



UL 987

STANDARD FOR SAFETY

Stationary and Fixed Electric Tools

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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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1

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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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CONTENTS

INTRODUCTION

1	Scope	9
2	Units of Measurement	9
3	Undated References	10
4	Glossary	10

CONSTRUCTION

5	General	11
6	Components	11
6.1	General	11
6.2	Attachment plugs, receptacles, connectors, and terminals	13
6.3	Batteries	14
6.4	Boxes and raceways	14
6.5	Capacitors and filters	14
6.6	Controls	14
6.7	Cords, cables, and internal wiring	16
6.8	Cord reels	17
6.9	Film-coated wire (magnet wire)	17
6.10	Ground-fault, arc-fault, and leakage current detectors/interrupters	17
6.11	Insulation systems	18
6.12	Light sources and associated components	18
6.13	Marking and labeling systems	18
6.14	Motors and motor overload protection	19
6.15	Overcurrent protection	21
6.16	Polymeric materials and enclosures	21
6.17	Power supplies	22
6.18	Printed wiring boards	22
6.19	Semiconductors and small electrical and electronic components	22
6.20	Supplemental insulation, insulating bushings, and assembly aids	23
6.21	Switches	23
6.22	Transformers	24
7	Frame and Enclosure	24
7.1	General	24
7.2	Enclosures of metallic materials	24
7.3	Enclosures of polymeric materials	25
8	Accessibility of Live Parts	26
9	Exclusion of Foreign Matter	28
10	Mechanical Assembly	29
11	Protection Against Corrosion	29
12	Power Supply Connections— Permanently Connected Tools	30
12.1	General	30
12.2	Wiring compartments	30
12.3	Wiring terminals and leads	30
12.4	Grounded power-supply conductor	31
12.5	Equipment-grounding conductor	31
13	Power Supply Connections – Cord-Connected Tools	31
13.1	Cords and plugs	31
13.2	Strain relief	34
14	Live Parts	35
15	Internal Wiring	35
16	Interconnecting Cords	37



17	Insulating Material	38
18	Motors	38
19	Switches and Controls	38
20	Lampholders	39
21	Overcurrent-Protective Devices	39
22	Capacitors	39
23	Spacings	40
24	Grounding	42
25	Lasers	44

PROTECTION AGAINST INJURY TO PERSONS

ALL TOOLS

26	General	44
27	Attachments and Accessories	45
28	Temperatures	45
29	Rotating Members	45
30	Enclosures and Guards	45
31	Stability	48
32	Mechanical Assembly	49
33	Switches and Controls	49
34	Controls – End Product Test Parameters	50
	34.1 General	50
	34.2 Auxiliary controls	50
	34.3 Operating Controls (regulating controls)	50
	34.4 Protective controls (limiting controls)	52
	34.5 Controls using a temperature sensing device	53
35	Tables	54
36	Miter Grooves	54

SPECIFIC TOOLS

37	Drill Presses	54
38	Bench and Pedestal Type Grinders	55
39	Jointers	63
40	Band Saws	65
41	Radial-Arm Saws	65
42	Scroll Saws and Jigsaws	67
43	Table Saws	67
	43.1 Glossary	67
	43.2 General	68
	43.3 Table saw blade guard	68
	43.4 Riving knife	69
	43.5 Extended riving knife (fixed or adjustable)	70
	43.6 Antikickback device(s)	70
	43.7 Rip fence for table saws	71
	43.8 Table saw insert	71
	43.9 Table saw arbor	71
	43.10 Additional table saw requirements	71
44	Sanding Machines	72
45	Shapers	72
46	Lathes	73
47	Miter Saws	74
48	Abrasive Cutoff Machines	74

49	Table Tile Saws	77
50	Panel Saws.....	77

PERFORMANCE

51	General	83
52	Leakage Current Test	84
53	Starting Current Test	87
54	Current Input Test.....	87
55	Temperature Test	89
	55.1 General.....	89
	55.2 Temperature measurements	91
	55.3 Operation for temperature test	92
56	Dielectric Voltage Withstand Test.....	93
57	Leakage Current Test Following Humidity Conditioning	93
58	Impact test.....	93
59	Strain Relief Test	94
60	Push Back Relief Test.....	94
61	Sharp Edges Test.....	95
62	Switches and Controls Test	95
	62.1 General.....	95
	62.2 Reversing controls.....	96
	62.3 Speed change controls.....	96
63	Capacitor Test.....	96
64	Abnormal Operation Test	96
65	Bonding Overload Test	97
66	Resistance of Grounding Path Test.....	97
67	Conditioning of Polymeric Materials	97
68	Tests of Polymeric Enclosures Following Oven Conditioning.....	98
69	Polymeric Material as Described in 69.2	98
	69.1 General.....	98
	69.2 Flame resistance test.....	98
	69.3 Thermal stability test	99
	69.4 Strain relief test	99
	69.5 Impact test	99
	69.6 Abnormal operation test	99
70	Polymeric Material as Described in 70.2	100
	70.1 General.....	100
	70.2 Burning rate	100
	70.3 Hot-wire ignition test	101
	70.4 Hot-wire ignition (HWI) – abnormal overload test.....	101
	70.5 Spacings to enclosure.....	104
	70.6 Arc resistance test	104
	70.7 Arc-ignition test.....	104
	70.8 Abnormal operation test	105
	70.9 Impact test	105
	70.10 Thermal stability	105
71	Drip Test.....	105
72	Flooding Test	106
73	Overflow Test.....	106
74	Test For Deterioration Of Parts	106
75	Test For Reliability Of Parts	107

MANUFACTURING AND PRODUCTION TESTS

76	Dielectric Voltage Withstand Test.....	108
77	Grounding Continuity Test.....	110

RATING

78	Electrical Rating	110
----	-------------------------	-----

MARKING

79	General	110
80	Details	111
81	Cautionary	113
81.1	All tools	113
81.2	Combination tools	114
81.3	Grinders	114
81.4	Drill presses	114
81.5	Jointers	115
81.6	Radial-arm saws	115
81.7	Table saws	116
81.8	Band saws	116
81.9	Lathes	116
81.10	Shapers	117
81.11	Sanders	117
81.12	Miter saws	118
81.13	Other tools	118
81.14	Garage (Automotive) Tools	118
81.15	Tile saws	118
81.16	Vertical panel saws	119

INSTRUCTIONS

82	Instruction Manual	119
83	Instructions Pertaining to a Risk of Injury	120
83.1	General	120
83.2	Grinders	125
83.3	Drill Presses	125
83.4	Jointers	125
83.5	All saws	126
83.6	Radial arm saws	126
83.7	Band saws	127
83.8	Tile saws	127
83.9	Miter saws	128
83.10	Panel saws	128
83.11	Lathes	129
83.12	Shapers	129
83.13	Sanders – belt, disc, and belt-and-disc	129
83.14	Other Tools	129

ACCESSORIES AND ATTACHMENTS

84	Scope	130
85	Construction	130
85.1	General	130



	85.2 Materials	131
86	Performance	131
	86.1 Impact testing – general	131
	86.2 Sharp edges and projections	132
	86.3 Rotating members test	132
	86.4 Stability test.....	132
87	Marking	133
88	Instructions	135
	88.1 General.....	135
	88.2 All accessories and attachments.....	135
	88.3 Specific accessories	135

DOUBLE-INSULATED TOOLS

89	Scope.....	136
90	Construction	136
	90.1 Glossary	136
	90.2 General.....	138
	90.3 Accessibility of live parts.....	139
	90.4 Flexible Cord	140
	90.5 Attachment plug	141
	90.6 Internal wiring.....	141
	90.7 Capacitors	142
	90.8 Brush caps.....	142
	90.9 Commutators and armature end turns	143
	90.10 Switches	143
	90.11 Brush holders	144
	90.12 Spacings.....	145
91	Performance	145
	91.1 Dielectric voltage withstand test.....	145
	91.2 Leakage current test	145
	91.3 Insulation resistance test.....	147
	91.4 Resistance to impact test	147
	91.5 Overload test.....	148
	91.6 Armature investigation test	153
	91.7 Leakage current following humidity test	156
92	Tests by the Manufacturer	156
93	Markings.....	157

SUPPLEMENT SA – BATTERY-POWERED STATIONARY AND FIXED ELECTRIC TOOLS AND BATTERY PACKS

SA1	Scope	159
SA4	Glossary	159
SA5	Construction.....	159
SA7	Frame and Enclosure.....	160
SA8	Accessibility of Live Parts	160
SA9	Exclusion of Foreign Matter	160
SA11	Protection Against Corrosion.....	160
SA12	Power Supply Connections – Permanently Connected Tools.....	161
SA13	Power Supply Connections – Cord Connected Tools	161
SA14	Live Parts	161
SA15	Internal Wiring	161
SA16	Interconnecting Cords	162
SA17	Insulating Material.....	162
SA18	Motors	162

SA19	Switches and Controls.....	162
SA20	Lampholders	163
SA21	Overcurrent Protective Devices.....	163
SA22	Capacitors.....	163
SA23	Spacings	163
SA24	Grounding	164
SA28	Temperatures	164
SA47	Miter Saws	165
SA51	Performance – General	165
SA52	Leakage Current Test.....	165
SA53	Starting Current Test	165
SA54	Current Input Test	165
SA55	Temperature Test.....	165
SA56	Dielectric Voltage Withstand Test	165
SA57	Leakage Current Test Following Humidity Conditioning.....	165
SA58	Impact Test	166
SA59	Strain Relief Test.....	167
SA60	Push Back Relief Test	167
SA62	Switches and Controls Test	167
SA63	Capacitor Test	168
SA64	Abnormal Operation Test.....	168
SA65	Bonding Overload Test.....	168
SA66	Resistance of Grounding Path Test	168
SA67	Conditioning of Polymeric Materials.....	169
SA68	Tests of Polymeric Enclosure Following Oven Conditioning	169
SA69	Polymeric Material as Described in 69.2	170
SA70	Polymeric Material as Described in 70.2	170
SA71	Drip Test	170
SA72	Flooding Test.....	170
SA73	Overflow Test	170
SA74	Test for Deterioration of Parts.....	170
SA75	Test for Reliability of Parts	170
SA76	Dielectric Voltage Withstand Test	170
SA77	Grounding Continuity Test	170
SA78	Electrical Rating.....	170
SA79	General – Marking	170
SA80	Details	171
SA81	Cautionary	171
SA83	Instructions Pertaining to a Risk of Injury	171
SA89	Double Insulated Tools – Scope	172
SA90	Construction	172
SA91	Performance.....	172
SA92	Tests by the Manufacture.....	172
SA93	Markings	172

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 form 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 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:

- The requirement in [7.3.3](#) and [67.1](#) and with the requirements for Polymeric Materials, Section [69](#) or [70](#), whichever is applicable; and
- 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:

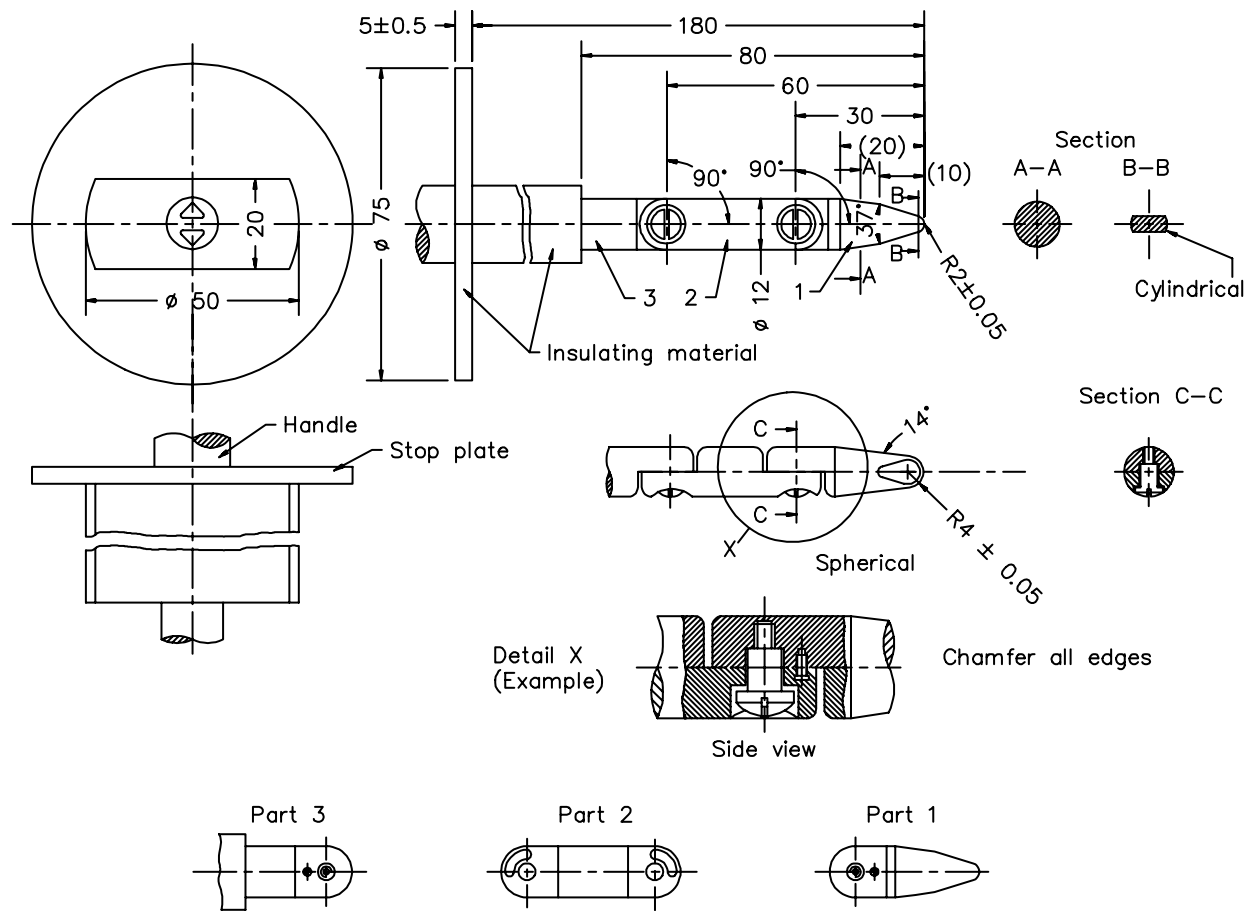
- a) The material has a temperature index, based on historical data or a long-term thermal aging program, more than the maximum temperature to which it is exposed during its normal use;
- b) The maximum temperature to which the material is exposed during normal use does not exceed 65°C (149°F); or
- 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



SA1788A

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 $+10^\circ$ 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 $+10^\circ$ tolerance.

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 mm²) 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 mm²).

Exception: A No. 8 screw may be used at a field-wiring terminal intended only for the connection of a 14 AWG (2.1 mm²) 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.

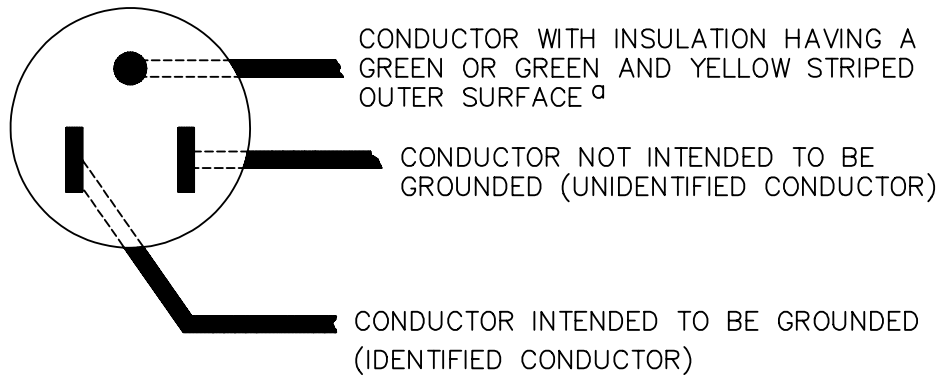
13.1.10 The attachment plug of a tool and the cord of a motor shipped detached from a tool shall be rated not less than the rated current and the rated voltage of the tool. If a tool has provision for being adapted for use on two or more different values of voltage by field alteration of internal connections, 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.

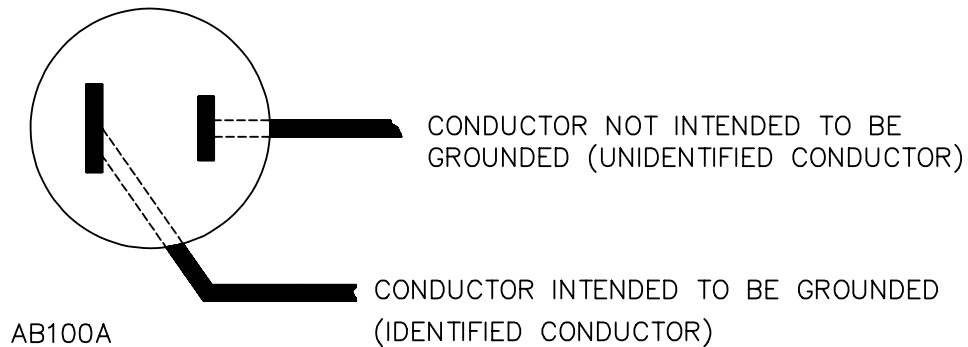
13.1.12 If a 3-wire grounding type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connections shall be as shown in [Figure 13.1](#). See [13.1](#).

Figure 13.1**Connection to attachment plug**

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



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



^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.

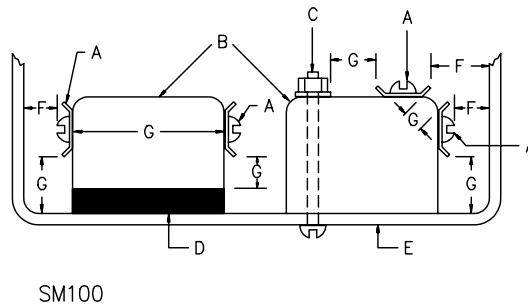
^b A spacing of not less than 3/32 in (2.4 mm), over surface and through air, is acceptable between film-coated wire, rigidly supported and held in place on a coil, and dead metal parts.

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\(b\)](#).