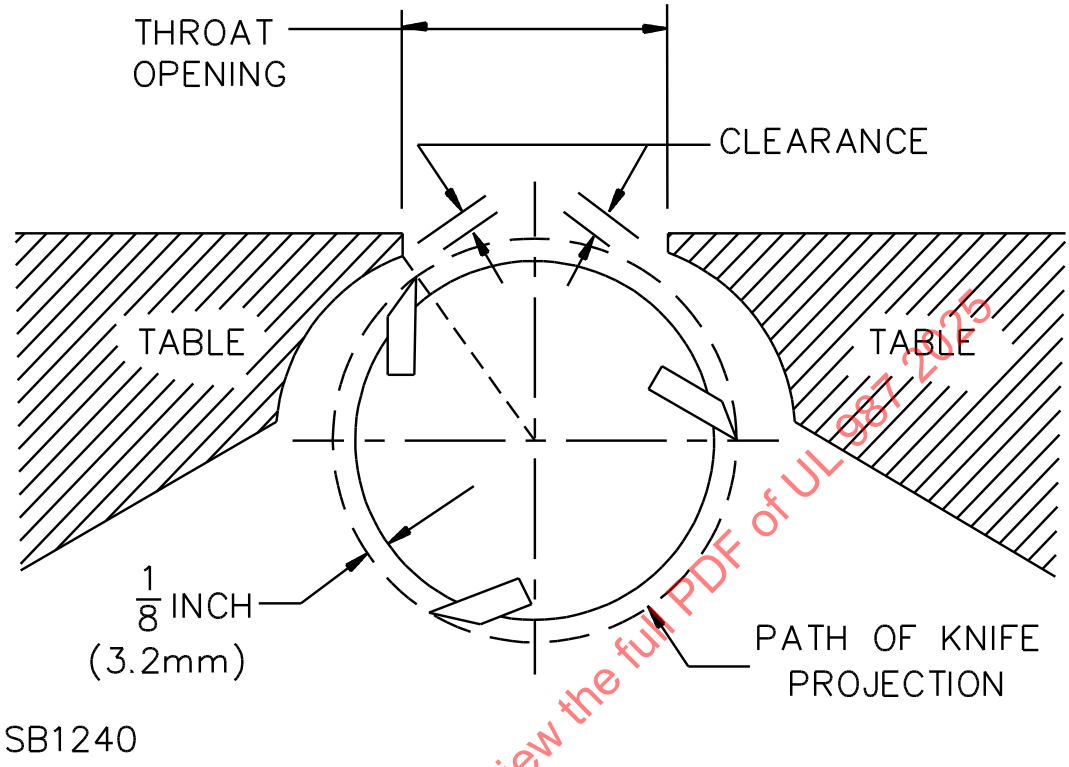
c) Removal of the swing guard shall not permit an additional unguarded operation to be performed; and

d) The distance from the end of the jointer knives to the guard hub, perpendicular to the direction of motion of the workpiece, shall not exceed 3/4 in (19 mm), i.e. the uncut portion of the workpiece following a rabbet cut shall be limited to 3/4 in.

39.3 A jointer shall be equipped with a cutter head, the knife projection of which extends beyond the body of the head not more than 1/8 in (3.2 mm). The clearance between the path of the knife projection and the rear table shall not be more than 1/8 in – the clearance is to be measured radially from the path of the knife projection to the closest point on the table and with the rear table level with the path of the knife projection. See Figure 39.1. The clearance between the path of the knife projection and the front table shall not be more than 3/16 in (4.8 mm) – the clearance is to be measured as described in the preceding sentence and with the tables coplanar. See Figure 39.1. The table throat opening shall not be more than 2-1/2 in (63.5 mm) when the front and rear tables are set or aligned with each other for zero cut.

Figure 39.1

Table clearance for jointers



39.4 Guarding beneath the table level shall be provided so as to enclose the cutter knives from unintentional contact and to prevent contact with moving parts of the drive mechanism.

39.5 The jointer frame, motor including a motor shipped detached from the jointer, an exhaust hood, and other enclosures under the table may be considered as a portion of the guarding required by 39.4.

39.6 If a open-bottomed enclosure is used to guard the cutter knives or other moving parts from contact, the depth of the enclosure shall be such that the plane of the bottom is 2-1/2 in (63.5 mm) or more below the bottom of the path of the knife projections with the cutter head in its lowest position.

39.7 A jointer shall be equipped with a guard requiring the use of a tool for removal. The guard shall cover all sections of the cutter head on the working side of the fence, and shall automatically adjust horizontally with the fence. The sections of the cutter head on the other side of the fence shall be totally enclosed at all times. A sheet-metal telescoping guard is acceptable.

39.8 All operations for which a jointer is recommended shall be readily performed with the guard in place. On a jointer with a depth capacity greater than 1/8 in (3.2 mm), the guard shall be designed to accommodate normal stop chamfering and tapering operations.

39.9 The depth of cut obtainable with a jointer shall not exceed 1/8 in (3.2 mm) unless a positive stop for the 1/8 in depth is incorporated in the jointer. The stop shall require manual release to provide a cutting depth greater than 1/8 in and shall be self-restoring when returned to the 1/8-in setting.

39.10 A minimum of 2 hold-down/push blocks shall be supplied with the jointer for use for all jointing and planing operations for which such blocks are recommended.

40 Band Saws

40.1 A band saw as covered by these requirements may be of the two- or three-wheel design; and may incorporate a tilting table, or a stationary table with a tilting frame or wheel assembly.

40.2 A band saw shall be guarded as follows:

a) All portions of the saw blade other than the working portion of the blade between the sliding guide and the table shall be enclosed or guarded; and

b) The wheels shall be fully enclosed or guarded.

40.3 The guard for the portion of the saw blade above the sliding guide shall prevent contact with the cutting edge and outer side of the blade. This portion of the guard shall be self-adjusting to raise and lower with the guide.

40.4 The enclosure of a wheel shall have a solid outside periphery. The front and back shall be enclosed by solid material or by wire mesh or perforated metal not less than 0.037 in (0.94 mm) thick with openings having no dimension more than 3/8 in (9.5 mm). Solid material shall have equivalent strength and rigidity.

40.5 A band saw shall have a tension-control device and an indicator to provide for proper tensioning of the saw blades intended for use with the tool.

40.6 The insert or the material of the table surrounding the blade if no insert is provided:

a) Shall be of nonsparking material;

b) Shall not be of magnesium or other material likely to be ignited by sparking; and

c) Shall be sufficiently soft so that contact between the table or insert and the blade will not result in rupture or splitting of the blade.

40.7 An insert shall be firmly held in place and prevented from rotating.

41 Radial-Arm Saws

41.1 These requirements cover radial-arm saws equipped with blade guards and accessories for such saws.

41.2 A radial-arm saw shall be:

a) Provided with automatic or manual arbor braking such that a 10-in (254-mm) or smaller blade will stop within 15 seconds and a larger blade will stop within 25 seconds; or

b) Constructed so that inherent friction losses, such as from gearing, preclude coasting of the saw blade beyond the limits specified in 41.2(a).

41.3 A blade guard shall be provided as a part of a radial-arm saw. The guard shall completely enclose the upper half of the blade and at least 50 percent of the end of the arbor.

Exception: The guard may have an opening for the ejection of sawdust provided:

a) The opening is located beyond the outer circumference of the blade; or

b) A 1/2-in (12.7-mm) diameter probe cannot be made to contact the blade when inserted 2-1/2 in (63.5 mm) into the opening.

41.4 For a saw intended for ripping, antikickback means shall be provided on both sides of the saw blade of the outfeed side. When properly adjusted, the means shall:

a) Reduce the likelihood of wrong-way feed; and

b) Reduce the risk of kickback – the blade hurling the workpiece out the infeed side when ripping.

The means shall be functional for bevel angles of 45° or less and shall provide holding power to prevent infeed removal of soft-pine having a thickness within the capacity of the saw.

41.5 A hold-down device shall be provided on a saw intended for ripping. The device shall be designed to prevent the blade from lifting the workpiece off the table.

41.6 The unguarded portion of the blade shall not extend beyond the table or mounting frame when the carriage is at any position on the arm at any miter angle from 30° left to 45° right. The blade shall be over the table when:

a) The saw is set for outrip;

b) The carriage is at the end of the arm; and

c) The miter angle is set at 0°.

41.7 Permanently attached, fixed – not drop leaf – table extensions and carriage stops that cannot be adjusted beyond the point to which the blade extends beyond the table are acceptable means of complying with the requirements in 41.6 if such extensions and stops are standard equipment for the assembly.

41.8 Provision shall be incorporated in a radial-arm saw so that the arm cannot be positioned to the rear of a position parallel to the back edge of the table.

41.9 A saw blade shall be furnished with a saw.

41.10 The construction and size of a blade guard or other fixed nonremovable stop shall be such as to limit the size of the blade that can be installed on the arbor. The maximum size shall be tested in the assembly.

41.11 The manufacturer shall make available a lower blade guard that will:

a) Cover both sides of the teeth of the blade not covered by the upper guard when the blade and lower guard are clear of the workpiece and table;

Exception: A one-piece combination upper and lower blade guard may have a 1-1/4-in (31.8-mm) side slot on the motor side, extending from the motor-shaft to the bottom of the guard, for motor-shaft clearance.

b) Cover the teeth of the blade to their full depth;

c) For miter and bevel angles of 45° and less, comply with (a) and (b) in a radial direction, and (d); and

d) Automatically ride over the workpiece and return to the original position upon leaving the workpiece.

Exception: A mechanical means may be provided to raise and lower the lower guard during crosscutting.

41.12 The manufacturer shall make a spreader available for a saw used for ripping. When in use, the spreader shall be aligned with the saw blade.

41.13 A spreader, if provided, shall move automatically with the arbor when the saw is set for bevel cuts.

41.14 The arbor shall have a nominal diameter not less than 1/2 in (12.7 mm) for a blade having a diameter less than 8 in (203 mm) and not less than 5/8 in (15.9 mm) for a blade having a diameter of 8 in or more.

41.15 The thread for the blade-retaining nut shall have such direction that the nut is tightened by being rotated in the direction opposite to normal rotation of the blade.

41.16 Normal rotation of the arbor shall be clockwise when viewed from the left of the position normally assumed by the operator when the saw is in the 90°- cutoff position.

41.17 A diameter of a saw-blade supporting collar shall be at least 1 3/8 in (34.9 mm) for a 7-in (178-mm) diameter blade and shall be increased 1/8 in (3.2 mm) for each 1-in (25.4-mm) increase in blade diameter.

42 Scroll Saws and Jigsaws

42.1 These requirements cover scroll saws and jigsaws.

42.2 If speed changes are intended to be made by changing the belt position, the guard shall be nonremovable, but may be hinged to allow access for this operation.

42.3 A scroll saw or a jigsaw capable of causing injury to persons shall be provided with a holddown mechanism that includes a guard in front of the blade immediately above the workpiece.

42.4 A saw powered by a motor developing 1/10 hp (74.6 W output) or more shall be provided with a means to turn the saw by hand through 1 cycle to determine that the blade is correctly installed.

Exception No. 1: A saw powered by a vibrator need not comply.

Exception No. 2: A saw having a linear motion output need not comply with this requirement.

43 Table Saws

Section 43 deleted

43.1 Glossary

43.1.1 *Deleted*

43.1.2 *Deleted*

43.1.3 *Deleted*

43.1.4 *Deleted*

43.1.5 *Deleted*

43.1.6 *Deleted*

43.1.7 *Deleted*

43.1.8 *Deleted*

43.1.9 *Deleted*

43.1.10 *Deleted*

43.1.11 *Deleted*

43.1.12 *Deleted*

43.1.13 *Deleted*

43.1.14 *Deleted*

43.1.15 *Deleted*

43.2 General

43.2.1 *Deleted*

43.2.2 *Deleted*

43.2.3 *Deleted*

43.2.4 *Deleted*

43.2.5 *Deleted*

43.2.6 *Deleted*

43.2.7 *Deleted*

43.3 Table saw blade guard

43.3.1 *Deleted*

Figure 43.1

Test probe "a"
Figure deleted

Figure 43.2

Table saw probe application
Figure deleted

Figure 43.3

Table saw quadrants
Figure deleted

43.3.2 *Deleted*

43.4 Riving knife

43.4.1 *Deleted*

43.4.2 *Deleted*

43.4.3 *Deleted*

Figure 43.4

Distance between riving knife and blade
Figure deleted

Figure 43.5

Highest point of riving knife
Figure deleted

43.4.4 *Deleted*

Table 43.1
Test forces
Table deleted

Figure 43.6

Pull test for riving knife
Figure deleted

Figure 43.7

Side pull test for riving knife
Figure deleted

43.4.5 *Deleted*

43.5 Extended riving knife (fixed or adjustable)

43.5.1 *Deleted*

43.5.2 *Deleted*

43.5.3 *Deleted*

43.5.4 *Deleted*

43.5.5 *Deleted*

43.5.6 *Deleted*

43.6 Antikickback device(s)

43.6.1 *Deleted*

43.6.2 *Deleted*

Figure 43.8

Antikickback device test block
Figure deleted

43.6.3 *Deleted*

43.7 Rip fence for table saws

43.7.1 *Deleted*

43.8 Table saw insert

43.8.1 *Deleted*

43.9 Table saw arbor

43.9.1 *Deleted*

43.10 Additional table saw requirements

43.10.1 *Deleted*

43.10.2 *Deleted*

43.10.3 *Deleted*

43.10.4 *Deleted*

43.10.5 *Deleted*

43.10.6 *Deleted*

43.10.7 *Deleted*

43.10.8 *Deleted*

43.10.9 *Deleted*

43.10.10 *Deleted*

Table 43.2
Minimum push stick length
Table deleted

Figure 43.9

Push stick
Figure deleted

Figure 43.10

Push stick force test

Figure deleted

44 Sanding Machines

44.1 These requirements cover sanding machines employing sanding discs, belts, or drum sanders.

44.2 Unless it can be demonstrated that no risk of injury to persons exists, a guard or guards shall be provided to reduce the risks from the nip of the abrasive-belt drive and driven pulleys.

44.3 The clearance between a fixed table and the abrasive surface shall not be more than 1/16 in (1.6 mm). A movable table shall be capable of being adjusted to within 1/16 in from the abrasive surface for all angles of the table.

Exception: The clearance need not be met for a sanding machine employing a drum sander if:

a) It can be demonstrated that no increased risk of injury to a person exists; and

b) A guard or guards is provided to reduce the risk of injury from the drive pulleys.

44.4 A device shall be provided for adjusting the tension of the sanding belt.

44.5 A device shall be provided for tracking the sanding belt.

44.6 An adjusting mechanism and a positioning device shall maintain their settings accurately during operation of the sander at full load for ten minutes, including 12 intentional stalls of the abrasive belt or disc. Positive adjusting means shall be provided if necessary to permit the sander to be adjusted for intended operation initially and to compensate for wear that may affect the initial adjustment.

45 Shapers

45.1 These requirements cover shapers of the under-the-table, vertical-spindle type intended for shaping natural and manufactured wood products.

45.2 Other than the table-insert opening, there shall be no opening through the top surface of the table in the area from the miter slot to the rear of the table that may permit an operator or his clothing to come into contact with any moving part.

45.3 An opening in the work area shall have relieved edges to reduce the likelihood of hangup of the workpiece.

45.4 The spindle shall be accessible from the top of the tool to permit changing collars and cutters. The spindle shall be equipped with a keyway and a keyed washer to prevent the spindle nut from rotating during shaping operations.

Exception No. 1: A keyway and a keyed washer are not required to be provided on a nonreversible shaper when the spindle nut is tightened by being rotated in the direction opposite to normal rotation of the spindle.

Exception No. 2: A keyway and a keyed washer are not required when two nuts are provided, and each nut is tightened by being rotated in a direction opposite to each other, such that the two nuts tighten against each other regardless of direction of rotation of the spindle.

45.5 A cutter shall be stable and shall not vibrate when operated at design speed.

45.6 The table or the table insert shall support the workpiece to within 1/4 in (6.4 mm) of the outside diameter of the cutter or the collar. An insert shall be of a color contrasting to that of wood and to that of the table.

45.7 A ring guard enclosing the upper end of the cutter and its sides down to the workpiece shall be provided. The guard shall be fully adjustable and easily and quickly installed. The guard may also be used as a hold-down.

45.8 The cutter guard shall be an integral part of the adjustable-fence frame, and shall guard the rear of the cutter when the adjustable fence is used.

45.9 An adjustable fence shall be provided. Means shall be provided for firmly securing the fence to the table. The adjustment and locking of the individual faces shall be such that the settings will be maintained during normal operation of the tool. Adjustment equal to one-half of the cutter diameter shall be provided.

45.10 A miter gauge is considered to be an accessory, and need not be provided with a shaper.

45.11 Means of adjustment shall be provided:

a) To position the ring guard vertically;

b) To position individual fences in the feeding direction for depth of cut and cutter diameter;

c) To align the fence parallel to the miter-gauge slot;

d) To square the miter-gauge head to the gauge bar; and

e) To adjust the tension in the drive belt, if used.

45.12 An adjusting mechanism and a positioning device shall be constructed so that they will maintain their settings accurately during operation at full load for ten minutes, including 12 intentional stalls of the cutter during straight-line shaping.

46 Lathes

46.1 These requirements cover bench lathes and floor lathes.

46.2 A machine and motor pulley shall be guarded to reduce the risk of the operator's fingers or loose clothing, including a tie, from entering the nip of the belt and pulley.

46.3 A guard, a spindle cap, or other protection shall be provided for the exposed and unused end of the spindle if the lathe is equipped for outboard turning.

46.4 The tool-support base shall clamp firmly to the bed in any operational position. It shall be capable of adjustment throughout the bed length and of adjustment both vertically and laterally.

46.5 The tail stock shall clamp firmly to the bed in any operational position.

46.6 A faceplate:

a) Shall be constructed to withstand the centrifugal force of free turning; and

b) Shall not cause sensible vibration during operation at top speed and with the thrust applied during a faceplate turning operation.

46.7 All internally-mounted headstock and tailstock centers shall mount firmly into the spindle or ram with nonself-releasing tapers or other mechanical devices that show no tendency to release when subjected to normal operating conditions for not less than 15 minutes.

47 Miter Saws

Section 47 deleted

47.1 *Deleted*

47.2 *Deleted*

47.3 *Deleted*

47.4 *Deleted*

47.5 *Deleted*

47.6 *Deleted*

47.7 *Deleted*

47.8 *Deleted*

47.9 *Deleted*

47.10 *Deleted*

47.11 *Deleted*

47.12 *Deleted*

47.13 *Deleted*

Figure 47.1

Miter saw guarding

Figure deleted

Figure 47.2

Miter saw guarding using 15° triangle gage

Figure deleted

47.14 *Deleted*

47.15 *Deleted*

47.16 *Deleted*

47.17 *Deleted*

48 Abrasive Cutoff Machines

48.1 An abrasive cutoff machine shall comply with the applicable requirements in 38.2 – 38.5 and 38.20 – 38.27, supplemented by the requirements in 48.2 – 48.4. A rigid work rest shall be provided for support of the workpiece.

48.2 The maximum angular exposure of the abrasive wheel periphery and sides for wheel guards used on abrasive cutoff machines shall not exceed 180°, and the top half of the wheel shall be enclosed in all positions. The peripheral and side protective members of a guard for a cutoff wheel shall be of material as specified in Table 48.1.

48.3 The peripheral and side protective members of a guard for a cutoff wheel 30 in (762 mm) or less in diameter shall be of a material and thickness as specified in Table 48.1.

Exception: The members of a guard may be of other material or thinner provided that when tested as described in 48.4:

a) There is no breakage of the guard; or

b) The guard remains structurally intact and capable of performing the intended guarding function.

48.4 For the test specified in the Exception to 48.3, a cutoff wheel having the maximum diameter and thickness recommended by the manufacturer is to be assembled to the spindle. The abrasive cutoff machine is then to be operated at maximum no-load speed, and the wheel is to be caused to break while running.

Table 48.1
Minimum thicknesses for peripheral and side members of a guard for a cutoff wheel

Materials used in construction of a guard	Maximum thickness of cutoff wheel, inches	(mm)	Maximum perimeter speed of cutoff wheel, surface feet per minute (smpm)		Diameter of cutoff wheel, inches (mm)					
					6 through 11 (152-297)		More than 11 through 20 (280-508)		More than 20 through 30 (509-762)	
					A[a]	B[a]	A[a]	B[a]	A[a]	B[a]
Structural Steel, Minimum Tensile Strength 60,000 psi (11 MPa)	1/2 or less	(12.7)	14,200	(4330)	1/16 (1.6)	1/16 (1.6)	3/32 (2.4)	3/32 (2.4)	1/8 (3.2)	1/8 (3.2)
	1/2 or less	(12.7)	16,000	(4880)	3/32 (2.4)	1/8 (3.2)	1/8 (3.2)	1/8 (3.2)	3/16 (4.8)	1/8 (3.2)

[a] A is the required thickness of the peripheral protective member, and B is the required thickness of the side members.

49 Table Tile Saws

49.1 A tile saw employing baths that utilize non-flammable liquids shall comply with the requirements in 49.2 – 49.12.

49.2 A tile saw cutting wheel blade shall be furnished with a tile saw. The blade shall be free of openings and grooves.

49.3 The arbor shall be accessible to facilitate changing cutting wheels.

49.4 The arbor shall have a nominal diameter not less than 5/16 in (8 mm) for a tile wheel having a diameter less than 5 in (127 mm), not less than 7/16 in (11 mm) for a tile wheel having a diameter less than 6 in (152 mm), not less than 1/2 in (12.7 mm) for a tile wheel having a diameter less than 8 in (203 mm), and not less than 5/8 in (15.9 mm) for a tile wheel having a diameter of 8 in or more.

49.5 The thread for the wheel-retaining nut shall have such direction that the nut is tightened by being rotated in the direction opposite to normal rotation of the wheel.

49.6 Normal rotation of the arbor shall be clockwise when viewed from the left of the position normally assumed by the operator.

49.7 A cutting wheel supporting collar shall not be less than 1-3/8 in (34.9 mm) in diameter for wheels less than 7 in (178 mm) diameter and the diameter shall be increased at least 1/8 in (3.2 mm) for each 1-in (25.4-mm) increase in wheel diameter.

49.8 A splash hood shall be provided with a tile saw. The splash hood shall reduce the likelihood of water and particles from being dissipated by enclosing the sides and top portion of the disc above the table, and shall be adjustable to the thickness of the workpiece.

49.9 A splash hood shall not offer any considerable resistance to the initial entrance of the workpiece to the wheel blade or to passage of material being cut.

49.10 If provided, a guide fence shall be constructed so that it is firmly secured to the table and so that it does not loosen under normal operating conditions.

49.11 The design of a tile saw shall be such as to limit the size of a cutting wheel that may be installed on the arbor to one not larger than that tested on the assembly.

49.12 A water fill line shall be permanently marked on the unit where it is readily visible when filling the water compartment with water.

Exception: A unit which has all live parts including power supply cord connections above the top most edge of the water tray is not required to comply with this requirement.

50 Panel Saws

50.1 These requirements cover panel saws that utilize circular saw blades powered by a motor unit that is mounted to a movable carriage.

50.2 A saw blade shall be furnished with a panel saw.

50.3 The blade stop time shall be 15 seconds or less for blades less than 10 in (254 mm) in diameter. For larger blades, one additional second of stop time is allowed for each additional 1 in (25.4 mm) increment of blade diameter.

50.4 To determine compliance with 50.3, the saw is to be operated at no load and at rated voltage for a period of 15 minutes prior to the test. The saw is then to be cycled on and off 10 times, with a 30 second period between the blade stopping and the next actuation. For each cycle, the blade shall come to a complete stop in the time specified in 50.3.

50.5 For a panel saw, a vertical cut is defined as a cut made by moving the carriage from the top position down through the work piece. A horizontal cut is defined as a cut where the carriage is locked in place and adjusted with the blade horizontal so that work piece is fed into the blade.

50.6 A movable carriage shall be constructed so that it moves freely and smoothly between any positions with all adjustments to the least favorable setting. The carriage shall automatically return to the original position after a vertical cut is complete.

50.7 The carriage return mechanism shall be constructed so that it withstands the stresses it may be subjected to in normal use and shall comply with 50.8. The return mechanism shall be capable of preventing the carriage from free falling during a vertical cut and the maximum force required to move the carriage system vertically shall be 11.2 lbf (50 N).

50.8 Without energizing the unit, the carriage shall be moved from the maximum vertical up position to the finished vertical down position for a total of 6,000 cycles, with each downward motion counting as one cycle. Following the test, there shall be no loosening of parts and the cable shall show no signs of breakage or fraying and the carriage is able to return to within 1 in (25 mm) of the starting maximum vertical up position. If a guard is provided with a connecting means for an exhaust hose, the hose is to be connected during the test and shall remain intact at the conclusion of the test. See 50.22.

50.9 Counterbalances or weights that utilize cables and fittings shall be suitable for the stresses that they may be subjected to in normal use. Cables shall be suitable for the expected load and employ a double crimped, or equivalent, connection. Cables shall be arranged in such a way to reduce the likelihood of entanglement and routed such that they are not subjected to abrasions. A hole in the enclosure through which a cable passes shall be a smooth, rounded bushing or shall have a smooth, rounded surface upon which the cable bears.

50.10 A panel saw shall only be capable of making a downward vertical cut. Limitations shall be provided to prevent the saw blade from being adjusted so it is capable of cutting in an upward motion.

50.11 The movable carriage shall be provided with an operating handle positioned so that it does not interfere with stationary parts of the panel saw. The control switch shall be located in close proximity to the operating handle.

50.12 A panel saw that allows for both a vertical cut and a horizontal cut that involve multiple positions while being operated normally shall not create additional risk of injury from loss of control of the work piece or power head. For a carriage that is capable of adjusting the saw blade to more than one position, the maximum force required to turn the carriage system shall be 22.5 lbf (100 N).

50.13 The arbor of a panel saw shall be readily accessible to perform required maintenance on the blade.

50.14 The arbor shall have a nominal diameter not less than 1/2 in (12.7 mm) for the blade having a diameter less than 8 in (203 mm), and not less than 5/8 in (15.9 mm) for a blade having a diameter of 8 in (203 mm) or greater.

50.15 The thread for the blade-retaining nut shall have such a direction that the nut is tightened by being rotated in the direction opposite to the normal rotation of the blade.

50.16 A saw-blade supporting collar shall not be less than 0.15 times the blade.

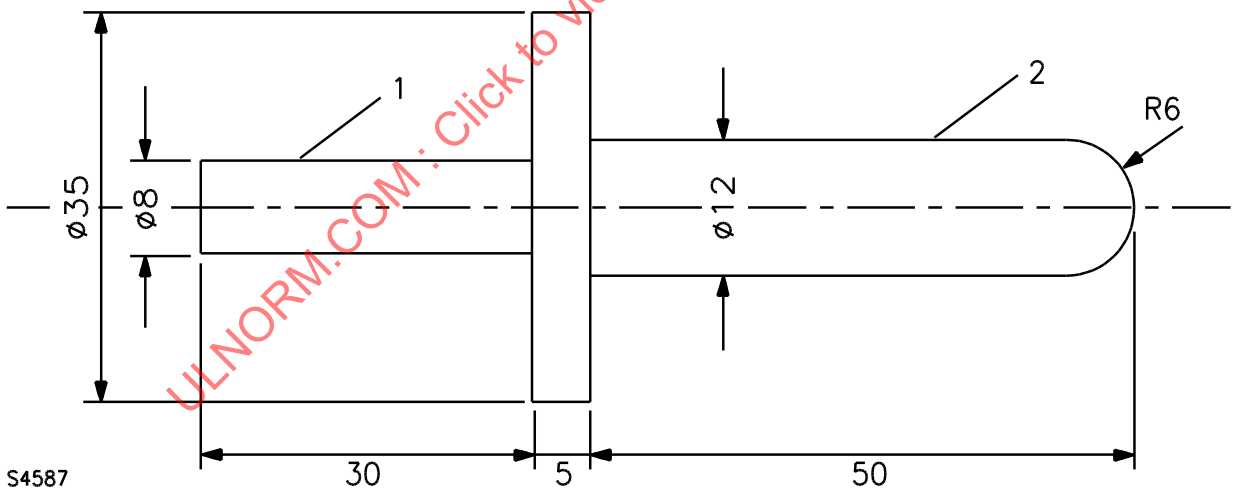
50.17 A panel saw shall be so guarded as to minimize the risk of accidental contact with the rotating blade, as far as conditions of use will permit.

50.18 Guarding above the carriage shall enclose the cutting edge zone (the outer 20 percent of the radius of a saw blade). The supporting platen for the carriage may be considered a barrier to direct contact with the cutting edge zone. The probe illustrated in Figure 8.1 shall not contact the cutting edge zone or other moving parts of the blade drive mechanism when moved along the edge of the platen with the probe stop plate in contact with the platen edge. The probe finger may be manipulated at the joints to ensure contact with the blade is not possible when the carriage is located in each applicable cutting position from the top side of the platen and areas surrounding the blade guard and power head.

50.19 The upper guard on the side opposite the motor need not completely cover the blade. The perpendicular projection of the upper guard on to the blade shall cover at least the smallest recommended blade-cutting edge zone. The space between the upper guard and the blade shall be designed such that the test probe 'a' of Figure 50.1 when inserted at any angle and to the depth allowed by its stop, shall not be able to contact the saw blade teeth tips of the recommended blade. This requirement does not supersede the probe requirements in 50.18.

Figure 50.1

Test probe 'a'



Dimensions in mm

Key

1 Handle section

2 Test section

50.20 A guard(s) shall be constructed so that the saw blade can be removed without difficulty. If the arbor is accessible with the guard in its intended position, the guard shall be retained in such a way that removal of its parts will require the use of tools. If the guard totally encloses the arbor, the guard may be retained by

use of fasteners that do not require the use of a tool to remove, such as thumb screws. If tools are not necessary for guard removal, the marking specified in 81.16.6 shall be provided.

50.21 All openings provided in the guard for the purpose of ejection or collection of dust shall direct the dust discharge away from the operator and:

a) Be located beyond the outer circumference of the blade; or

b) Not allow contact with the blade when applying a 1/2 in (12.7) diameter probe when inserted 2-1/2 in (63.5 mm) into the opening.

50.22 A guard may be provided with means for connecting an exhaust hose. If connections are provided, the exhaust hose shall be able to be firmly attached to the connection, shall move freely when the carriage system is moved in any direction, and shall not contact moving parts or create a risk of injury to the user. See 50.8.

50.23 The area directly behind the power head shall be guarded against direct contact with the blade. The probe illustrated in Figure 8.1 is applied along the edges of the barrier while the representative hand area behind the 2.36 in (60 mm) finger joint remains in contact with the edges of the barrier. The probe finger may be manipulated at the joints to ensure contact with the blade is not possible when the power head is located in each applicable cutting position.

50.24 The distance between the power head carriage assembly and the work support shall not exceed the blade depth.

50.25 Switches intended to energize the tool shall be protected against accidental activation and comply with the requirements outlined in Switches and Controls, Sections 19 and 33.

50.26 The angle between the work piece and the vertical position shall be a minimum of 5°. The panel saw shall be stable and shall comply with the applicable stability test specified in 31.2 – 31.4 and the requirements specified in 50.27 or 50.28.

50.27 A panel saw thatis not likely to be secured to a permanent structure shall be subjected to a pull test. A force equal to 1/5 of the total weight of the panel saw shall be applied 5 ft (152 cm) above the base of the unit at any point along the panel saw structure that would allow it to become less stable. Following the application of the force, the panel saw shall remain upright without tipping over or having parts become displaced from the saw structure.

50.28 A panel saw intended for wall mounting is to be subjected to a loading test. The panel saw is to be mounted to a test wall in accordance with the manufacturer's installation instructions. When the instructions do not specify minimum acceptable wall conditions, the test wall is to be constructed of 3/8-in (9.5-mm) thick plasterboard (dry wall), mounted on nominal 2 by 4 in (38 by 89 mm)] wood studs spaced on 16 in (406 mm) centers. The panel saw is to be fastened between the studs and secured into the plasterboard. A test load equal to four times the weight of the unit, but not less than 300 lbf (136 kg), is to be gradually applied to the panel saw, horizontally through the center of the support brackets. The force is to be increased in 5-10 second intervals until the full test load is applied. The full test load is then to be applied for a period of one minute. As a result of the test, a bracket shall not break, loosen, or pull out of the wall, nor shall the unit separate from the bracket.

50.29 The base of the machine which supports the work piece shall be provided with a device, such as flanged rollers, to prevent the work piece from slipping off the machine onto the floor. The appropriate number of rollers shall be provided and designed to allow for smooth travel and support of the work piece for both horizontal and vertical cuts.

50.30 The cord of a panel saw shall not be cut, abraded, or damaged and the cord routing assembly shall function as intended after extended use. The cord and cord assembly shall comply with the test specified in 50.31.

50.31 The cord assembly shall be installed on the panel saw in accordance with the manufacturer's instructions. The carriage shall be moved from the maximum vertical up position to the lowest vertical down position for a total of 6,000 cycles of movement, with each downward motion counting as one cycle. After the 6,000 cycles of movement:

a) Each current-carrying conductor shall be capable of carrying its rated ampacity for two minutes without interruption. A grounding conductor, if provided, shall be capable of carrying twice its rated ampacity for two minutes without interruption.

b) Following the test specified in (a), a potential of 1000 V plus twice the rated voltage of the panel saw is to be applied for one minute between the individual conductors of the cord with the internal connections to the saw severed and insulated, and between live parts and accessible metal parts. As a result of the test, there shall be no dielectric breakdown of the cord insulation.

c) The cord jacket or individual conductor insulation shall not be cut or abraded and no wires shall be exposed through conductor insulation.

50.32 A riving knife, when provided, shall:

a) Have a body thickness not thinner than the body of the blade recommended by the manufacturer but thinner than the kerf of that saw blade;

b) Be located behind the saw blade and pass freely through the cutting groove;

c) Not contact the blade, be rigidly fixed and in alignment with the plane of the blade, and as a result of any operation, maintain the spacing and alignment with the blade;

d) Have its tip rounded, with a radius of not less than 0.08 in (2 mm). The faces of the riving knife shall be parallel planes and smooth; the edges shall not be sharp and shall be slightly chamfered on the edge facing the blade;

e) Have a width of at least equal to 1/8 of the largest blade diameter recommended by the manufacturer. The width is measured at the guide plate level for the maximum cutting depth of the saw;

f) Be made of steel with a hardness of between 38 HRC and 48 HRC and a resistance to rupture at least equal to 800 Mpa (116,000 psi) or other equivalent material; and

g) The thickness of the riving knife and the range of saw blade diameters for which it is intended shall be permanently marked on the riving knife, for example by engraving, stamping or etching. In addition, instructions shall be provided to explain how to properly match the blade diameter and the blade body and kerf dimensions to the riving knife thickness.

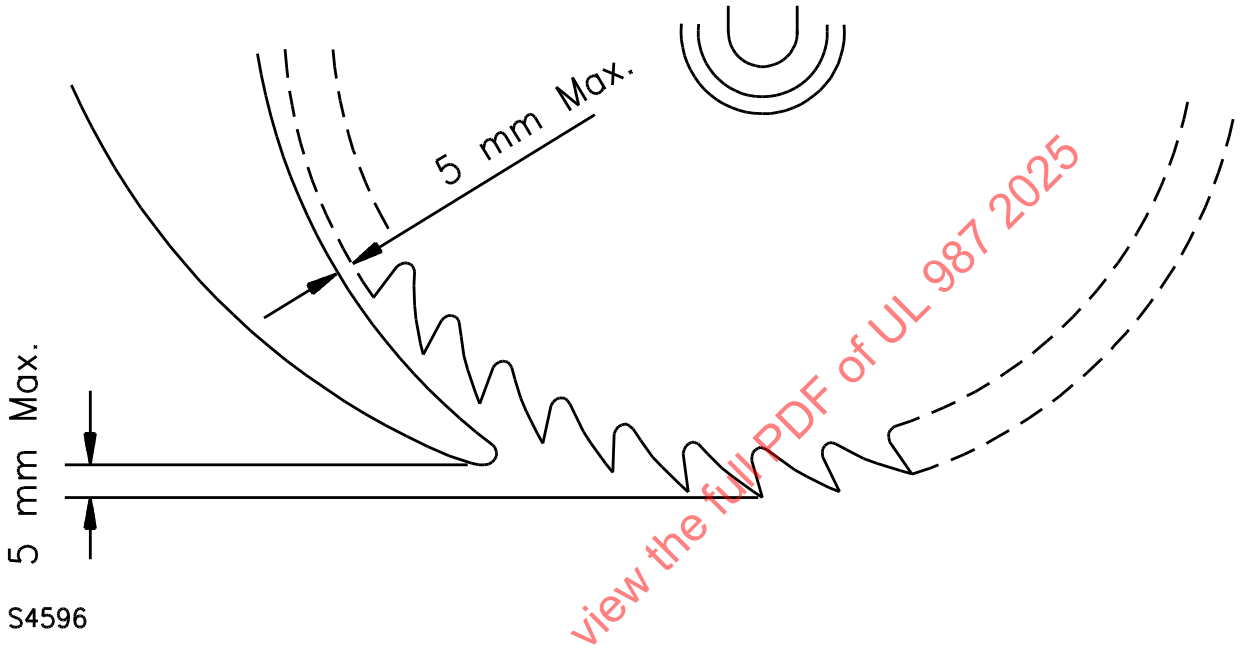
50.33 The riving knife and its holder shall be so constructed that for all through cutting saw blades recommended by the manufacturer, the blade diameters and for any cutting depth adjustment with the blade set perpendicularly to the guide plate, the riving knife shall comply with the following specifications while mounted on the saw as intended:

a) Below the guide plate, the radial gap between the riving knife and the outer circumference of the blade shall not at any point along the riving knife exceed 0.20 in (5 mm), as illustrated in Figure 50.2 and;

b) The distance from the tip of the riving knife to a line that is parallel to the guide plate and tangent to the outer circumference of the blade shall not exceed 0.20 in (5 mm), as illustrated in Figure 50.2.

Figure 50.2

Riving knife adjustment



50.34 The riving knife and its holder shall have the rigidity to comply with the following:

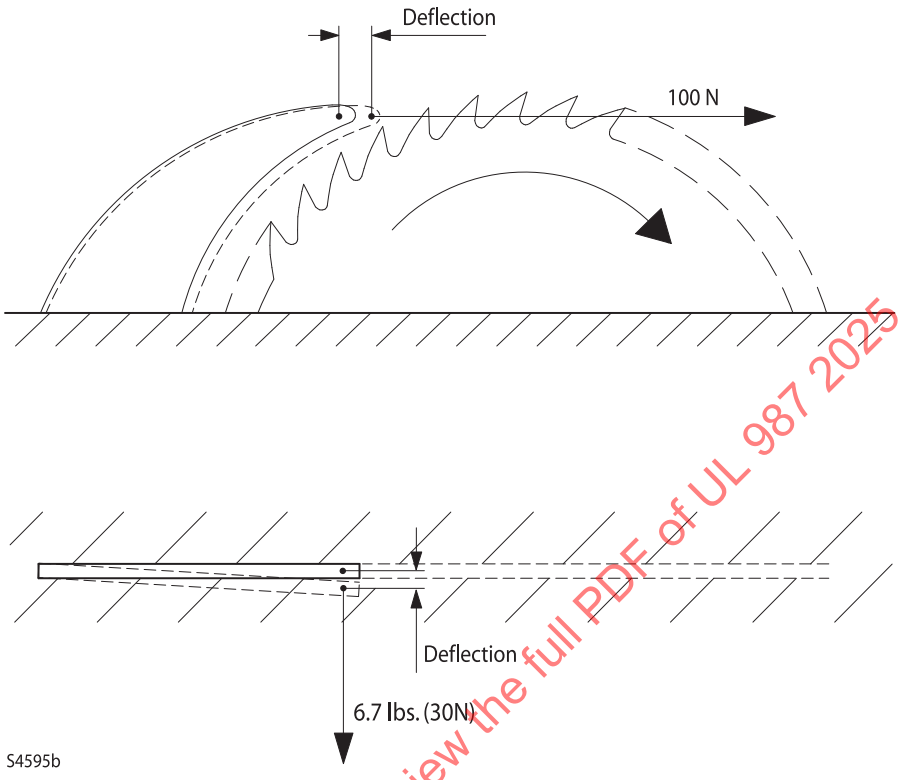
a) For these tests, the blade is set to maximum depth of cut at 90° and the riving knife is mounted in accordance with the manufacturer's instructions that is provided with the saw;

b) Within the construction limits of the riving knife and its holder, the riving knife is adjusted to the maximum distances as specified in 50.33. At the center of the riving knife tip, a force of 22.5 lbf (100 N) shall be applied for one minute perpendicular to the cutting direction and parallel to the guide plate as shown in Figure 50.3. While the force is being applied, the riving knife shall not deflect or displace to contact the saw blade tips. In addition, after the test, the linear spacing between the tips of the saw blade and the riving knife shall not be less than 0.08 in (2 mm); and

c) The riving knife is adjusted to the maximum distance in accordance with 50.33. At the center of the riving knife tip, a force of 6.7 lbf (30N) is applied perpendicular to the cutting direction and parallel to the guide plate, as shown in Figure 50.3. The test is conducted in both directions. While the force is being applied, the tip of the riving knife shall not deflect in the direction of the force by more than half the thickness of the riving knife. After each test, the riving knife shall be within the planes defined by the kerf of the blade supplied with the saw.

Figure 50.3

Riving knife stability test



PERFORMANCE

51 General

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

51.2 The means for controlling the speed mentioned in 54.3, 55.3.3, and 55.3.7 includes a controller having a number of discrete settings, as well as a controller having an infinite number of settings.

51.3 Unless otherwise specified, all tests are to be conducted at the applicable voltage specified in Table 51.1.

Table 51.1
Values of test voltage

Rated voltage	Test voltage, ac/dc
110 – 120	120
121 – 219	Max rated voltage
220 – 240	240

Table 51.1 Continued on Next Page

Table 51.1 Continued

Rated voltage	Test voltage, ac/dc
241 – 253	Max rated voltage
254 – 277	277
278 – 439	Max rated voltage
440 – 480	480
481 – 525	Max rated voltage
526 – 600	600

51.4 During the abnormal tests described in 69.6, 70.8, and Abnormal Operation Test, Section 64, the tool is to be connected in series with a nontime-delay fuse of the maximum size branch circuit device that the equipment is likely to be connected (but no less than 30 A). Opening of the fuse before a risk of fire, electric shock, or injury to persons results is an acceptable conclusion of a test.

51.5 An alternate magnet wire coating used in a tool motor subject to tests 90.6.7 – 90.12.2, shall:

a) Be an investigated magnet wire of the same:

1) ANSI grade designation, or

2) Generic material type and construction with the same temperature rating as the original magnet wire tested; or

b) Be tested as indicated in 90.6.7 – 90.12.2 as appropriate.

52 Leakage Current Test

52.1 When tested in accordance with 52.3 – 52.7, the leakage current of a grounded cord-connected tool shall not be more than 0.75 mA.

52.2 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 surfaces of the tool.

52.3 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 that has been investigated and found to be acceptable to reduce the risk of electric shock – see 7.3.1 – 7.3.4. 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. If all accessible surfaces are bonded together and connected to the grounded conductor of the power-supply cord, leakage current may be measured between the grounding conductor and the grounded supply conductor.

52.4 If a 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 cm by 20 cm in contact with the surface. If the surface is less than 10 cm 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.

52.5 The measurement circuit for leakage current is to be as illustrated in Figure 52.1. The measurement instrument is defined in 52.5(a) – 52.5(c). 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 Ω resistive shunted by a capacitance of 0.15 μF.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 KHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-Ω resistor shunted by a 0.15-μF capacitor of 1500 Ω. At an indication of 0.75 mA, the measurement is to have an error of not more than 5 percent at 60 Hz.

52.6 Unless the meter is used to measure leakage from one part of a tool to another, it is to be connected between accessible parts and the grounded supply conductor.

52.7 A sample of the tool is to be tested for leakage current starting with the as-received condition – as received being without prior energization – but with its grounding conductor, if any, open at the grounding terminal or attachment plug. The supply voltage is to be adjusted to the voltage specified in 51.3. The test sequence with reference to the measuring circuit, Figure 52.1, is to be as follows:

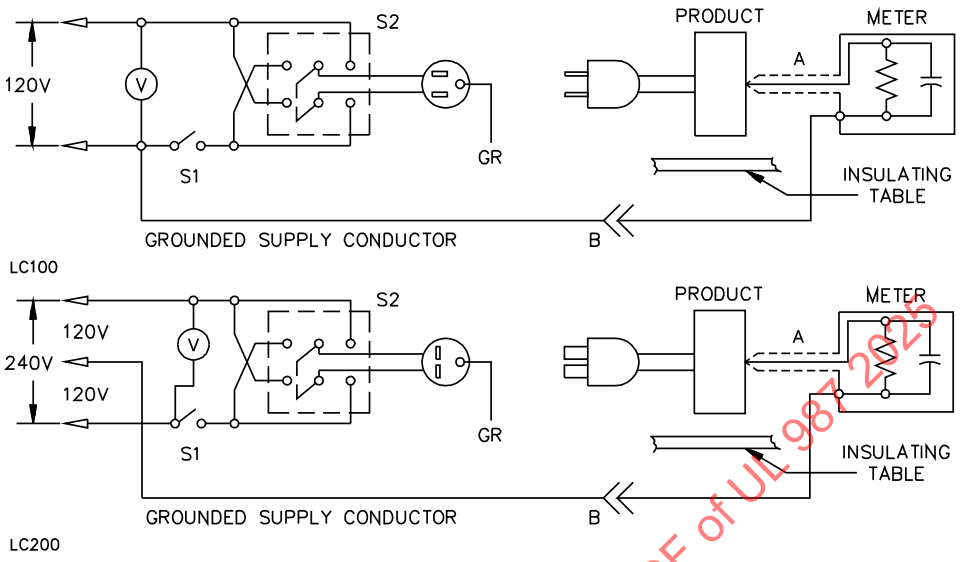
a) With switch S1 open, the tool is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the tool switching devices in all their normal operating positions.

b) Switch S1 is then to be closed energizing the tool and within 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) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is considered to be obtained by operation under no-load conditions.

Figure 52.1

Leakage current measurement circuits



NOTE:

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of tool to another.

52.8 Normally, the complete leakage current test, as specified in 52.7 is to be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted for the purpose of conducting other nondestructive tests.

53 Starting Current Test

53.1 When operated as described in 51.2, a tool shall start and operate normally without:

a) Tripping an overload protector provided as part of the tool; or

b) Opening the fuse, when connected to a circuit protected by a fuse of other than the time-delay type having a current rating corresponding to that of the branch circuit of the lowest rating to which the tool can properly be connected.

Exception: A time-delay fuse may be employed for the test provided the construction of the tool or the nature of the usage is such that the tool is likely to be used continually on the same branch circuit after installation, and the instruction manual or the tool is marked in accordance with 80.11.

53.2 To determine whether a tool complies with the requirements in 53.1, the tool is to be connected to a supply circuit protected by a fuse as specified in 53.1. The tool is to be started three times, with the tool at room temperature at the beginning of the test. Each start of the tool is to be made under conditions representing the beginning of normal operation, and the tool is to be allowed to come to rest between successive starts.

53.3 Cord connected products provided with plug configurations of the same type that can be connected to the same branch circuit shall comply with the starting current test with all cord plugs of the tool connected to the same branch circuit that are required to operate the tool under normal conditions.

54 Current Input Test

54.1 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 54.1 shall not be more than 120 percent of rated current.

54.2 For tools of the most common types, Table 54.1 specifies the conditions of loading for the input test. These have been found to be close approximations of the most severe conditions of normal use. However, a tool, regardless of type, having features not contemplated in these test procedures may be tested as considered necessary to meet the intent of these requirements. A tool intended to perform two or more different operations, such as sanding, polishing, grinding, and the like, is to be tested with the load that results in maximum temperatures.

54.3 For the test, a tool provided with means for controlling the speed is to be operated in accordance with the manufacturer's recommendations with respect to:

a) Speeds;

b) Size and type of accessory – drill bit, saw blade, and the like – intended for use with the tool; and

c) Dimensions and material of the work stock for the operation.

Table 54.1
Loads for input test

Tool	Test Procedure
1. Bandsaw	The test is to be conducted with the saw ripping soft-pine board having a thickness equal to 2/3 the maximum thickness of board it is intended to cut.
2. Drill press	The input is to be measured with the tool drilling holes in a mild-steel plate of thickness not less than the diameter of the drill, using a drill of the largest diameter that the chuck will accommodate.
3. Grinder, bench	A. For a grinder intended for use with grinding wheels less than 6 in (152 mm) in diameter, the test is to be conducted at no load, with the wheels mounted. B. For a grinder intended for use with grinding wheels 6 in or larger in diameter, the test is to be conducted grinding cold-rolled steel, 1/4 in (6.4 mm) thick, and having a width exceeding the width of the grinding wheel. A thrust calculated by the following formula is to be applied to the steel: *T = (18875W x P)/SFPM = (1350.6W x P)/SMPM* *in which:* *T is the thrust in pounds (N),* *P is the rated hp (kW) of grinder,* *W is the width of wheel in inches (mm), and* *SFPM (SMPM) is the surface ft/min (surface m/min) at no load.*
4. Hacksaw	The test is to be conducted with the tool sawing a mild-steel plate, 1/4 in thick, using the blade recommended by the manufacturer. It is assumed that the design of the tool is such that a reasonably constant pressure forces the saw blade against the stock.
5. Jigsaw	The test of a saw having a blade not more than 6 in long is to be conducted with the saw cutting plywood 1/2 in (12.7 mm) thick.
5A. Abrasive cutoff machine	The test is to consist of cutting a 3/4 in (19.05 mm) piece of rebar. The test is to be conducted with a force applied to the handle equal to 110 percent of the force required to cause the blade mechanism to travel the distance of a full cut when the saw is not energized.
6. Saw, scroll	The test is to be conducted in the same manner as that of a jigsaw.
7. Saw, radial	The test is to consist of ripping a soft-pine board having a thickness equal to 75 percent of the maximum depth of cut recommended by the manufacturer and fed at the rate of 4 ft/min (1.22 m/min).
8. Saw, table	The test is to be conducted in the same manner as that of a radial saw.
8A. *Deleted*	
8B. Saw, tile	The test is to consist of cutting a twice fired ceramic tile with a thickness equal to 75 percent of the maximum cutting depth allowed by the construction of the saw. No appreciable force is to be applied to the workpiece, other than that necessary to advance the cutting operation.
9. Planer, jointer, or shaper	The test is to be conducted with the tool cutting soft-pine board, with a width of cut equal to 100 percent of the design capacity, and a depth of 1/16 in (1.6 mm) for surface planing, 1/8 in (3.2 mm) for edge jointing, and 100 percent of the maximum depth permitted by the design of the tool for shaping.
10. Sander, belt	The test is to be conducted with the sander sanding soft-pine wood. A medium-grip sandpaper is to be used. The sanding is to be done with the grain of the wood. The width of the wood is to be the width of the belt minus 1/4 in.
11. Sander, disc	The test is to be conducted in the same manner as that of a belt sander with the disc permitted to revolve across as well as with the grain.
12. Lathe, wood	The test is to consist of inboard faceplate turning of a round, soft-pine wood block having a diameter equal to 80 percent of the swing capacity of the lathe and a maximum thickness of 3 in (76.2 mm). The test of a lathe not equipped for faceplate turning is to consist of turning a round, soft-pine wood block having a maximum diameter of 4 in (102 mm) and a length equal to the capacity of the lathe. The test is to be conducted with the lathe running at the recommended speed.
13. Lathe, metal	The test is to be conducted with the tool cutting metal at the recommended speed and cutting depth as specified by the manufacturer.

55 Temperature Test

55.1 General

55.1.1 A tool shall be tested as described in 55.2.1 – 55.3.8. The temperature at any point shall not be high enough to cause a risk of fire, or to damage any material used, and the applicable temperature rises specified in Table 55.1 shall not be exceeded.

55.1.2 All values for temperature rises in Table 55.1 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).

Table 55.1
Maximum acceptable temperature rises

Materials and Components	°C	°F
1. Varnished-cloth insulation	60	108
2. Fuses	65	117
3. Fiber employed as electrical insulation	65	117
4. Wood and other similar material	65	117
5. Any point on or within a terminal box of a permanently-connected tool – see 81.8	65	117
6. A surface upon which a permanently connected tool may be mounted in service, and surfaces that may be adjacent to the tool when so mounted	65	117
7. Insulation systems on stator windings of an a-c motor having a diameter of 7 in (178 mm) or less (not including a universal motor); and on a vibrator coil[a,b] :		
A. Class A insulation systems		
1. In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	135
2. In a totally enclosed motor:		
Thermocouple or resistance method	80	144
B. Class B insulation systems		
1. In an open motor and on a vibrator coil:	95	171
Thermocouple or resistance method		
2. In a totally enclosed motor:	100	180
Thermocouple or resistance method		
8. Insulation systems on stator windings of an a-c motor having a diameter of more than 7 in (178 mm), of a d-c motor, and of a universal motor[a,b] :		
A. Class A insulation systems		
1. In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
2. In a totally enclosed motor:		
Thermocouple method	70	126

Table 55.1 Continued on Next Page

Table 55.1 Continued

Materials and Components	°C	°F
Resistance method	80	144
B. Class B insulation systems		
1. In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
2. In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
9. Class E insulation systems on coil winding		
Thermocouple method	75	135
Resistance method	85	153
10. Class 105 insulation systems on windings of a relay, a solenoid, and the like:		
Thermocouple method	65	117
Resistance method	85	153
11. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[c]	125	225
12. Rubber- or thermoplastic-insulated wires and cords[c,d,e]	35	63
13. Capacitors:		
Electrolytic[f]	40	72
Other types[g]	65	117
14. Sealing compound	h	h
15. Class 130 insulation systems on windings of a relay, a sole-noid, and the like:		
Thermocouple method	85	153
Resistance method	105	189

[a] See 55.2.3. Temperature limits are based upon stator windings. The temperature of the armature is recorded by a convenient means as a reference temperature for establishing the armature oven conditioning temperature as specified in 91.6.2.

[b] See footnote a to Table 23.2.

[c] Phenolic composition and rubber and thermoplastic insulation that has been investigated and found acceptable for use at higher temperatures may be used at those temperatures.

[d] A rubber-insulated conductor within a motor employing Class A insulation systems, and a rubber-insulated motor lead may be subjected to a higher temperature rise if the conductor is provided with a braid that has been investigated and found acceptable for use at the higher temperature; and a rubber-insulated conductor of a flexible cord may be subjected to a higher temperature rise. This does not apply to thermoplastic-insulated wires or cords.

[e] 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:

1) Supplementary heat-resistant insulation having acceptable dielectric strength is employed on the individual conductors of the cord to prevent deterioration of the conductor insulation; and

2) The strain-relief means is not dependent on that portion of the insulation subjected to the excessive temperature.

[f] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may not be more than 65°C (117°F).

Table 55.1 Continued on Next Page

Table 55.1 Continued

Materials and Components	°C	°F
[g] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.		
[h] The maximum acceptable sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined in accordance with the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus , ASTM E28.		

55.2 Temperature measurements

55.2.1 Temperatures are to be measured by thermocouples unless the change-of-resistance method is used in accordance with 55.2.2. The thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

55.2.2 A thermocouple is to be used for determining the temperature of a coil or winding if it can be mounted, without removal of encapsulating compound or the like:

a) On the integrally applied insulation on a coil not having a wrap; or

b) On the outer surface of a wrap that is not more than 1/32 in (0.8 mm) thick and consists of cotton, paper, rayon, or the like, but not of asbestos or similar thermal insulation.

The change-of-resistance method is to be used if a thermocouple cannot be mounted in accordance with the foregoing considerations. For a thermocouple-measured temperature of a motor coil as mentioned in items 7 and 8 of Table 55.1, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

55.2.3 When using the change-of-resistance method, the windings are to be at ambient temperature at the start of the test. The temperature rise of a winding is to be calculated from the formula:

$$\Delta t = \frac{R_2}{R_1}(K + t_1) - (K + t_2)$$

in which:

Δt is the temperature rise in °C;

R_2 is the resistance of the coil at the end of the test in ohms;

R_1 is the resistance of the coil at the beginning of the test in ohms;

t_1 is the ambient temperature at the beginning of the test in °C;

t_2 is the ambient temperature at the end of the test in °C; and

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

55.2.4 A thermocouple junction and an adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material the temperature of which is being measured. In most

cases, acceptable thermal contact results from securely taping or cementing the thermocouple in place; when a metal surface is involved, brazing or soldering the thermocouple to the metal is to be used when necessary.

55.3 Operation for temperature test

55.3.1 Unless indicated otherwise, the test is to be continued until constant temperatures are reached. A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previous elapsed duration of the test, but not less than 5-min intervals, indicate no change.

55.3.2 Temperatures are not to be measured after final shutdown; however, they are to be observed during the off or idling intervals if loading during the test is of a cyclic nature.

55.3.3 A bandsaw, an abrasive cut-off saw, a drill press, a hacksaw, a planer, a jointer, a shaper, a router, a radial-arm saw, a belt or disc sander, or a lathe is to be operated continuously while loaded so that the current input equals the rated current input of the tool. Loading is to be by eddy-current brake, dynamometer, or the like. If the tool is provided with means for controlling the speed, the test is to be conducted:

a) At the maximum speed setting of the control with the tool loaded so that the current input equals the current rating of the tool; and

b) At any other speed setting that may result in a higher temperature with the tool loaded so that the current input equals the current measured at that speed during the current input test – see 54.1.

55.3.4 A bench grinder intended for use with 6-in (152-mm) diameter or larger grinding wheels is to be operated continuously while loaded to the input value measured in accordance with item 3 of Table 54.1. The test is to be continued until constant temperatures are reached.

55.3.5 A bench grinder intended for use with grinding wheels less than 6 in (152 mm) in diameter is to be operated continuously at no load with the wheels mounted.

55.3.6 A scroll saw and a jigsaw intended for use with blades not more than 6 in (152 mm) long are to be operated as specified below, cutting plywood 1/2 in (12.7 mm) thick.

a) A motor-powered saw is to be operated until constant temperatures are reached, using a duty cycle of five minutes of sawing followed by one minute of idling.

Exception: A motor-powered saw may be connected to an eddy-brake and loaded in accordance with 55.3.3 until constant temperatures are reached.

b) A vibrator-powered saw rated 3 A or less and 125 V or less is to be operated for 12 cycles with each cycle consisting of two minutes of sawing followed by one minute off.

c) A vibrator-powered saw other than as mentioned in (b) is to be operated sawing continuously until constant temperatures are reached.

55.3.7 If a jig or scroll saw having a blade not more than 6 in (152.4 mm) long is provided with means to control the speed (see 83.1.2), the test is to be conducted in accordance with the manufacturer's recommendations regarding:

a) The blade or other accessory intended for use with the tool;

b) The work stock, such as steel or wood; and

c) The speed.

55.3.8 A tile saw is to be operated continuously for 30 minutes while loaded so that the current input equals the rated input of the tool. Loading is to be by eddy-current brake, dynamometer, or the like.

56 Dielectric Voltage Withstand Test

56.1 Other than as specified in 56.2, a tool shall withstand for one minute without breakdown the application of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage, between live parts and dead metal parts, with the tool at the temperature reached during the temperature test.

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

56.3 In the application of 56.2 and Table 76.1 to a motor not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, 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.

56.4 A capacitor for radio-interference elimination or power-factor correction shall withstand for one minute without breakdown the application of a 60-Hz essentially sinusoidal potential of 1000 V plus twice the rated voltage of the tool between terminals of the capacitor.

56.5 For the dielectric voltage-withstand test, the tool is to be tested by means of a 500-VA or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for one minute. The applied potential is to be increased at a substantially uniform rate and as rapidly as is consistent with its value being correctly indicated by a voltmeter.

56.6 Printed foil patterns placed on a printed wiring board provided with a conformal coating as specified in 23.9(a) or 23.9(b), shall withstand the potential specified in 56.1 when applied between printed wiring traces of opposite polarity for one minute without breakdown. Clean dry samples with and without 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.

57 Leakage Current Test Following Humidity Conditioning

57.1 A tool shall comply with the requirements for leakage current in 52.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

57.2 To determine whether a tool complies with the requirement in 57.1, a sample tool is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and conditioned for 48 hours under the conditions specified in 57.1. Following conditioning, the sample is to be tested unenergized as described in 52.7(a). The sample is then to be energized and tested as described in 52.7(b) and 52.7(c). The test is to be discontinued when the leakage current stabilizes or decreases.

58 Impact test

58.1 A component as mentioned in 4.3 and 4.7 that is exposed to impact shall withstand the ball-impact test described in 58.2 – 58.7 when mounted in its normal position:

a) Without cracking that affects the function of the part;

b) Without being affected to the extent that any moving part involving a risk of injury to persons would be exposed to unintentional contact; and

c) Without affecting the mechanical performance of a tool in a manner that could result in a risk of injury to persons.

58.2 The ball-impact test is to be conducted with a smooth steel sphere having a diameter of 2 in (51 mm) and weighing 1.18 lbf (0.54 kg). If the component being tested can be impacted from above, the sphere is to be dropped from rest to strike the component. Otherwise, the sphere is to be suspended by a cord and is to be allowed to fall from rest as a pendulum to strike the component. In either case, the vertical travel of the sphere is to be 51 in (1.29 m).

58.3 A component as mentioned in 4.3 and 4.7 that is subject to impact and that is made of plastic or other nonmetallic material shall comply with the requirements in 58.1 after conditioning as described in 58.4. After the conditioning and before being subjected to the ball-impact test, the component shall not be checked, cracked, distorted or otherwise affected so as to impede proper operation of the tool.

58.4 A component as mentioned in 58.3 that has been previously tested is to be conditioned for 7 hours in an air oven at 70°C (158°F). The sample is to be supported in the same manner it is supported in the tool. Upon removal from the oven, the component is to be inspected for damage as mentioned in 58.3. The component is to be allowed to cool to room temperature before being subjected to the ball-impact test described in 58.2.

58.5 A guard that becomes disassembled during the ball-impact test is acceptable if the damage is obvious and it can be reassembled readily to function properly.

58.6 Deformation of a guard or other part, such as a spreader, during the ball-impact test is acceptable if the part can be readily restored to its original shape.

58.7 Damage to the cutting tool or a portion of the drive system, other than a guard, as a result of the ball-impact test is acceptable if, after the test, it is obvious that the tool is incapable of normal operation, or the tool complies with the applicable requirements in Sections 29 – 50.

59 Strain Relief Test

59.1 When tested as described in 59.2, the strain-relief means provided on a flexible cord shall withstand for one minute, without displacement, a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the tool disconnected.

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

60 Push Back Relief Test

60.1 To determine compliance with 13.2.2, a product shall be tested in accordance with 60.2 without occurrence of any of the conditions specified in 13.2.2 (a) – (d).

60.2 The supply cord or interconnecting cable is to be held 1 in (25.4 mm) from the point where the cord or interconnecting cable emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 in is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or interconnecting cable is to be pushed back into the product in 1 in (25.4 mm) increments until the cord buckles or the force to push the cord into the product exceed 6 lb-f (26.7 N). The supply cord or interconnecting cable within the product is to be manipulated to determine compliance with 13.2.2.

61 Sharp Edges Test

61.1 When a test is required to determine whether the edges of an opening through which a power-supply cord passes are smoothly rounded, the tool shall be tested as described in 61.2; and the cord shall not be cut, abraded, or permanently scratched.

61.2 With all mechanical and electrical connections in place, the cord is first to be twisted clockwise 360° and then counterclockwise 360°. The cord is to be twisted 2 in (51 mm) outside the opening of the hole through which it passes, while an axial pull in a force determined by the following is applied along the longitudinal axis of the cord:

a) 10 lb (44.5 N) for a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) cord; or

b) 15 lb (66.7 N) for a 14 AWG (2.1 mm^2) cord.

The plane of the opening is not to be less than 60° from the vertical.

61.3 If it is not obvious that a wire as mentioned in Section 15 will not be abraded by the edges of a hole through which it passes, a projection in a wireway, and the like, the tool shall be tested as described in 61.4; and the conductor insulation on the wire shall not be visibly abraded or cut.

61.4 To determine whether a tool complies with the requirement in 61.3:

a) A wire as mentioned in 61.3 is to be pulled back and forth 100 times by hand over the part likely to cause damage; and

b) The tool is to be operated for 48 hours without load at rated voltage. If the output function of the tool is oscillating, reciprocating, or impacting, this portion of the test is to be conducted with the tool in the as-received condition. If the output function is rotary, an accessory that is 1 oz-in (7.1 N·mm) out of balance is to be fixed to the spindle.

62 Switches and Controls Test

62.1 General

62.1.1 Other than a speed-changing switch or a reversing switch, a switch or other device that controls the motor of a tool, unless it has a horsepower rating acceptable for the application or unless interlocked so that it will not have to break the locked-rotor motor current, shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the tool. There shall be no electrical breakdown or mechanical malfunction of the device. The on/off function of the switch shall function properly on the 51st cycle when energized under a no load condition. The fuse in the grounding connection shall not open during the tests.

62.1.2 To determine whether a switch or other control device complies with the requirement in 62.1.1, the tool is to be connected to a grounded supply circuit of rated frequency – see 51.1 – and maximum rated voltage – see 80.2 – with the rotor of the motor locked in position. During the test, exposed dead metal parts of the tool are to be connected to ground through a 3-A plug fuse, and the connection is to be such that any single-pole, current-rupturing device is in the ungrounded conductor of the supply circuit. If the tool is intended for use on direct current, or on direct current as well as alternating current, exposed dead metal parts of the tool are to be connected to be positive with respect to any single-pole, current-rupturing control device. The device is to be operated so that it is left in the on position as briefly as possible, and at a rate of 10 cycles/min. However, with the concurrence of those concerned, a faster rate of operation may be employed with the device left in the on position as briefly as possible.

62.2 Reversing controls

62.2.1 A switch or other device for reversing the motor of a tool shall perform acceptably when subjected to a test consisting of 25 cycles of operation as described in 62.2.2. There shall be no:

a) Electrical breakdown or mechanical malfunction of the device;

b) Switch malfunction on the 26th cycle;

c) Emission of molten metal or flame from the enclosure; and

d) Opening of the fuse in the grounding connection.

62.2.2 For the test mentioned in 62.2.1, the tool is to be connected to a circuit of maximum rated voltage, without load. Each cycle of operation is to consist of throwing the switch to the position in which the tool rotates in one direction, allowing it to reach full operating speed in that direction; then, without pause in any intermediate off position unless the switch will not function otherwise, throwing the switch to the position in which rotation is reversed, allowing the tool to reach normal speed in that direction, and then reversing the rotation again by throwing the switch to the initial on position. Connections, including the grounding connection, are to be made as described in 62.1.2.

62.3 Speed change controls

62.3.1 A switch or other device for changing the speed of the motor of a tool, other than an on-off switch, shall perform acceptably when subjected to a test consisting of 50 cycles of operation as described in 62.3.2. There shall be no:

a) Electrical breakdown or mechanical malfunction of the device;

b) Welding or undue pitting or burning of the contacts;

c) Emission of molten metal or flame from the enclosure; and

d) Opening of the fuse in the grounding connection.

62.3.2 For the test mentioned in 62.3.1, the tool is to be connected to a circuit of maximum rated voltage, without load. Each cycle of operation is to consist of allowing the tool to operate at one speed, throwing the switch to cause operation at the other speed, and then changing the setting back to the position that results in the first value of speed. During the test the dead metal parts of the tool are to be connected to ground through a 3-A plug fuse.

63 Capacitor Test

63.1 A capacitor as mentioned in 22.1(d) shall be tested as described in 63.2 and the cotton placed around it shall not ignite.

63.2 For the test mentioned in 63.1, three samples of the capacitor are to be mounted in the usual manner, and cotton is to be placed around openings in the enclosure. The samples are to be subjected to such overvoltage as to cause breakdown.

64 Abnormal Operation Test

64.1 A tool employing a rectifier, a transistor, or a similar component or a capacitor in combination with such a component, where failure is likely to result in an increased risk of fire or electric shock, shall be

tested as described in 64.2. The test shall not result in a risk of fire or electric shock, and the fuse in the grounding connection shall not open.

64.2 For the test mentioned in 64.1, exposed dead metal parts of the tool are to be connected to ground through a 3-A fuse. Only one condition of simulated malfunction or breakdown is to be imposed at a time. The component or capacitor is to be tested both open- and short-circuited between any two of its terminals, and all combinations of terminals are to be tested. With the component or capacitor opened or shorted, the tool is to be operated as it would be in use. If there is indication of malfunction, such as smoking or operation of the tool in other than its intended manner, the test is to be discontinued when such malfunction would become evident to the operator. Otherwise, the test is to be continued until ultimate results are reached.

64.3 During each test:

a) The unit is to be placed on a softwood surface covered with white tissue paper; and

b) A single layer of cheesecloth is to be draped loosely over the entire enclosure. The cheesecloth is to be untreated cotton cloth running 14 – 15 yd/lb (26 – 28 m^2 /kg) and for any in^2, a count of 32 threads in one direction and 28 in the other direction.

65 Bonding Overload Test

65.1 A bonding conductor smaller than that required by 24.10 shall not open when carrying for two minutes a current equal to twice the rating of the overcurrent device of the branch circuit to which the tool would normally be connected, but not less than 20 A.

66 Resistance of Grounding Path Test

66.1 The resistance of the grounding path between a dead metal part and the equipment-grounding terminal or lead or the point of attachment of the wiring system shall not be more than 0.1 Ω.

66.2 With reference to the requirements in 66.1, the resistance may be determined by any convenient method. If unacceptable results are recorded, either a direct or alternating current at a potential of not more than 12 V, and equal to the current rating of the largest branch-circuit overcurrent-protective device that may be employed with the tool is to be passed from the equipment-grounding terminal or from the point of attachment of the wiring system to the dead metal part, and the resulting drop in potential is to be measured between those two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

67 Conditioning of Polymeric Materials

67.1 The tests required by the following references shall be conducted on samples or specimens conditioned as described in 67.2:

a) Tests of Polymeric Enclosures Following Oven Conditioning, Section 68; and

b) 69.2, 69.5, and 69.6 or 70.2 – 70.4 and 70.6 – 70.8.

Exception: The tests required by 67.1(b) may be conducted on unconditioned samples if:

a) It has been determined by a long-term thermal aging program, which included samples or specimens no thicker than the enclosure, that thermal aging will not result in an adverse change in the properties of the material; or

b) The maximum temperature to which the material is exposed during normal use does not exceed 65°C (149°F).

67.2 Samples or specimens of polymeric material required to be conditioned are to be placed in an air-circulating oven. The oven is to be maintained at the temperature specified in Table 67.1 for 1000 hours.

Table 67.1
Oven temperature for thermal aging

Maximum normal operating temperature of enclosure				Oven temperature	
More than		Not more than			
°C	°F	°C	°F	°C	°F
65	149	75	167	85	185
75	167	90	194	95	203
85	185	95	203	105	221

68 Tests of Polymeric Enclosures Following Oven Conditioning

68.1 After the enclosure or a part of the enclosure if it is representative of the enclosure is conditioned as described in 67.2, the enclosure shall comply with the requirements for accessibility of live parts, mechanical strength, flammability, and the like.

69 Polymeric Material as Described in 69.2

69.1 General

69.1.1 Polymeric material as described in 69.2 shall comply with the requirements in 69.3 – 69.6.

69.2 Flame resistance test

69.2.1 The enclosure is to be tested as described in 69.2.2 – 69.2.4, and shall not support combustion for more than one minute after the second application of the test flame, nor shall there be complete destruction of the sample as a result of this test. A flame-retardant coating shall not be depended upon for acceptable results for this test.

Exception: An enclosure of material classed V-0, V-1, or V-2 in accordance with the Standard For Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if it is within the same thickness range for which the material was classed, need not be tested.

69.2.2 Three sections of the enclosure most likely to be ignited are to be selected – see 69.2.4. During the test:

a) The enclosure is to be supported in its normal operating position in a draft-free location;

b) Nonpolymeric portions of the enclosure in contact with or fastened to the polymeric portions are not to be removed; and

c) Insofar as possible, the internal mechanism of the tool is to be in place.

69.2.3 The flame of a Bunsen burner is to be adjusted to have a 3/4-in (19-mm) yellow flame with no blue cone. With a different sample in each case, each section is to be subjected to two 30-second applications of the tip of the flame with a 1-minute interval between the applications.

69.2.4 With reference to 69.2.2, the sections most likely to be ignited are to be considered those adjacent to a coil winding, a splice, or an open switch or other arcing or sparking part.

69.3 Thermal stability test

69.3.1 Conditioning as described in 69.3.2 shall not:

a) Reduce spacings below the minimum acceptable values;

b) Make any uninsulated live part or internal wiring accessible to contact; or

c) Produce any other condition that may increase the risk of fire or electric shock.

Exception: Polymeric material conditioned as described in 67.2 need not comply with these requirements.

69.3.2 Three samples of the enclosure or a part of the enclosure if it is representative of the enclosure are to be conditioned in an air-circulating oven maintained at a uniform temperature at least 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, but not less than 70°C (158°F). The samples are to remain in the oven for 7 hours. After careful removal from the oven and return to ambient temperature, they are to be investigated to determine whether they comply with the requirements in 69.3.1.

69.4 Strain relief test

69.4.1 After the test samples have cooled to ambient temperature following the conditioning described in 67.2 or 69.3.2, they shall be subjected to the strain-relief test described in 59.1 and 59.2, if the strain relief is dependent on the polymeric material.

69.5 Impact test

69.5.1 The enclosure shall withstand the impact described in 69.5.2 without:

a) Reducing spacings below the minimum acceptable values;

b) Making any uninsulated live part or internal wiring accessible to contact; or

c) Producing any other condition that may increase the risk of fire or electric shock.

69.5.2 Each of three samples of the enclosure or a part of the enclosure if it is representative of the enclosure is to be subjected to an impact of 5 ft-lbf (6.8 J) on any surface that is exposed to a blow during normal use. The impact is to be produced by dropping a steel sphere, 2 in (51 mm) in diameter, and weighing 1.18 lb (0.54 kg) from a height of 51 in (1.29 m) to produce the specified impact, or by permitting the ball to swing as a pendulum.

69.6 Abnormal operation test

69.6.1 When a tool is tested as described in 69.6.2, there may be warping, shrinkage, expansion, or cracking of the material of the enclosure, but there shall be no:

a) Ignition of the material of the enclosure;

b) Exposure of a live part; or

c) Emission of flame or molten metal, or glowing or flaming of the combustible material upon which the tool is placed.

Exception: Emission of flame or molten metal, or glowing or flaming of the combustible supporting surface that may result from such emission occurring through an opening provided as a part of the design and construction of the enclosure – but not through an opening that occurs as a result of the test.

69.6.2 The tool is to be operated under a condition of abnormal operation appropriate for the specific application, such as stalled rotor, overload, overvoltage, undervoltage, operation with current-carrying parts short-circuited, and the like. During the test, the tool is to be connected to a circuit containing a 30A fast acting supply fuse while resting on white tissue paper on a softwood surface. The tool is to be operated continuously until the ultimate results have been obtained. In most cases, continuous operation for 7 or 8 hours will be necessary to determine that the ultimate results have been obtained, or constant temperatures are reached, or the 30A fuse opens.

70 Polymeric Material as Described in 70.2

70.1 General

70.1.1 Polymeric material as described in 70.2 shall comply with the requirements in 70.3 – 70.10.

Exception: Material as described in 70.2 need not comply with the requirements in 70.3 – 70.10 if it complies with one of the following:

a) The material:

1) Complies with the requirement for impact in 69.5.1 and 69.5.2;

2) Does not enclose an uninsulated live part; and

3) Is not relied upon to provide strain relief for the cord.

b) The material:

1) Complies with the requirements for thermal stability, strain relief, impact, and abnormal operation in 70.3 – 70.6; and

2) Does not enclose an uninsulated live part.

c) The material:

1) Is not used in quantities more than 10 ft^2 (0.93 m^2) in area; and

2) Does not enclose an electrical part.

70.2 Burning rate

70.2.1 The rate of burning of the polymeric material shall not be more than 1.5 in/min (38.1 mm/min) when tested as described in 70.2.2 – 70.2.6.

70.2.2 Three samples of the material, each 5 in (127 mm) long, 1/2 in (12.7 mm) wide, nominally 1/8 in thick [minimum thickness 0.12 in (3.05 mm)] and having smooth edges are to be tested. On each sample, a line is to be marked across the width of the sample 1 in (25 mm) from one end and a similar line is to be marked 1 in from the other end.

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

70.2.4 A sample is to be clamped at one end with its longitudinal axis horizontal and its transverse axis inclined 45° to the horizontal. The wire gauze is to be clamped horizontally beneath the sample, with a separation of 3/8 in (9.5 mm) between the lower edge of the sample and the gauze and with the free end of the sample extending approximately 1/2 in (12.7 mm) beyond the gauze. The Bunsen burner is to be adjusted to provide a blue flame approximately 1 in (25 mm) high, and the tip of the flame is to be applied to the free end at the lower edge of the sample. The tube of the burner is to be in the same vertical plane as the longitudinal axis of the sample and inclined toward the end of the sample at an angle of approximately 45° to the horizontal. The flame is to be applied for 30 seconds without changing the position of the burner, and is then to be removed from the sample.

70.2.5 If the sample continues to burn after removal of the test flame, the time for the flame to travel along the lower edge of the sample from one mark to the other is to be measured, and the rate of burning is to be calculated in in/min (mm/min).

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

70.3 Hot-wire ignition test

70.3.1 The polymeric material shall resist being ignited for 7 seconds or longer when tested as described in 70.3.2 and 70.3.3.

Exception: A polymeric material that complies with the Hot-Wire Ignition (HWI) Abnormal Overload Test, Section 70.4 need not be tested in accordance with 70.3.2 and 70.3.3.

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

70.3.3 The wire is to be 24 AWG (0.21 mm^2), iron-free, 20 percent chromium and 80 percent nickel, running 1.61 Ω/ft (5.28 Ω/m), and 865 ft/lb (580 m/kg). The wire is to carry such current as to dissipate 6.5 W/in (0.26 W/mm), and the time measurement is to begin when the current begins to flow.

70.4 Hot-wire ignition (HWI) – abnormal overload test

70.4.1 Materials that do not comply with 70.3.1 may be evaluated by an abnormal overload test that passes abnormal currents through current-carrying members as described in 70.4.2. Over-current values and times are shown in Table 70.1 as a function of the circuit overcurrent device rating.

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

70.4.2 A polymeric material shall be capable of withstanding the temperatures that are generated during or as a result of the abnormal overload test described in 70.4.5 and 70.4.6 without ignition.

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

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

70.4.5 To determine whether a polymeric material complies with 70.4.2, separate samples of the tool or representative sections of the tool are to be loaded to each indicated overcurrent values for the corresponding test times indicated in Table 70.1. Except as indicated in 70.4.6, only one sample need be subjected to each of the specified overload tests.

70.4.6 If a current-carrying conductor within any of the samples of the tool opens before the minimum test time tabulated in Table 70.1 has elapsed without resulting in ignition, then three samples are to be loaded to a lesser current value, as indicated in 70.4.10 (b) – (i) for the minimum test time tabulated in Table 76.1 corresponding to the largest overload value that does not result in a current-carrying conductor opening before the minimum test time, or 7 hours.

70.4.7 For the sequence of tests described in 70.4.10, if the abnormal overload test continues for 7 hours or the full test time indicated in Table 70.1 without a winding or an acceptable protective device opening, the remaining tests need not be conducted. For example, if the test described in 70.4.10(a) continues for 7 hours using 110 percent of the overcurrent protective device rating load (namely 33 A for a 30 A overcurrent protective device), 60 minutes using 135 percent of the overcurrent protective device rating load (namely 40.5 A), and two minutes using 200 percent of the overcurrent protective device rating load (namely 60 A) the tests described in 70.4.10 (b) – (i) need not be conducted.

70.4.8 The overload current value indicated in 70.4.10 (b) – (h) is the lesser overload value tabulated in Table 76.1 that resulted in a current-carrying conductor opening before the minimum test time. The base test current value indicated in 70.4.10 (b) – (i) is the largest overload value tabulated in Table 76.1 that does not result in a current-carrying conductor opening before the minimum test time. If a current-carrying conductor opens before 7 hours within the sample loaded to 110 percent of the overcurrent protective device rating, then the base test current value shall be the rated current of the tool.

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

Example A:

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

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

Example B:

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

Table 70.1
Abnormal overload test

Overcurrent Protective Device Rating	Minimum Test Time		
	110-percent current[a]	135-percent current	200-percent current
0 – 30 A	7 h	60 minutes	Two minutes
31 – 60	7	60	4
61 – 100	7	120	6
101 – 200	7	120	8
201 – 400	7	120	10

[a] The test may be terminated when the temperatures have stabilized, indicating that ultimate results have already been achieved.

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

a) Loading the tool to the specified overload values per Table 70.1.

b) Loading the tool to a current equal to the base test current plus 75 percent of the difference between the overload current and the base test current.

c) Loading the tool to a current equal to the base test current plus 50 percent of the difference between the overload current and the base test current.

d) Loading the tool to a current equal to the base test current plus 25 percent of the difference between the overload current and the base test current.

e) Loading the tool to a current equal to the base test current plus 20 percent of the difference between the overload current and the base test current.

f) Loading the tool to a current equal to the base test current plus 15 percent of the difference between the overload current and the base test current.

g) Loading the tool to a current equal to the base test current plus 10 percent of the difference between the overload current and the base test current.

h) Loading the tool to a current equal to the base test current plus 5 percent of the difference between the overload current and the base test current.

i) Loading the tool to the base test current.

70.4.11 To determine whether a material complies with the requirement in 70.4.6, three samples of the complete tool are to be subjected to each condition described in 70.4.10 (a) – (i).

70.4.12 For the loading conditions, a variable resistor is to be connected in series with the tool. The tests described in 70.4.10 (a) – (i) are to be continued for the test times indicated in Table 70.1, unless a current-carrying conductor within the tool or an acceptable protective device opens in a shorter time. In conducting the tests described in 70.4.10 (b) – (i) the variable resistance load is to be adjusted to the required value as quickly as possible and readjusted, if necessary, one minute after application of voltage to the tool.

70.4.13 For a tool that is provided with a built-in, acceptable, protective device (as indicated in 70.4.4) the tests described in 70.4.10 (a) – (h) are to be conducted if the protective device opens the circuit. If the protective device is of the automatic recycling type, the test is to be continued for the full time indicated in Table 70.1.

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

a) The complete tool is to be placed on a white tissue paper covered softwood surface.

b) The tool is to be connected to a suitable supply circuit, that may use a low voltage current source, fused at not less than 30 A.

70.4.15 Each abnormal-overload test is to be continued until ignition of the material occurs, the circuit under test burns open, or until the test time indicated in 70.4.6 and Table 70.1 is achieved.

70.5 Spacings to enclosure

70.5.1 The spacings between the polymeric enclosure and a nonarcing uninsulated live part, such as a bus bar, a connecting strap, a terminal, or the like, shall not be less than 1/32 in (0.8 mm).

70.5.2 The spacings between the polymeric enclosure and an arcing part, such as a commutator, unenclosed switch contacts, or the like, shall not be less than 1/2 in (12.7 mm).

Exception: The spacing may be less than 1/2 in but not less than 1/32 in (0.8 mm) if the polymeric material does not ignite when tested in accordance with 70.7.

70.5.3 The spacing mentioned in 70.5.2 is to be measured from the source of the arc – that is, from the interface of the brush and the commutator, or from the interface of the switch contacts.

70.6 Arc resistance test

70.6.1 A material that does not comply with 70.5 may be evaluated by using the power (current, voltage, and power factor) of the circuit in the tool by conducting a short-circuit test using the procedures described in 70.6.2.

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

70.7 Arc-ignition test

70.7.1 When tested as described in 70.7.2 – 70.7.5, there shall be no ignition of the polymeric material with 60 or fewer arcs.

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

70.7.3 The test is to be conducted using a pair of electrodes and a variable-inductive impedance load connected in series to a high-capacity alternating-current source. The stationary electrode is to be a 8 AWG (8.4 mm^2) solid copper conductor having a horizontal chisel point. The movable electrode is to be a 1/8-in (3.2-mm) diameter stainless steel rod with a pyramidal point. The major axis of each electrode is to be 45° from the horizontal, and the major axes of both electrodes are to be in the same vertical plane. With the electrodes short-circuited, the variable-inductance impedance is to be adjusted until the current is 32.7 A at 240 V alternating current, with a 50 percent power factor.

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

70.7.5 The movable electrode is to be moved in a horizontal direction to make and break electrical contact with the fixed electrode at a rate of 40 contacts/min.

70.8 Abnormal operation test

70.8.1 A tool shall comply with the requirements for abnormal operation in 69.6.

70.9 Impact test

70.9.1 The enclosure shall comply with the requirements for impact in 69.5.

70.10 Thermal stability

70.10.1 A tool shall comply with the requirements for thermal stability in 69.3.

71 Drip Test

71.1 A tile saw which has a drip or splash pan at a higher level than live parts including the power supply cord connection shall comply with this Section. At the conclusion of the drip test specified in 71.2 a tile saw:

a) Rated for a nominal 120 V supply shall comply with the requirements in 52.1 or 91.2, as applicable, in a repeated leakage current test, except that the test is to be discontinued when leakage current stabilizes.

b) Of a type other than that mentioned in (a) shall have an insulation resistance not less than 50,000 Ω between live parts and interconnected dead metal parts.

c) Shall withstand without breakdown for one minute the application of a 60-Hz essentially sinusoidal potential between live parts and exposed dead metal parts. The dielectric test potential shall be:

1) In accordance with 56.1 for a grounded appliance;

2) Twenty-five hundred V for a double-insulated appliance rated a nominal 120 V; or

3) Thirty-five hundred volts plus twice the rated voltage of the appliance for a double-insulated appliance rated other than a nominal 120 V.

71.2 The enclosure is to be mounted beneath a drip pan that produces both splashing and dripping and extends beyond all exposed sides of the enclosure. The bottom of the drip pan is to be equipped with uniformly distributed spouts; one spout for each 20 in^2 (129 cm^2) of pan area. Each spout is to drip water at a rate of at least 20 drops/min. The enclosure is to be subjected to continuously dripping water for 30 minutes.

71.3 Parts that are removable without the use of the tool and that are removed or adjusted by the user under normal operation are to be removed for the test.

72 Flooding Test

72.1 A tile saw, after being operated for 1 hour with any component described in 72.3 loosened to simulate a fault or loose connection, shall comply with the requirements in 70.1. The reservoir is to remain filled to the maximum level specified during the test.

72.2 While conducting the test described in 72.1, the tile saw is to be in a normal position and oriented to be most likely to cause entrance of water into, or on, electrical components and insulation.

72.3 Parts that are removable without the use of the tool and that are removed or adjusted by the user under normal operation are to be removed for the test.

72.4 The deterioration of breakdown of a component, such as a timer switch, a float- or pressure-operated switch, a hose, flexible tubing, a gasket, a boot, a seal, or a diaphragm, shall not result in a risk of electric shock due to:

a) Leakage current;

b) Insulation breakdown; or

c) Obvious wetting of any live part having only basic insulation resulting from such deterioration or breakdown.

Exception: A part that complies with Section 74, Test For Deterioration Of Parts, or Section 75, Test For Reliability Of Parts, is not required to meet this requirement.

72.5 Obvious wetting, as used in 72.4(c), means wetting by a stream, spray, or dripping of water that will obviously be repeated during each flooding. Obvious wetting is not meant to include wetting by random drops of water that may not be regularly repeated during subsequent flooding.

73 Overflow Test

73.1 A tool, such as a tile saw, with a reservoir or liquid storage chamber that is likely to be overfilled in intended use, shall be such that liquid overflowing from the reservoir or chamber shall not wet live parts or enamel insulated wires, and shall not wet electrical insulation that is likely to be adversely affected by the liquid usually used in the reservoir or chamber. Following the test, the tool shall comply with the requirement in 71.1.

73.2 To determine whether a product complies with the requirements in 73.1, it is tested as follows: water is to be used for the test and is to be poured into the reservoir through an orifice 3/8 in (9.5 mm) in diameter. The reservoir is to be filled to maximum capacity (not recommended capacity). Additional water, equal to 50 percent of the volume just mentioned, but not more than 1 qt, is then to be poured into the reservoir through the orifice. Determination of whether live parts have become wet as a result of the overflow is to be by means of visual inspection.

73.3 Parts that are removable without the use of the tool and that are removed or adjusted by the user under normal operation are to be removed for the test.

74 Test For Deterioration Of Parts

74.1 To determine whether a tile saw complies with the requirements in 72.4 with regard to parts subject to flexing, the deterioration of a part made of rubber, plastic, or similar material shall be simulated by operating the tile saw for one hour with the part completely removed.

Exception No. 1: Infrequent motion of small amplitude, such as that encountered during normal operation of a diaphragm covering a pressure-operated switch, does not constitute flexing.

Exception No. 2: A part that has been investigated to determine that the part is reliable in accordance with Section 75, Test for Reliability of Parts, is not required to be subjected to this test.

74.2 After being tested in accordance with 74.1, a tile saw shall comply with the requirements in 71.1.

75 Test For Reliability Of Parts

75.1 To determine compliance with 72.4, a material used for a gasket, a diaphragm, a seal, or other part shall have physical properties as specified in Table 75.1 before and after the accelerated aging specified in 75.5 and Table 75.2. The material shall not harden, deform, melt, or otherwise deteriorate to a degree that will adversely affect the sealing properties.

Exception No. 1: A material of a component not under compression is not required to be subjected to the compression set requirements.

Exception No. 2: A material of a part not subject to flexing that has been investigated in accordance with 75.5 is not required to have physical properties as specified in Table 75.1.

Exception No. 3: A noncomposite material that has been found to comply with the requirements in Part B of the Standard for Gaskets and Seals, UL 157, and that complies with the minimum acceptable elongation, tensile strength, set, and compression set after aging as specified in Table 75.1 is in compliance with these requirements.

Table 75.1
Physical Properties For Gaskets And Seals

Physical properties	Elastomers (neoprene, rubber, ethylene, propylene and the like)		Nonelastomers (polyvinyl chloride, and the like, excluding cork, fiber, and similar materials)	
	Before conditioning	After conditioning	Before conditioning	After conditioning
Minimum acceptable elongation[a]	250 percent	65 percent of original	200 percent	65 percent of original
Minimum acceptable tensile strength	1500 psi (10.3 MPa)	75 percent of original	1500 psi (10.3 MPa)	75 percent of original
Maximum acceptable set[b]	1/4 in (6.4 mm)	–	Not specified	–
Maximum acceptable compression set[c]	15 percent	–	Not specified	–

[a] Percent increase in distance between gauge marks at break compared to initial distance of 1 in (25.4 mm). For example, a distance at break of 3.5 in (88.9) is 250 percent elongation.

[b] Difference between 1.0 in (25.4 mm) and final distance when specimen is stretched so that gauge marks initially 1 in apart are 2.5 in (63.5 mm) apart, held for two minutes, and measured two minutes after release.

[c] Percent set measure after Type 1 button specimens are compressed to two-thirds of original thickness, unless the construction of the gasket joint effectively limits initial compression to less than one-third of original, in which case actual compression will be used, and heat conditioned for 24hoursat 70°C (158°F) or 10°C (18°F) higher than normal operating temperature, whichever is higher, following the procedure in Standard Test Methods for Rubber Property Compression Set, ASTM D395, Method B.

75.2 A gasket of material other than those mentioned in 75.1, such as bonded cork or impregnated fiber, that is not known to be reliable, shall be investigated for equivalent resistance to aging and temperature. Absorptive materials, such as cork or fiber shall not be used where they may contact a live part.

75.3 A boot shall comply with requirements for nonelastomeric material, and a diaphragm that is compressed at the circumference shall comply with requirements for elastomeric material.

75.4 The temperatures specified in Table 75.2 correspond to the maximum temperature rise measured on the material during the temperature test described in Section 55, Temperature Test.

75.5 To determine reliability of a part such as a gasket, a diaphragm, or a seal, the part is to be subjected to accelerated-aging conditions specified in Table 75.2. The gasket, diaphragm, or seal is then to be installed in the tool and operated for one hour. The reservoir is to remain filled to the maximum level specified during the test. The entire tool assembly may be subjected to the accelerated-aging conditioning. When an entire tool assembly is subjected to the accelerated-aging test, the gasket, diaphragm, or seal temperature shall be monitored and maintained at the values indicated in Table 75.2.

75.6 Following the test of 75.5, the tool shall comply with the requirements of 71.1.

Table 75.2
Accelerated-Aging Conditions

Measured temperature rise		Material	Test program
°C	°F		
35	63	Rubber or Neoprene	70 hours in an air circulating oven at 100 ±2°C (212 ±3.6°F)
35	63	Thermoplastic	7 days in an air circulating oven at 87°C (189°F)
50	90	Rubber or Neoprene	7 days in an air circulating oven at 100 ±2°C (212 ±3.6°F)
50	90	Thermoplastic	10 days in an air circulating oven at 100°C (212°F)
55	99	Rubber, Neoprene, or Thermoplastic	7 days in an air circulating oven at 113°C (235°F)
65	117	Rubber or Neoprene	10 days in an air circulating oven at 121°C (250°F)
65	117	Thermoplastic	7 days at 121°C (250°F) or 60 days at 90°C (207°F) in an air circulating oven
80	144	Rubber, Neoprene, or Thermoplastic	7 days in an air circulating oven at 136°C (277°F)

MANUFACTURING AND PRODUCTION TESTS

76 Dielectric Voltage Withstand Test

76.1 Each tool shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 Hz between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized.

76.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 76.1.

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

Table 76.1
Production-line test conditions

Tool rating and form[a]	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
250 V or less with an induction motor rated 1/2 hp (373 W) or less	1000	60	1200	1
600 V or less with a universal motor	1000	60	1200	1
All other tools	1000 + 2V[b]	60	1200 + 2.4V[b]	1

[a] See 56.3.

[b] V is the maximum marked voltage but not less than 120 V for a tool with a rating between 105 – 120 V inclusive, and not less than 240 V for a tool with a rating between 210 – 240 V inclusive.

76.4 The test shall be conducted when the tool is complete – fully assembled. It is not intended that the tool be unwired, modified, or disassembled for the test.

Exception No. 1: A part, such as a snap cover or a friction-fit knob, that would interfere with performance of the test need not be in place.

Exception No. 2: The test may be conducted before final assembly if the test represents that for the completed tool.

76.5 A tool employing a solid-state component that is not relied upon to reduce a risk of electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected provided a random sampling of each day's production is tested at the potential specified in Table 76.1. The circuitry may be rearranged for the purpose of the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

76.6 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown, or an automatic reject feature of any unacceptable unit.

76.7 If the output of the test equipment transformer is less than 500 VA, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

76.8 If the output of the test equipment transformer is 500 VA or larger, the test potential may be indicated:

a) By a voltmeter in the primary circuit or in a tertiary-winding circuit;

b) By a selector switch marked to indicate the test potential; or

c) In the case of equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential. When marking is used without an indicating voltmeter, the equipment shall include a positive means such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

76.9 Test equipment other than that described by 76.6 – 76.8 may be used if found to accomplish the intended factory control.

76.10 During the test, the primary switch is to be in the on position, both sides of the primary circuit of the tool are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the dead metal.

Exception No. 1: A tool – resistive, high-impedance winding, and the like – having circuitry not subject to excessive secondary-voltage build-up in case of electrical breakdown during the test may be tested:

a) With a single-pole primary switch, if used, in the off position; or

b) With only one side of the primary circuit connected to the test equipment when the primary switch is in the on position, or when a primary switch is not used.

Exception No. 2: The primary switch is not required to be in the on position if the testing means applies full test potential between primary wiring and dead metal parts with the switch not in the on position.

77 Grounding Continuity Test

77.1 Each tool shall be tested, as a routine production-line test, to determine whether the tool complies with the requirements in 13.1.13(c) or 24.5, whichever is applicable.

77.2 Only a single test need be conducted if the dead metal parts selected are conductively connected by design to all other dead metal parts as mentioned in 13.1.13(c) or 24.5, whichever is applicable.

77.3 Any indicating device, such as an ohmmeter, a battery-and-buzzer combination, or the like, may be used to determine compliance with the requirement in 77.1.

RATING

78 Electrical Rating

78.1 A tool shall be rated in volts; frequency, expressed in hertz, Hz, cycles-per-second, cps, cycles/second, or c/s; and in amperes. If a tool is intended for use on a polyphase circuit, the number of phases shall be included in the rating.

Exception No. 1: A tool may be rated in watts, rather than amperes, if the full-load power factor is 0.80 or more.

Exception No. 2: A tool may be rated "ac-dc" or "ac Only" if provided with a universal motor.

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

MARKING

79 General

79.1 Markings are required:

a) On a tool as specified in Section 80, Details, and Section 81, Cautionary;

b) In the instruction manual provided with a tool as specified in Section 82, Instruction Manual, and Section 83, Instructions Pertaining to a Risk of Injury; and

c) On an accessory or an attachment as specified in Section 80, Details, and Section 87, Marking.

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

79.3 A marking as specified in this section shall be permanent, and shall be located on a permanent part of the tool or on a part that cannot be removed without impairing the operation of the tool.

79.4 A pressure-sensitive label or a label secured by cement or adhesive shall comply with the requirements in Marking and Labeling Systems, Section 6.13.

79.5 Unless its function is obvious, a handle, a lever, a knob, or another electrical or mechanical control shall be identified to indicate its function.

79.6 A tool with a motor shipped detached from the tool shall be marked to indicate the correct direction of rotation.

Exception: A shaper need not be marked.

79.7 An optional cutting tool that may be provided with a drill press shall be marked on the accessory or on the shipping container for the accessory:

a) For a mortising-chisel bit and a mortising chisel, with the recommended speed for the particular size of bit or chisel; and

b) For a plug cutter and a router bit, with the recommended maximum operating speed.

79.8 Equivalent wording may be used for the instructional information in 83.2 – 83.13.

79.9 In 81.6.1 and 81.11.1, wording in parentheses indicates an acceptable alternative.

80 Details

80.1 A tool shall be legibly marked where it will be readily visible after the tool has been installed as intended, but not on a removable part of the tool, such as on the blades of an attachment plug, with the following:

a) The manufacturer's name, trade name, or trademark;

Exception: The manufacturer's identification may be in a traceable code if the tool is identified by the brand or trademark owned by a private labeler.

b) The date or other dating period of manufacture not exceeding any three consecutive months;

Exception: The date of manufacture may be abbreviated or in an established or otherwise acceptable code. The code shall not require reference to the manufacturer's records to determine when the product was manufactured.

c) A distinctive catalog number or the equivalent; and

d) The electrical rating.

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

80.3 A permanently connected tool employing a single motor with other loads or more than one motor with or without other loads shall be marked with one of the following:

a) The minimum supply conductor ampacity and maximum current rating of the overcurrent-protective device.

Exception: If both the minimum supply conductor ampacity and the maximum rating of the overcurrent-protective device are 15 A or less the marking need not be provided.

b) The rating of the largest motor in volts and amperes, and the rating of any other loads in volts and either amperes or watts.

Exception: This marking need not include the ampere value of a motor rated 1/8 hp (93.2 W output) or less or a nonmotor load 1 A or less, unless either constitutes the principal load.

80.4 If a tool employs a single motor with or without one or more lamps as the only electric energy-consuming components, and the motor nameplate is readily visible after the motor has been installed, the electrical rating given on the motor nameplate need not be shown elsewhere on the tool.

80.5 A tool provided with an incandescent lamp shall be plainly marked to indicate the maximum wattage rating of the lamp to be used. If the tool is rated other than a nominal 120 V, the marking shall also include the voltage. The marking shall be legible and located so that it is readily visible during replacement of the lamp.

80.6 If a tool employs a dual-voltage motor and if the motor nameplate is employed to give the electrical rating of the tool as indicated in 80.4, the tool shall be additionally marked, not necessarily in a permanent manner, to indicate the voltage for which it is connected when shipped from the factory.

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

80.8 If a terminal box or compartment intended for power-supply connections reaches a temperature of more than 60°C (140°F) during the normal temperature test, the tool shall be marked with the following statement or the equivalent, at or near the point where the supply connections are to be made, and located so that it will be readily visible during and after installation: "For supply connections, use wires suitable for at least __°C (___°F)." The temperature value to be used in the preceding statement shall be in accordance with Table 80.1.

Table 80.1
Supply-connection wire temperature

Temperature reached during test in terminal box or compartment		Temperature marking	
°C	°F	°C	°F
61 – 75	142 – 167	75	167
76 – 90	168 – 194	90	194

80.9 A motor that is shipped detached from a tool and packaged separately shall be marked with the motor manufacturer's name and a distinctive designation.

80.10 A single-phase motor that is shipped detached from a tool shall be marked to indicate the direction of rotation as shipped from the factory. The marking shall not be permanent if there is a means for changing direction of rotation.

80.11 If a tool will not start and reach normal running speed when connected to a circuit protected by an ordinary – not a time-delay – fuse as described in 53.1, but will start and operate normally when connected to a circuit protected by a time-delay fuse, the instruction manual or the tool shall be marked with the words "Connect to a supply circuit protected by a circuit breaker or time-delay fuse," or with an equivalent wording.

80.12 A power control switch shall be marked with either "On", "Off" or "1", "0" to indicate the switch setting.

Exception No. 1: A momentary-contact switch need not have an on-off marking.

Exception No. 2: A switch that cannot result in a risk of injury to persons if unintentionally operated need not be marked.

80.13 A circular saw blade shall be marked with a maximum operating speed and with an arrow for proper direction of rotation.

80.14 *Deleted*

80.15 A directional arrow shall be provided on a disc sander to indicate proper rotation of the sanding disc.

80.16 A cord-connected tool as mentioned in the Exception to 13.1.1 shall be marked to indicate that an acceptable extension cord for use with the tool is available from the tool manufacturer. This marking need not be on the tool if this information or its equivalent is given in the instruction manual, or the like, provided with the tool.

81 Cautionary

81.1 All tools

81.1.1 A cautionary marking intended to instruct the operator shall be legible, contrast with the background, and be visible from the position assumed by the operator when starting the tool or from the specific position of the specific operation involved. Other such markings for servicing or making settings and adjustments shall be legible, contrast with the background, and be visible to the operator when such work is being accomplished.

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

81.1.3 With reference to the requirements in 81.1.2, the word "DANGER" in letters not less than 3/32 in (2.4 mm) high, may be substituted for the word "WARNING."

Exception: In lieu of prefixing a marking by the word "WARNING" or the word "DANGER," individual items of such a marking may be prefixed by either of these words provided:

a) All items are prefixed by one of these words; and

b) All items prefixed by the word "DANGER" appear before all items prefixed by the word "WARNING."

81.1.4 With reference to the Exception to 81.1.3, two or more items of a marking as mentioned in 81.1.1 may be grouped under either prefix word.

81.1.5 If an adjustment must be made adjacent to an area involving a risk of injury to persons, the tool shall be marked to indicate that no adjustment should be made until the tool has been stopped.

Exception: The adjustment tongue or tool rest of a bench grinder need not be marked.

81.1.6 Under certain conditions in which guarding could not reduce the risk of injury to persons due to improper use of a tool – for example, feeding a workpiece the wrong direction through a radial-arm saw set up for ripping – the tool shall be marked to instruct the user concerning the risk of injury involved and how it can be reduced.

81.1.7 A tool not intended for use an area accessible to children and not provided with a lockout as indicated in Exception No. 1 to 33.7 shall be marked "WARNING," and with the following or the equivalent: "Risk of injury due to accidental starting. Do not use in an area where children may be present."

81.1.8 Permanently connected and cord connected tools employing more than one electrical supply connection shall be marked: "WARNING" and the following or the equivalent: "To reduce the risk of shock or injury, disconnect all electrical supplies to the tool prior to servicing." A diagram shall be employed on the tool to indicate wiring configuration.

Exception: A cord connected tool is not required to employ a diagram when the tool utilizes an accessible cord and plug as disconnect means, so long as the cord is clearly identified with a permanently attached flag label as to what it controls.

81.2 Combination tools

81.2.1 If an unused accessory of a combination tool is in motion while the tool is used to perform another of its intended functions, and if this motion could result in a risk of injury to persons, the tool shall be permanently marked "WARNING – Unused _____ May Cause Personal Injury – Remove this _____ when using other accessories." The marking shall be visible to the operator while performing the other functions for which the tool is intended. The blanks shall be completed with the name of the accessory.

81.3 Grinders

81.3.1 A grinder shall be marked with:

a) The size of the arbor;

b) The no-load speed in revolutions/min;

c) The proper direction of rotation if a 3-phase motor is employed; and

d) The following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Grinder

1) Wear eye protection.

2) Use grinding wheel suitable for speed of grinder.

81.4 Drill presses

81.4.1 A drill press shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Drill Press

a) Wear eye protection.

b) Do not wear gloves, necktie, or loose clothing.

c) Clamp workpiece or brace against column to prevent rotation.

d) Use recommended speed for drill accessory and workpiece material.

81.5 Jointers

81.5.1 A jointer shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Jointer

a) Wear eye protection.

b) Always keep cutter head and drive guards in place and in proper operating condition. Do not remove guard for rabbeting operations.

c) Never make jointing, planing, or rabbeting cut deeper than 1/8 in.

Exception: A jointer not provided with a rabbeting edge need not be marked to reference rabbeting.

d) Always use hold-down/push blocks for jointing material narrower than 3 inches, or planing material thinner than 3 inches.

e) Never perform jointing, planing, or rabbeting cuts (with jointers provided with a rabbeting guard) on pieces shorter than 8 inches (203 mm) in length.

Exception: A jointer not provided with a rabbeting edge need not be marked to reference rabbeting.

81.5.2 The fence provided with a jointer shall be marked to show the limits of exposure of the cutter head.

81.6 Radial-arm saws

81.6.1 A radial-arm saw shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Saw

a) Wear eye protection.

b) Keep hands out of path of saw blade.

c) Pay particular attention to instructions on reducing risk of kickback. (or "Know how to reduce risk of kickback.")

d) Use push-stick for narrow work. (or "Use Push-stick for ripping narrow work.")

e) Do not perform any operation freehand.

f) Never reach around saw blade. (or "Never reach in back of saw blade.")

g) Return carriage to the full rear position after each crosscut operation.

h) Turn off tool and wait for saw blade to stop before moving workpiece or changing settings.

i) Disconnect power (or unplug tool, as applicable) before changing blade or servicing.

81.6.2 A radial-arm saw equipped for ripping shall be marked "WARNING – For your own safety, do not feed material into cutting tool from this end." The marking shall not be smaller than 1-1/2 by 3/4 in (38.1 by 19.1 mm); and shall be located on:

a) The outfeed end of the blade guard; or

b) The saw head or guard so that it is visible from the outfeed end of the saw head for any ripping position.

81.6.3 The upper guard provided with a radial-arm saw shall be marked with an arrow indicating the correct direction of rotation of the arbor.

81.6.4 The unguarded end of the motor of a radial-arm saw, if there is provision for driving from that end, shall be marked with an arrow indicating the correct direction of rotation of the arbor.

81.7 Table saws

81.7.1 *Deleted*

81.8 Band saws

81.8.1 A band saw shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Saw

a) Wear eye protection.

b) Do not remove jammed cutoff pieces until blade has stopped.

c) Maintain proper adjustment of blade tension, blade guides, and thrust bearings.

d) Adjust upper guide to just clear workpiece.

e) Hold workpiece firmly against table.

81.9 Lathes

81.9.1 A lathe shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Lathe

a) Wear eye protection.

b) Do not wear gloves, necktie, or loose clothing.

c) Tighten all locks before operating.

d) Rotate workpiece by hand before applying power.

e) Rough out workpiece before installing on faceplate.

f) Do not mount split workpiece or one containing knot.

g) Use lowest speed when starting new workpiece.

Exception: The markings required by 81.9.1 (d) – (g), are not required to be included on a metal lathe.

81.10 Shapers

81.10.1 A shaper shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Shaper

a) Wear eye protection.

b) Be sure keyed washer is directly under spindle nut and spindle nut is tight.

Exception No. 1: This marking is not required to be provided on a shaper not employing a keyway and keyed washer in accordance with the Exceptions 1 and 2 to 45.4.

Exception No. 2: Units employing two spindle nut construction shall include the following: "Always use both spindle nuts and make sure spindle nuts are tight."

c) Feed work piece against rotation of cutter.

d) Do not use awkward hand positions.

e) Keep fingers away from revolving cutter – use fixtures when necessary.

f) Use overhead guard when adjustable fence is not in place.

81.11 Sanders

81.11.1 A belt sander, a disc sander, and a belt-and-disc sander shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Sander

a) Wear eye protection.

b) Support workpiece with miter gage, backstop, or worktable. (Or for a disc sander, "Support workpiece on worktable.")

c) Maintain 1/16 in maximum clearance between table and sanding belt or disc.

81.11.2 For disc sanders, the warning marking shall include the following in addition to the markings required by 81.11.1: "Avoid kickback by sanding in accordance with the directional arrows."

81.12 Miter saws

Section 81.12 deleted

81.12.1 *Deleted*

81.12.2 *Deleted*

81.12.3 *Deleted*

81.12.4 *Deleted*

81.12.5 *Deleted*

81.13 Other tools

81.13.1 All other tools shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Tool.

Wear Eye Protection.

81.14 Garage (Automotive) Tools

81.14.1 Garage (automotive) tools, such as brake lathes, shall be marked with the following:

WARNING

Risk of Fire or Explosion.

This equipment incorporates parts such as snap switches, receptacles, and the like, which tend to produce arcs or sparks, and, therefore, when located in a garage should be in a room or enclosure provided for the purpose or should be 18 in (457 mm) above the floor.

81.15 Tile saws

81.15.1 A tile saw shall be marked with the following:

WARNING

For Your Own Safety Read Instruction Manual Before Operating Saw

a) Wear eye protection.

b) Use splash hood for every operation for which it can be used.

c) Disconnect saw before servicing, when changing cutting wheels, and cleaning.

d) Use tool only with smooth edge cutting wheels free of openings and grooves.

e) Replace damaged cutting wheel before operating.

f) Do not fill water bath above water fill line.

Exception: This marking is not required for a tool complying with the Exception to 49.12.

81.16 Vertical panel saws

81.16.1 A panel saw shall be marked with the following or the equivalent:

"WARNING"

"For Your Own Safety Read Instruction Manual Before Operating Panel Saw"

a) "Always wear eye protection while operating saw."

b) "Do not operate without the guard(s) in place."

c) "Do not cut material smaller than carriage assembly."

d) "Do not use push sticks."

e) "Keep hands away from saw blade. Never place hands under carriage."

f) "Disconnect power from saw before removing saw guard or making any adjustments."

g) "Material being cut may kickback. Keep hands, body and bystanders out of path of material."

h) "No load speed."

i) For saws provided with a riving knife:

"Do not operate without the riving knife in place."

81.16.2 The saw shall be marked with the recommended blade size and the direction of blade rotation.

81.16.3 The carriage shall be marked in such a way to clearly designate the feed direction when making horizontal cuts.

81.16.4 Dust exhaust ports shall be clearly marked, "WARNING: Do Not Operate Without Dust Cover or Hose in Place."

81.16.5 The motor carriage assembly shall be clearly marked, "DANGER: Rotating saw blade. Do not place hands under saw carriage or near blade. Do not operate the saw without the blade guard(s) in place."

81.16.6 The following marking shall be provided on panel saws having a construction where tools are not necessary for guard removal as specified in paragraph 50.20, "WARNING – To Reduce The Risk of Injury, Do Not Operate Without Guard(s) In Place", or equivalent. The marking shall be placed in the vicinity and in a location other than on the guard. The marking shall be visible when the guard is installed.

INSTRUCTIONS

82 Instruction Manual

82.1 An instruction manual shall be provided with a tool.

82.2 The instruction manual shall specifically warn the user against reasonably foreseeable risks of injury and state the precautions that should be taken to reduce such risks.

82.3 The instructions shall be legible and visible, and shall contrast with the background.

82.4 Wording in parentheses is intended to be explanatory, indicating options, alternatives, and the like.

82.5 Specific identification and warning information applicable to accessories and attachments shall be included in the instruction manual in accordance with 82.6 and 82.7.

82.6 The instruction manual provided with a tool shall:

a) Specify only those accessories and attachments that have been found to be acceptable for use with the tool – see 82.7 and 82.8;

b) Warn the operator that the use of accessories or attachments not recommended by the manufacturer may result in a risk of injury to persons; and

c) Instruct the operator in the proper use of the accessory or attachment to reduce the risk of injury to persons.

Exception: A tool provided with accessories not required for the normal functioning of the tool need not be provided with instruction manuals that include separate proper use instructions for accessories and/or attachments if each accessory or attachment is packaged with a separate instruction manual in accordance with 88.1.1.

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

82.8 For an accessory or attachment such as described in the Exception to 87.1, the information required by 82.6(a) may be given in a form such as "For use with drill bits ____ inches or less in diameter" or "For use with saw blades ____ inches or less in diameter." For any other accessory or attachment, the instruction manual shall give the catalog number or any other identification as mentioned in 87.1.

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

83 Instructions Pertaining to a Risk of Injury

83.1 General

83.1.1 The instruction manual shall include the following warning instructions or the equivalent, as applicable:

A. GROUNDING INSTRUCTIONS

1. All grounded, cord-connected tools:

In the event of a malfunction or breakdown, grounding provides a path of least resistance for electric current to reduce the risk of electric shock. This tool is equipped with an electric cord having an equipment-grounding conductor and a grounding plug. The plug must be

plugged into a matching outlet that is properly installed and grounded in accordance with all local codes and ordinances.

Do not modify the plug provided – if it will not fit the outlet, have the proper outlet installed by a qualified electrician.

Improper connection of the equipment-grounding conductor can result in a risk of electric shock. The conductor with insulation having an outer surface that is green with or without yellow stripes is the equipment-grounding conductor. If repair or replacement of the electric cord or plug is necessary, do not connect the equipment-grounding conductor to a live terminal.

Check with a qualified electrician or service personnel if the grounding instructions are not completely understood, or if in doubt as to whether the tool is properly grounded.

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

Repair or replace damaged or worn cord immediately.

2. Grounded, cord-connected tools intended for use on a supply circuit having a nominal rating less than 150 V:

This tool is intended for use on a circuit that has an outlet that looks like the one illustrated in Sketch A in Figure 83.1. The tool has a grounding plug that looks like the plug illustrated in Sketch A in Figure 83.1. A temporary adapter, which looks like the adapter illustrated in Sketches B and C, may be used to connect this plug to a 2-pole receptacle as shown in Sketch B if a properly grounded outlet is not available. The temporary adapter should be used only until a properly grounded outlet can be installed by a qualified electrician. The green-colored rigid ear, lug, and the like, extending from the adapter must be connected to a permanent ground such as a properly grounded outlet box.

3. Grounded, cord-connected tools intended for use on a supply circuit having a nominal rating between 150 – 250 V, inclusive:

This tool is intended for use on a circuit that has an outlet that looks like the one illustrated in Sketch D in Figure 83.1. The tool has a grounding plug that looks like the plug illustrated in Sketch D in Figure 83.1. Make sure the tool is connected to an outlet having the same configuration as the plug. No adapter is available or should be used with this tool. If the tool must be reconnected for use on a different type of electric circuit, the reconnection should be made by qualified service personnel; and after reconnection, the tool should comply with all local codes and ordinances.

4. Permanently connected tools:

This tool should be connected to a grounded metal permanent wiring system; or to a system having an equipment-grounding conductor.

B. FOR ALL DOUBLE-INSULATED TOOLS

1. Replacement Parts

When servicing use only identical replacement parts.

2. Polarized Plugs

To reduce the risk of electric shock, this equipment has a polarized plug (one blade is wider than the other). This plug will fit in a polarized outlet only one way. If the plug

does not fit fully in the outlet, reverse the plug. If it still does not fit, contact a qualified electrician to install the proper outlet. Do not change the plug in any way.

C. FOR ALL TOOLS AS APPLICABLE

1. KEEP GUARDS IN PLACE and in working order.

2. REMOVE ADJUSTING KEYS AND WRENCHES. Form habit of checking to see that keys and adjusting wrenches are removed from tool before turning it on.

3. KEEP WORK AREA CLEAN. Cluttered areas and benches invite accidents.

4. DON'T USE IN DANGEROUS ENVIRONMENT. Don't use power tools in damp or wet locations, or expose them to rain. Keep work area well lighted.

5. KEEP CHILDREN AWAY. All visitors should be kept safe distance from work area.

6. MAKE WORKSHOP KID PROOF with padlocks, master switches, or by removing starter keys.

7. DON'T FORCE TOOL. It will do the job better and safer at the rate for which it was designed.

8. USE RIGHT TOOL. Don't force tool or attachment to do a job for which it was not designed.

9. USE PROPER EXTENSION CORD. Make sure your extension cord is in good condition. When using an extension cord, be sure to use one heavy enough to carry the current your product will draw. An undersized cord will cause a drop in line voltage resulting in loss of power and overheating. Table ____ (see Table 83.1) shows the correct size to use depending on cord length and nameplate ampere rating. If in doubt, use the next heavier gage. The smaller the gage number, the heavier the cord.

Exception No. 1: The reference to the table and the table itself may be omitted if a statement indicating the appropriate gage and length is incorporated into the instruction.

Exception No. 2: The information regarding extension cords need not be provided for a permanently connected tool.

10. WEAR PROPER APPAREL. Do not wear loose clothing, gloves, neckties, rings, bracelets, or other jewelry which may get caught in moving parts. Nonslip footwear is recommended. Wear protective hair covering to contain long hair.

Exception: The reference to gloves may be omitted from the instructions for a grinder.

11. ALWAYS USE SAFETY GLASSES. Also use face or dust mask if cutting operation is dusty. Everyday eyeglasses only have impact resistant lenses, they are NOT safety glasses.

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

13. DON'T OVERREACH. Keep proper footing and balance at all times.

14. MAINTAIN TOOLS WITH CARE. Keep tools sharp and clean for best and safest performance. Follow instructions for lubricating and changing accessories.

15. DISCONNECT TOOLS before servicing; when changing accessories, such as blades, bits, cutters, and the like.

16. REDUCE THE RISK OF UNINTENTIONAL STARTING. Make sure switch is in off position before plugging in.

17. USE RECOMMENDED ACCESSORIES. Consult the owner's manual for recommended accessories. The use of improper accessories may cause risk of injury to persons.

18. NEVER STAND ON TOOL. Serious injury could occur if the tool is tipped or if the cutting tool is unintentionally contacted.

19. CHECK DAMAGED PARTS. Before further use of the tool, a guard or other part that is damaged should be carefully checked to determine that it will operate properly and perform its intended function – check for alignment of moving parts, binding of moving parts, breakage of parts, mounting, and any other conditions that may affect its operation. A guard or other part that is damaged should be properly repaired or replaced.

20. DIRECTION OF FEED. Feed work into a blade or cutter against the direction of rotation of the blade or cutter only.

21. NEVER LEAVE TOOL RUNNING UNATTENDED. TURN POWER OFF. Don't leave tool until it comes to a complete stop.

Exception: The instructions for a bench grinder need not contain the statement pertaining to leaving the tool until it comes to a complete stop.

Figure 83.1

Grounding methods

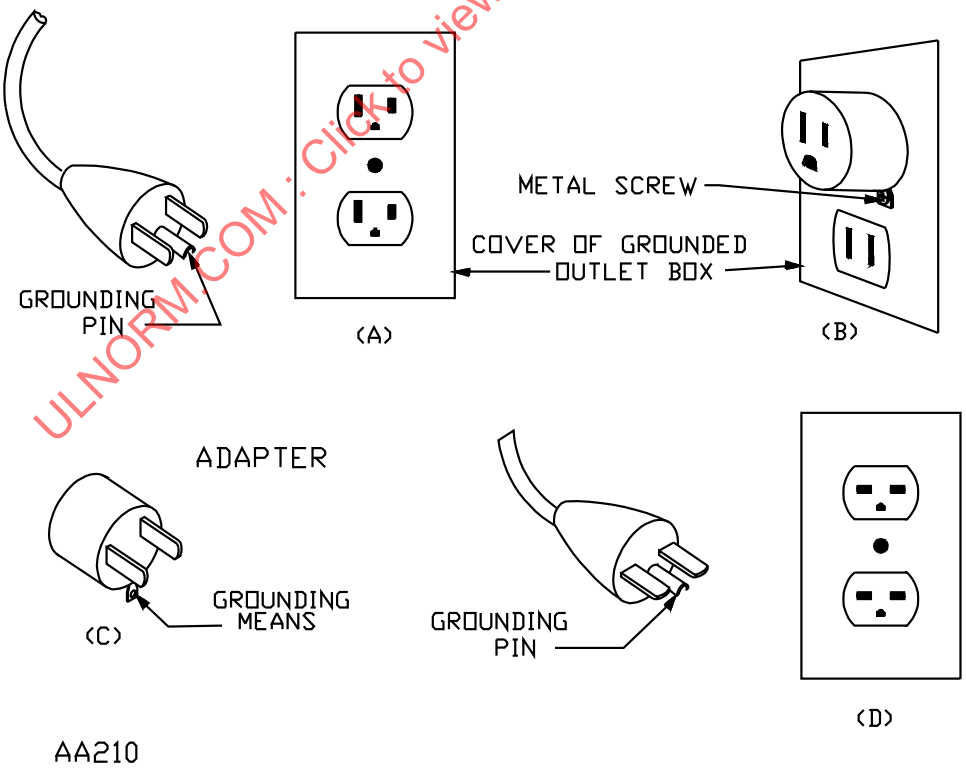


Table 83.1
Minimum gage for cord[a]

Ampere Rating		Volts	Total length of cord in feet			
		120 V	25 ft	50 ft	100 ft	150 ft
		240 V	50 ft	100 ft	200 ft	300 ft
More Than	Not More Than	AWG				
0	6		18	16	16	14
6	10		18	16	14	12
10	12		16	16	14	12
12	16		14	12	Not Recommended	

[a] Only the applicable parts of the Table need to be included. For instance, a 120-V product need not include the 240-V heading.

83.1.2 If a tool is provided with means for controlling the speed, the instruction manual shall indicate the speed at which the tool should be operated, in accordance with pertinent factors such as:

a) The dimensions and material of the workpiece; and

b) The size and type of the accessory – drill bit, saw blade, and the like.

83.1.3 If a tool is shipped disassembled, clear assembly and adjustment instructions shall be provided with the tool. The instructions may be included in the instruction manual or provided separately.

83.1.4 The instruction manual for a tool employing a motor shipped detached from the tool shall include a detailed description of the motor installation and connections giving the applicable motor identification.

83.1.5 The instruction manual for a tool shall indicate that the tool is to be disconnected from the power supply while the motor is being mounted, connected, or reconnected.

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

Exception No. 1: A tool that is marked to indicate that it is intended for operation at a single voltage and with the value of that voltage need not include this instruction.

Exception No. 2: A tool in which the attachment plug and any receptacles provided are rated for the voltage for which the motor may be reconnected need not include this instruction.

83.1.7 The installation or operating instructions provided with the tool shall direct the user to secure the tool to the supporting structure if, during normal operation, there is any tendency for the tool to tip over, slide, or walk on the supporting surface.

Exception: A tool powered by a vibrator or a motor developing less than 1/10 hp (74.6 W output) and containing explicit instructions in the instruction manual as to how to prevent the tool from tipping, sliding, or walking on the supporting surface, if there is any tendency to do so need not comply.

83.1.8 A tool required to be provided with a means for locking the motor-control switch in the off position shall include instructions in the manual explaining the purpose and function.

83.2 Grinders

83.2.1 The instruction manual for a grinder shall include the marking information required by 81.3.1 and the following or the equivalent:

a) Replace cracked wheel immediately.

b) Always use guards and eye shields.

c) Do not overtighten wheel nut.

d) Use only flanges furnished with the grinder.

e) Adjust distance between wheel and work rest to maintain ___ inch or less separation as the diameter of the wheel decreases with use. The value of separation used in the marking is to be the separation recommended by the manufacturer, but shall not be more than 1/8 in (3.18 mm).

f) Frequently clean grinding dust from beneath grinder.

Exception No. 1: The word "WARNING" mentioned in 81.3.1 need not be included.

Exception No. 2: Grinders that are not ventilated in accordance with the Exception to 9.2 need not include the warning specified in 83.2.1(f) in the instruction manual.

83.3 Drill Presses

83.3.1 The instruction manual for a drill press shall include the marking information required by 81.4.1. For a drill press that complies with the requirement in 37.6 by employing an ejection mechanism that is an integral part of the key, the instruction manual shall include instructions to use only the key that is provided with the drill press by the manufacturer or a duplicate of it, and an explanation of the reasons for using only that key.

Exception: The word "WARNING" mentioned in 81.4.1 need not be included.

83.4 Jointers

83.4.1 The instruction manual for a jointer shall include the marking information required by 81.5.1 and the following or the equivalent:

a) Do not perform jointing operations on material shorter than (a dimension equal to the cutter head length plus 2 in), narrower than 3/4 in, or less than 1/4 in thick.

b) Do not perform planing operations on material shorter than (a dimension equal to the cutter head length plus 2 in), narrower than 3/4 in, or wider than (the cutter capacity in inches) or thinner than 1/2 in.

c) Maintain the proper relationships of infeed and outfeed table surfaces and cutter head knife path.

d) Support the work piece adequately at all times during operation; maintain control of the work at all times.

e) Do not back the work toward the infeed table.

f) Do not attempt to perform an abnormal or little-used operation without study and the use of adequate hold-down/push blocks, jigs, fixtures, stops, and the like.

Exception: The word "WARNING" mentioned in 81.5.1 need not be included.

83.4.2 The information required by 83.4.1 shall include, as an explanatory item, the definition of jointing and planing cuts.

83.5 All saws

83.5.1 The instruction manual for a saw with manual braking shall include the word "DANGER" and the following or the equivalent: "Coasting Cutting Tool Can Be Dangerous – Apply brake immediately to stop cutting tool when the switch is turned off."

83.5.2 The instruction manual for a saw with manual braking shall include a warning that the torque developed during braking may loosen the blade-retaining nut, and that the nut should be checked periodically and tightened if necessary, especially after braking.

83.6 Radial arm saws

83.6.1 The instruction manual for a radial-arm saw shall include the marking information required by 81.6.1 and 81.6.2 and the following:

a) Explicit instructions indicating how to prevent forward motion of the blade beyond the position necessary to complete the cut when performing repetitive cutting operations.

b) Definition of the terms push-stick, kickback, and freehand as they relate to a sawing operation.

Exception: The word "freehand" is not required to be defined when it is not used in the marking required by 81.6.1.

c) Explanation of the proper use of and construction of push-sticks.

d) Details on how to reduce the risk of kickback.

e) Instructions to bolt the saw to the supporting surface (table, bench, or floor, as appropriate) or use a sturdy outrigger support if a table extension more than 24 in long is attached to the saw.

f) Instructions on how to position a radial-arm saw so that the cutting head will not roll outward toward the operator.

g) Complete instructions describing how to use a spreader.

Exception: The word "WARNING" mentioned in 81.6.1 and 81.6.2 is not required to be included.

83.6.2 The instruction manual provided with a radial-arm saw shall include:

a) A statement indicating that a lower blade guard is available;

b) A statement or statements identifying the potential risks of injury to persons that may be introduced by the use of the guard, and the actions to be taken to reduce each risk;

c) Complete instructions describing when and how to use the guard; and

d) For saws capable of ripping, a statement that a spreader is available.

83.6.3 The lower blade guard of a radial-arm saw that is shipped as an accessory shall be provided with complete instruction describing when and how to use the guard.

83.7 Band saws

83.7.1 The instruction manual for a band saw shall include:

a) The marking information required by 81.8.1; and

b) An explanation of:

1) The need for properly adjusting the upper blade guide, blade tension, and thrust bearing; and

2) How the adjustments should be made.

83.8 Tile saws

83.8.1 *Deleted*

83.8.2 The instruction manual for a table tile saw shall include instructions for use of an extension cord, including the following text, or the equivalent:

A. POSITION OF TILE SAW

1. To avoid the possibility of the appliance plug or receptacle getting wet, position tile saw to one side of a wall mounted receptacle to prevent water from dripping onto the receptacle or plug. The user should arrange a "drip loop" in the cord connecting the saw to a receptacle. The "drip loop" is that part of the cord below the level of the receptacle, or the connector if an extension cord is used, to prevent water traveling along the cord and coming in contact with the receptacle.

2. If the plug or receptacle does get wet, DON'T unplug the cord. Disconnect the fuse or circuit breaker that supplies power to the tool. Then unplug and examine for presence of water in the receptacle.

B. EXTENSION CORDS

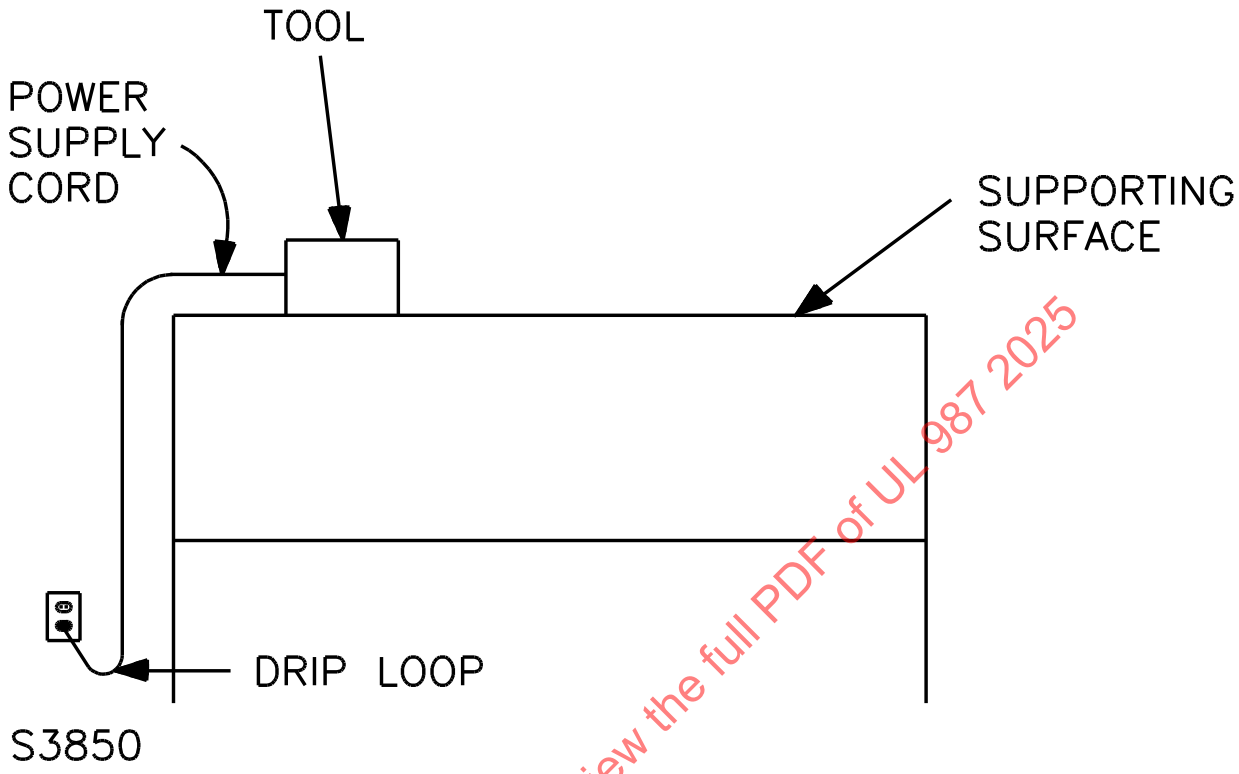
1. Use only extension cords that are intended for outdoor use. These extension cords are identified by a marking "Acceptable for use with outdoor appliances; store indoors while not in use." Use only extension cords having an electrical rating not less than the rating of the product. Do not use damaged extension cords. Examine extension cord before using and replace if damaged. Do not abuse extension cords and do not yank on any cord to disconnect. Keep cord away from heat and sharp edges. Always disconnect the extension cord from the receptacle before disconnecting the product from the extension cord.

2. WARNING – To reduce the risk of electrocution, keep all connections dry and off the ground. Do not touch plug with wet hands.

3. Ground Fault Circuit Interrupter (GFCI) protection should be provided on the circuit(s) or outlet(s) to be used for the tile saw. Receptacles are available having built-in GFCI protection and may be used for this measure of safety.

Figure 83.2

Drip Loop



83.9 Miter saws

Section 83.9 deleted

83.9.1 *Deleted*

83.9.2 *Deleted*

83.9.3 *Deleted*

83.10 Panel saws

83.10.1 The instruction manual for a panel saw shall include the marking information required by 81.16.1, 81.16.4, and 81.16.5 and an explanation of the following:

a) The use of proper eye protection;

b) The proper installation of the panel saw;

c) The proper assembly and routing of any power supply cords, interconnecting cables and exhaust hoses;

d) The proper use of riving knifes and their adjustments (i.e. maximum blade thickness as it relates to correct riving knife application);

e) The proper installation of the carriage assembly and counter balance;

f) The proper installation of blade guards;

g) The proper procedure for making a vertical (cross) cut, including specifications on the minimum number of roller supports and the minimum width of the work piece;

h) The proper procedure for making a horizontal (rip) cut, including specifications on the minimum number of roller supports and the minimum width of the work piece;

i) Details on ways to reduce kickback;

j) Details on making all necessary adjustments for rollers, guides, etc.;

k) Details on making connections to dust collection systems, if applicable;

l) Service and maintenance procedures; and

m) The proper installation of recommended accessories, if applicable.

Exception: The instructions specified in 83.10.1(d) is required only for a panel saw provided with a riving knife.

83.11 Lathes

83.11.1 The instruction manual for a lathe shall include the marking information required by 81.9.1.

Exception: The word "WARNING" mentioned in 81.9.1 need not be included.

83.12 Shapers

83.12.1 The instruction manual for a shaper shall include the marking information required by 81.10.1 and explanation of the use and construction of fixtures, including why and when they are needed.

Exception: The word "WARNING" mentioned in 81.10.1 need not be included.

83.13 Sanders – belt, disc, and belt-and-disc

83.13.1 The instruction manual for a sander shall include the following:

a) The marking information required by 81.11.1;

b) A definition of the terms "backstop" and "worktable"; and

c) For belt and disc sanders, an explanation that the sanding belt is designed to rotate down towards the table while the disc rotates both up from the table and down towards the table, and instructions on proper sanding techniques with an explanation of potential risk of injury to persons associated with sanding against the directional arrows on the disc.

Exception: The word "WARNING" mentioned in 81.11.1 is not required to be included.

83.14 Other Tools

83.14.1 The instruction manual for other tools shall include the marking information required by 81.13.1.

Exception: The word "WARNING" mentioned in 81.13.1 need not be included.

ACCESSORIES AND ATTACHMENTS

84 Scope

84.1 The requirements in Sections 84 – 88 cover accessories and attachments for use with stationary and fixed electric tools that are either:

a) Identified by catalog number or equivalent product designation in the instruction manual for the tool; or

b) Packaged with the tool.

See 1.2 and 1.5.

84.2 The requirements in Sections 84 – 88 supplement and, in some cases, modify the requirements in Sections 1 – 83.

84.3 An accessory or attachment not explicitly covered in this standard is to be investigated on the basis of compliance with the requirements of this standard, insofar as they are applicable, and further examination and tests to determine acceptability for its intended use.

84.4 These requirements cover carbide-tipped saw blades intended for use with radial arm saws, and carbide-tipped jointer cutters. Carbide-tipped drill bits, and solid (not carbide tipped) blades, cutters, and bits are not covered.

84.5 These requirements cover wire brushes of all types.

84.6 A guard or rotating backing pad may either be investigated for use with a specific tool or as an accessory or attachment, as applicable.

85 Construction

85.1 General

85.1.1 If a tool is converted by an attachment to perform the intended function (or functions) of another tool, the combination shall comply with the applicable requirements for the other tool.

85.1.2 After an accessory or attachment is installed on the intended tool, a handle, lever, knob, or other control shall be located so that, when reaching for the control, it is not necessary to traverse an area where a risk of injury to persons may exist. An area adjacent to the control where a risk of injury to persons exist, shall be so guarded or located that it cannot be entered unintentionally.

85.1.3 The shank of an accessory or attachment intended to be gripped in a chuck or the like shall be such that it can be clamped firmly in:

a) The holding device of the tool for which it is recommended; or

b) A representative holding device if the accessory or attachment is intended for use with a variety of tools.

85.1.4 An accessory or attachment that is intended to be fixed with relationship to the tool shall have provision for being securely mounted in such a manner that does not result in a risk of injury to persons.

85.1.5 Guarding required for an accessory or an attachment shall be provided as a part of the accessory or attachment unless a guard for the basic tool provides guarding for the accessory or attachment.

85.2 Materials

85.2.1 The material of a part, the malfunction of which may result in a risk of injury to persons, shall have properties acceptable for the conditions encountered during intended use. See Section 86.

85.2.2 The physical properties and the thicknesses of materials used in a cutting tool shall be acceptable for the stresses that may be encountered during intended use. See Section 86.

86 Performance

86.1 Impact testing – general

86.1.1 Other than a grinding wheel or one of the specific cutting tools mentioned in 86.2.1, an accessory or an attachment that is intended for use with a stationary or a fixed tool shall withstand the ball-impact test described in 86.1.2 without:

a) Cracking that may affect the function of the part so as to result in a risk of injury to persons;

b) Exposing to unintentional contact a moving part likely to cause injury to persons; and

c) Affecting the mechanical performance of the accessory or attachment or tool so as to result in a risk of injury to persons.

Exception No. 1: A part that becomes disassembled or detached during the ball-impact test is acceptable if:

a) The damage is obvious and it can be reassembled readily to function properly; or

b) The disassembly or detachment of the part does not result in a risk of injury to persons.

Exception No. 2: Breakage of a part that makes an accessory or an attachment inoperable is acceptable if there is no risk of injury to persons and the product is not usable.

Exception No. 3: Deformation of a guard or other part during the ball-impact test is acceptable if:

a) The part can be readily restored to its functional shape; or

b) The deformation does not result in a risk of injury to persons.

86.1.2 To determine compliance with 86.1.1, each of three samples of the accessory or attachment is to be subjected to an impact of 5 ft-lbs (6.8 J) on any surface that is exposed to a blow during normal use. This impact is to be produced by dropping a steel sphere, 2 in (50.8 mm) in diameter and weighing approximately 1.18 lbs (0.535 kg), from a height of 51 in (1.29 m). For surfaces other than the top, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum, dropping through a vertical distance of 51 in to strike the surface. During the test, the sample is to be installed on the recommended tool in the intended manner, or the intended manner of installation is to be simulated.

86.1.3 If an attachment is made of a polymeric material, the ball-impact test described in 86.1.2 is to be conducted on a sample in the as-received condition. The test is then to be repeated on a different sample or samples that have been cooled to room temperature after being conditioned for 7hoursin an air oven maintained at 70°C (158°F). During conditioning, a part is to be supported in the same manner that it is supported on the tool.

86.1.4 Upon removal from the oven and before being subjected to the ball-impact test described in 86.1.2, no sample shall show cracking, distortion, or other deleterious effects from the oven conditioning so as to result in a risk of injury to persons during operation of the tool.

86.2 Sharp edges and projections

86.2.1 An edge, projection, or corner of an accessory or attachment shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

Exception: This requirement does not apply to a part or a portion of a part needed to perform a working function.

86.3 Rotating members test

86.3.1 A rotating member, the malfunction of which may result in a risk of injury to persons, shall be constructed of such material and in such manner as to reduce the risk of:

a) Bending, breakage, or other malfunction of parts; or

b) The release or loosening of parts.

Exception No. 1: A wire brush may discharge wires but not burst.

Exception No. 2: The test may be waived if evaluation of the manufacturer's design calculations or examination of the product indicates that the part or parts are adequately strong.

86.3.2 To determine if a part complies with the requirements in 86.3.1, the part is to be rotated as indicated in Table 86.1 and shall not show breakage, separation of carbide tips from blade, or other effect that may result in risk of injury to persons.

Table 86.1
Rotating members test

Rotating member	Time or no. of revolutions	Speed of rotation, percent of maximum rotating member speed
Carbide-tipped circular saw blades	1,000,000 Rev.	150
Flexible backing pads	1 hour	120
Wire brushes with shank, all sizes	1 hour	120
Wire brushes without shank 2 to 6 in (50 to 150 mm)	1 hour	120
6 to 9 in (150 to 230 mm)		130
9 in (120 mm) and larger		150
All other rotating members	1 hour	150

86.4 Stability test

86.4.1 A base, a cabinet, a leg, a stand, a table, and similar attachments shall comply with the applicable stability test described in 86.4.2 – 86.4.7. The attachment is to be investigated in combination with the tool, installed in accordance with the manufacturer's instructions.

Exception: An attachment that is provided with instructions for the user to fasten the tool to the bench top or floor prior to installation need not be subjected to stability tests.

86.4.2 The stability of a bench-top attachment shall be such that it will not be overturned readily while in any position that may be encountered during intended use, including positions that may be encountered prior to and after operation.

86.4.3 To determine if an attachment complies with the requirement in 86.4.2, the combination of the attachment and a representative tool, mounted in accordance with the manufacturer's instructions, is to be placed, with the motor switched off, on a plane inclined at an angle of 7° to the horizontal. The power supply cord is to rest on the inclined plane in the most unfavorable position. If, however, the combination tool and attachment is such that, were it to be tilted to an angle of 7° when standing on a horizontal plane, a part of it not normally in contact with the supporting surface would touch the horizontal plane, the attachment is to be placed on a horizontal support and tilted in the direction most likely to decrease stability through an angle of 7°. The results are considered to be acceptable if the combination does not overturn.

86.4.4 The test is to be conducted under the most unfavorable conditions. The combination tool and attachment is to be placed on the inclined plane with all doors, drawers, and other movable or adjustable parts in the position tending to decrease the stability. The combination is to be tested in all possible positions that may typically be encountered while the attachment:

a) Is in a position of being assembled or prepared prior to operation – for example, positioning parts of the attachment prior to adding functional parts;

b) Is in position as if being used to perform one of its intended functions; and

c) Is in a position of being disassembled or cleaned after operation – for example, with applicable functional parts removed.

86.4.5 A floor supported attachment in combination with the recommended tool, mounted in accordance with the manufacturer's instructions, shall not tip over when it is placed at the center of an inclined plane that makes an angle of 7° with the horizontal and turned to the position most likely to cause tipover.

86.4.6 The test mentioned in 86.4.5 is to be conducted under conditions most likely to cause tipover. Consideration shall be given to all parts or options intended for use with the attachment. The attachment, in combination with the tool, is to be arranged in its intended position with all doors, drawers, casters, wheels, and other appurtenances in the position that results in the least stability. The assembly is to be tipped in the direction most likely to overturn the unit. Legs and other means of support may be blocked to preclude the assembly from sliding.

86.4.7 If an attachment is provided with wheels or casters for mobility, they are to be retractable or of a locking design, or other means are to be provided to reduce unexpected movement of the tool during operation.

87 Marking

87.1 An accessory or an attachment shall be marked with a catalog number or equivalent means of identification, or the package containing the accessory or attachment shall be so marked.

Exception: An accessory or attachment that is used with the tool in the performance of its intended function, such as a drill bit provided with a drill press or a circular saw blade provided with a table or radial arm saw need not be marked.

87.2 The literature accompanying a package containing a basic appliance and its attachments or accessories shall indicate which attachments or accessories are intended for use with the basic appliance if use of such attachments or accessories may expose the user to a risk of injury.

Exception: The attachments or accessories referenced in the Exception to 87.1 may be referenced generically.

87.3 An attachment or accessory that is packaged separately from the basic appliance, and recommended by the stationary or fixed tool manufacturer for use on the basic appliance, shall identify the basic appliance for which it is intended. The identification shall appear in at least one of the locations specified in the following:

a) On the attachment or accessory;

b) On the package housing the attachment or accessory;

c) In the instruction manual for the attachment or accessory; or

d) In information furnished with the attachment or accessory.

Exception: The attachments or accessories referenced in the Exception to 87.1 may be referenced generically such as "For Use With Drill Bits ___ Inches or Less in Diameter."

87.4 A carbide-tipped circular saw blade, a flexible backing pad, and a wire brush shall be permanently marked with the maximum speed, in revolutions/min, such as "___ RPM" or equivalent. The speed marking shall be located on each accessory as indicated in Table 87.1.

Table 87.1
Location of speed marking

Type of accessory	Location of marking
Saw blades	On blade
Flexible backing pads	On pad
Wire brushes	On brush

87.5 A grinding wheel 4 in (102 mm) or larger in diameter shall have the maximum operating speed in rpm clearly marked on the wheel. A grinding wheel less than 4 in (102 mm) in diameter shall be marked either on the wheel or package.

87.6 A marking intended to reduce the risk of injury to persons shall be prefixed by the word "CAUTION," "WARNING," or "DANGER" in letters no less than 3/32 in (2.4 mm) high. The marking shall:

a) Include an affirmative statement of the risk of injury and the precautionary measure or instructions as to how to reduce the risk of injury;

b) Be permanent, see 79.2; and

c) Be located on a permanent part of the accessory or attachment, or on a part that cannot be removed without impairing the operation of the accessory or attachment, if there is sufficient room. If there is not sufficient room, the markings shall be in the instructions furnished with the accessory or attachment.

87.7 A wire brush shall be permanently marked "Wear eye protection" or with an equivalent statement.

Exception: If there is not sufficient room, the marking shall be in the instructions furnished with the wire brush.

87.8 If the function of a handle, lever, knob, or other electrical or mechanical control is not obvious, it shall be identified either on the attachment or in instructions furnished with the attachment.

88 Instructions

88.1 General

88.1.1 An accessory or attachment shall be provided with instructions. The instructions shall specifically warn the user against reasonably foreseeable risks of injury and state the precautions that should be taken to reduce such risks. The instructions may be packaged with the accessory or attachment, or for small attachments and accessories, may be printed on the package. See 82.6.

88.2 All accessories and attachments

88.2.1 The instructions shall include as applicable:

a) A statement indicating the type or types of tools with which the attachment or accessory is intended to be used; and

b) The word "WARNING" and the following or equivalent "To reduce the risk of eye injury, always use eye protection."

88.3 Specific accessories

88.3.1 The following or equivalent wording shall appear either on the packaging of a wire brush or in the instructions provided with the wire brush: "Allow wire brushes to run at operating speed for at least one minute before using wheel. During this time no one is to stand in front of or in line with the brush."

88.3.2 The following instructions, as applicable, shall appear either on the packaging of the accessory or in the instruction manual provided with the accessory:

a) Dado Head – The instructions shall warn the user against cutting warped material with the convex side toward the table of a radial-arm.

b) Shaper Cutter – "Be sure to place a washer that cannot rotate with respect to the spindle between the shaper cutter and the spindle nut."

c) Molding Heads –

1) "Never mold or shape warped materials."

2) "Never edge-mold on a radial-arm saw (with saw arbor vertical) with a saw blade guard – always use a molding head guard."

3) "Always position the molding head guard on a radial-arm saw to just clear the workpiece on the in-feed side before starting the molding operation."

4) "When topside molding on a radial-arm saw with saw arbor horizontal:

i) Lock rip and bevel clamp securely.

ii) Position saw blade guard at in-feed end to just clear the workpiece.

iii) Use a push stick on a narrow workpiece.

iv) Maintain a firm push to reduce the risk of kickback (anti-kickback devices are normally ineffective when performing this type of operation)."

Exception: Equivalent wordings may be used for 88.3.2 (b) and 88.3.2(c).

DOUBLE-INSULATED TOOLS

89 Scope

89.1 These requirements cover double-insulated electric tools as indicated in 1.1(b). Coverage is restricted to tools that are intended for use in accordance with the National Electrical Code, ANSI/NFPA 70, on branch circuits involving potentials of not more than 150 V to ground.

89.2 A tool provided with double insulation shall comply with the applicable requirements in Sections 1 – 88 supplemented by – and, in some cases, amended by – the requirements in 91 – 93.

90 Construction

90.1 Glossary

90.1.1 ACCESSIBLE – Denotes accessible to contact by persons. In a determination of whether a part, live or dead metal, is accessible to such contact, the criteria specified in 90.3.1 and 90.3.2 are to be applied.

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

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

90.1.4 DOUBLE INSULATION – An insulation system comprised of basic insulation and supplementary insulation, with the two insulations physically separated and so arranged that they are not simultaneously subjected to the same deteriorating influences, such as temperature and contaminants, to the same degree. See Figure 90.1.

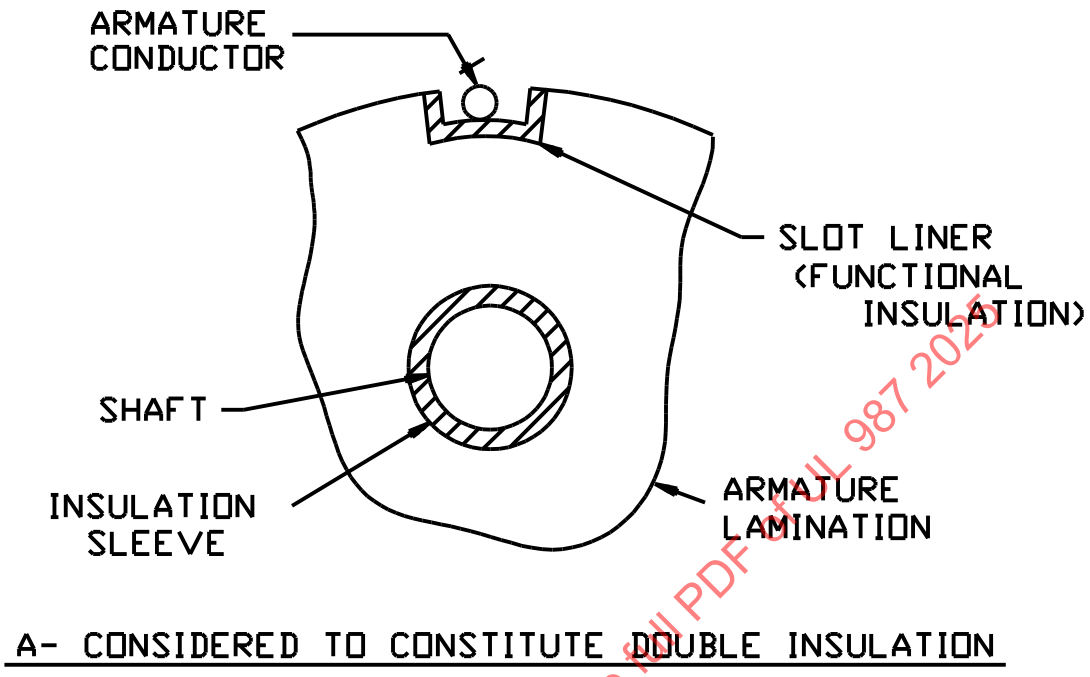
90.1.5 LIVE PART – Denotes a part consisting of electrically conductive material conductively connected to the power-supply circuit under conditions of intended use of the tool.

90.1.6 REINFORCED INSULATION – An improved basic insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as double insulation. It may consist of one or more layers of insulating material. Its acceptance in place of double insulation is described in 90.2.2.

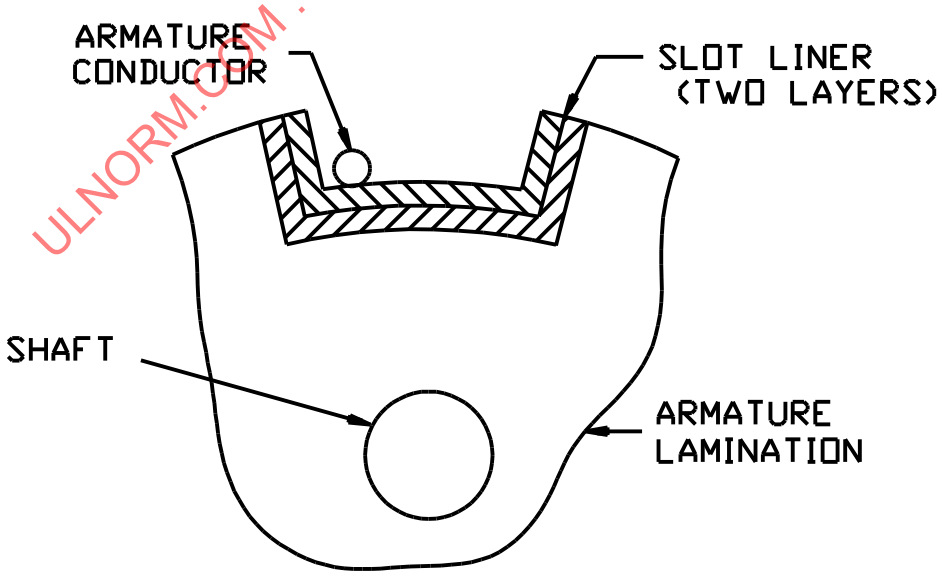
90.1.7 SUPPLEMENTARY INSULATION – An independent insulation provided in addition to the basic insulation to protect against electric shock in case of mechanical rupture or electrical breakdown of the basic insulation. An enclosure of insulating material may form a part or the whole of the supplementary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

Figure 90.1

Examples illustrating 90.1.4



A- CONSIDERED TO CONSTITUTE DOUBLE INSULATION



B-NOT CONSIDERED TO CONSTITUTE DOUBLE INSULATION

S0723