

UL 923

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Microwave Cooking Appliances

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Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Microwave Cooking Appliances, UL 923

Fifth Edition, Dated May 23, 2002

Revisions: This Standard contains revisions through and including January 16, 2003.

Summary of Topics

The revisions dated January 16, 2003 were issued to incorporate the following new and revised requirements:

- Removal of cord types HS and HSO from Table 13.1.
- Deletion of soldering all strands of a wire together as a means of preventing loose strands at internal wiring connections.
- Revision of paragraph 21.2 to harmonize the requirement with other UL standards that require compliance with the Standard for Overheating Protection for Motors, UL 2111.
- Revision to 36.6.4.1.6 that a temperature-limiting device shall not operate during the Temperature Test.
- Revision of the important instructions to caution users concerning heating liquids beyond the boiling point.
- Addition of Supplement SB to investigate microwave ovens utilizing tungsten-halogen lamps for cooking.

The revisions were also issued to reflect the December 11, 2002 ANSI recognition of the standard.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
July 16, 2003	Table 13.1 and 68.1.3
May 23, 2004	13.1.2.1 and Supplement SB

The revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated July 26, 2002. The bulletin(s) is now obsolete and may be discarded.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

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

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Page	Date
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7-8B	January 16, 2003
9-27	May 23, 2002
28	January 16, 2003
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33	January 16, 2003
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36-36B	January 16, 2003
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This ANSI/UL Standard for Safety, which consists of the Fifth Edition including revisions through January 16, 2003, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL Northbrook Standards Department, 333 Pfingsten Road, Northbrook, IL 60062.

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

The Department of Defense (DoD) has adopted UL 923 on June 29, 1990. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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FOREWORD

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

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

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

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover household and commercial microwave cooking appliances operated in the Industrial, Scientific and Medical (ISM) bands of 915 ± 25 and 2450 ± 50 MHz, for use in ordinary locations in accordance with the National Electrical Code, NFPA 70, and rated not more than 600 V.

1.2 These requirements also cover microwave cooking appliances intended for built-in installation, side-by-side mounting, stacking, wall mounting and installation over ranges.

1.3 For the purpose of these requirements, commercial microwave cooking equipment is that usually found in commercial kitchens, restaurants, or other business establishments where food may be dispensed. Household microwave cooking equipment is that intended for household use.

1.4 These requirements also cover the microwave cooking portion of a household electric range. The combination is to comply with the Standard for Household Electric Ranges, UL 858.

2 Glossary

2.1 For the purpose of this standard the following definitions apply.

2.2 AUTOMATICALLY CONTROLLED APPLIANCE – An appliance is considered to be automatically controlled under any one or more of the following conditions:

- a) If the repeated starting of the appliance, beyond one complete predetermined cycle of operation, is independent of any manual control;
- b) If, during any single predetermined cycle of operation, the appliance is caused to stop and restart, or change operating modes one or more times; or
- c) If, upon energizing the appliance, the initial starting of a motor may be intentionally delayed beyond normal, conventional starting.

2.3 CAVITY – That portion of the microwave cooking appliance in which food may be heated, cooked, or dried.

2.4 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 42.4 V peak supplied by:

- a) An inherently-limited Class 2 transformer;
- b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently-limited Class 2 transformer;
- c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;
- d) Any combination of (a), (b), and (c) that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

- e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A circuit derived from a line-connected circuit by connecting impedance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a Class 2 circuit. See Secondary Circuits, Section 31.

2.5 CONTROLLED ENVIRONMENT – An environment relatively free of conductive contaminants, such as normal cooking vapors, carbon dust, and the like, that may be a result of the end-use equipment to which a control will be installed or may be due to the location of the end-use equipment, and protected against humidity and the formation of condensation. A controlled environment may be provided by means of a:

- a) Hermetically sealed enclosure,
- b) Encapsulation,
- c) A conformal coating, or
- d) A gasketed, tight-fitting enclosure or filter system preventing contamination in conjunction with a system preventing condensation (for example, the maintaining of the surrounding air at constant temperature and a suitably low relative humidity).

2.6 "CROWBAR" CIRCUIT – A circuit that causes an electrical overload to exist in the event certain other operations are not completed. The overload condition in turn causes an overcurrent or thermal device to function.

2.7 DOOR – The movable barrier that permits access to the cavity for placement or removal of food, and whose function is to prevent emission of microwave energy from the passage or opening which provides access to the cavity.

2.8 EQUIVALENT PLANE-WAVE POWER DENSITY – The square of the rms electric field strength divided by the impedance of free space (377 ohms).

2.9 INTERLOCK – A device or system, either electrical, mechanical, or electromechanical, that serves to prevent exposure to an electric shock, or physical injury, or excessive radiation emission when a door, cover, or access panel is opened or removed.

2.10 INTERLOCK MONITOR – An electrical, mechanical, or electromechanical system that serves to render a microwave cooking appliance incapable of generating microwave energy in the event the designated primary or secondary interlock, or both does not perform its intended function.

2.11 MAGNETRON – A type of microwave generator usually used in microwave cooking appliances.

2.12 MICROWAVE ENCLOSURE – Refers to the inner cavity walls, the door, waveguide, and radiation shielding around magnetron filament connections.

2.13 MICROWAVE RADIATION EMISSION – The microwave energy to which persons might be exposed during operation or user servicing of a microwave cooking appliance.

2.14 OVER-THE-COOKTOP MICROWAVE OVEN – Any appliance, including a combination microwave oven vent-hood fan, that may be located above a range, cooktop, or similar heating appliance. It also includes appliances that can be located on a vent-hood shelf above a range or cooktop.

2.15 PRIMARY INTERLOCK – A designation for one of the oven door interlocks. The primary interlock is intended to de-energize the microwave generator upon opening the oven door, before microwave radiation emission exceeds the levels specified in 34.1.1.

2.16 PRIMARY CIRCUITS – The wiring and components that are conductively connected to the branch circuit.

2.17 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce a risk of fire, electric shock, injury to persons, or excessive radiation (microwave or x-radiation) emission. An interlock circuit, for example, is considered to be a safety circuit.

2.18 SECONDARY CIRCUIT – A secondary circuit is one that is supplied from an isolated secondary winding of a transformer.

2.19 SECONDARY INTERLOCK – A designation for one of the oven door interlocks. The operation of the secondary interlock is intended to prevent microwave radiation emission from exceeding the level specified in 34.1.1 when the door is opened.

2.20 STIRRER – That feature of a microwave cooking appliance that serves to continuously change the standing wave pattern within the oven cavity.

2.21 UNDER-CABINET MOUNTED MICROWAVE OVENS – A microwave cooking appliance that is installed under a cabinet and over a non-heat producing surface.

2.22 USER SERVICING – Any form of servicing that might be performed by personnel other than those who are trained to maintain the appliance. Some examples of user servicing are:

- a) Cleaning any areas that are accessible without the use of tools;
- b) Replacing lamps, fuses, or other parts that are accessible without the use of tools;
- c) Adjustment of any controls that do not involve the use of tools; and
- d) Any operation described or implied in the operator's manual, whether or not tools are required.

2.23 VIEWING SCREEN – That feature of a microwave appliance, usually part of the door assembly, that is opaque to microwave energy but visually transparent to provide for viewing the cavity contents.

2.24 VIEWING SCREEN BARRIER – An optically transparent material adjacent to a viewing screen, which serves to prevent insertion of a wire or other object into the cavity.

3 General

3.1 Components

3.1.1 Except as indicated in 3.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

3.1.2 A component is not required to comply with a specific requirement that:

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

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

3.1.4 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.

3.2 Units of measurement

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

3.2.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are root-mean-square (rms).

3.3 References

3.3.1 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.

CONSTRUCTION

4 General

4.1 A microwave cooking appliance shall be made and finished with the degree of uniformity and grade of workmanship that is practicable in a well-equipped factory.

5 Frame and Enclosure

5.1 A microwave cooking appliance shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses that it is likely to be subjected, without increasing the risk of fire, electric shock, injury to persons, or exposure to radiation emission in excess of the limits specified in these requirements due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

5.2 The enclosure of a microwave cooking appliance shall house all electrical parts, except a supply cord, that may cause a fire, electric shock, injury to persons, or exposure to radiation emission in excess of the limits specified in these requirements under any condition of use. No dependence shall be placed on adjacent walls or adjacent equipment to complete an enclosure. If a microwave cooking appliance is intended for permanent installation (intended for permanent connection to the power supply), the appliance shall be provided with means for mounting in the intended manner and shall be furnished with any necessary fittings, such as brackets, hangers, or sleeve.

5.3 Among the factors that shall be taken into consideration when an enclosure is being evaluated are its:

- a) Mechanical strength,
- b) Resistance to impact,
- c) Moisture-absorptive properties,
- d) Combustibility,
- e) Resistance to corrosion, and
- f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of use. For a nonmetallic enclosure, all of these factors shall be considered with respect to thermal aging.

5.4 An enclosure constructed of polymeric material shall comply with the requirement in 12.3.

5.5 Cast- and sheet-metal portions of the enclosure shall be no thinner than indicated in Table 5.1 unless the enclosure is found to be acceptable when evaluated under considerations such as are mentioned in 5.3 and 5.6.

5.6 In addition to being considered with reference to the factors mentioned in 5.3, an enclosure of sheet metal shall be evaluated with respect to its size and shape, the thickness of metal and its acceptability for the particular application, considering the intended use of the appliance.

Table 5.1
Minimum acceptable thickness of metal enclosure

Metal	At small, flat, unreinforced surfaces and at surfaces that are reinforced by curving, ribbing, or the like, (or are otherwise of a shape and/or size to provide acceptable physical strength)		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	in	(mm)	in	(mm)	in	(mm)
Die-cast metal	3/64	(1.2)	—		5/64	(2.0)
Cast malleable iron	1/16	(1.6)	—		3/32	(2.4)
Other cast metal	3/32	(2.4)	—		1/8	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.032	(0.81) ^a	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.034	(0.86) ^a	0.029	(0.74)
Nonferrous sheet metal	0.036	(0.91)	0.045	(1.14)	0.036	(0.91)

^a Sheet steel of a thickness less than that mentioned, but not less than 0.026 in (0.66 mm) if uncoated steel or not less than 0.029 in (0.74 mm) if galvanized steel, is acceptable if the area surrounding the knockout has a thickness not less than 0.053 in (1.35 mm).

5.7 If openings for exhaust ventilation are provided in the enclosure of a microwave cooking appliance they shall be so located that they will not vent into concealed spaces of a building structure, such as into false-ceiling space or into hollow spaces in the wall, when the appliance is installed as intended.

5.8 The microwave enclosure of a microwave cooking appliance shall be so constructed as to prevent microwave radiation emission in excess of the values specified in 34.1.1.

5.9 With reference to 5.8, there shall be no openings in external surfaces of an appliance that will enable insertion of an insulated wire of any diameter into the cavity, wave guide, or other microwave-energy-containing spaces while the door is closed, provided the wire, when inserted, could consist of two straight segments forming an obtuse angle of not less than 170 degrees. The appliance is to be fully assembled during the examination except for parts that are removable without the use of tools. Typically, a solid wire approximately 0.04 in (1.0 mm) in diameter is used to determine possible insertion paths. The rotating fan blade of a blower motor in the direct line of sight to a small hole or crack leading to a microwave containing space is considered an acceptable barrier to the insertion of a wire.

Exception: Entry of a wire of any diameter may be considered acceptable if it can be demonstrated that the insertion of any such wire will not result in an equivalent plane-wave power density of microwave radiation in excess of 1 mW/cm² at any point 5 cm or more from the external surface of the enclosure when subjected to the Microwave Radiation Emission Test, Section 34, with all interlocks in the circuit.

6 Accessibility of Live Parts

6.1 The electrical parts of an appliance shall be so located or enclosed that persons are protected against unintentional contact with uninsulated live parts. The method of evaluating openings in the enclosure is given in 6.2 – 6.6.

6.2 An opening in the enclosure of an appliance that will not permit entrance of a rod 1 in (25.4 mm) in diameter is acceptable if a probe as illustrated in Figure 6.1, when inserted into the opening, cannot be made to touch any part where leakage current to earth ground, or to other accessible parts, would exceed the levels specified in 33.1.

6.3 With respect to the requirement in 6.2, the probe may be articulated into any configuration and may be rotated or angled to any position before, during, or after insertion into the opening; and the penetration may be to any depth allowed by the opening size, including minimal depth combined with maximum articulation.

6.4 An opening that has a minor dimension of 1 in (25.4 mm) or more, in an enclosure, as illustrated in Figure 6.2, is acceptable if, within the enclosure, there is no uninsulated live part or film-coated wire less than, R distance from the inside edge of the perimeter of the opening and X distance from the plane of the opening. T equals the enclosure thickness, R equals X minus T, and X equals five times the diameter of the largest round rod that can be inserted through the opening but not less than 6-1/16 in (154 mm). In evaluating an opening, any barrier located within the volume is to be ignored unless it intersects the boundaries of the volume in a continuous, closed line.

Figure 6.1
Accessibility probe

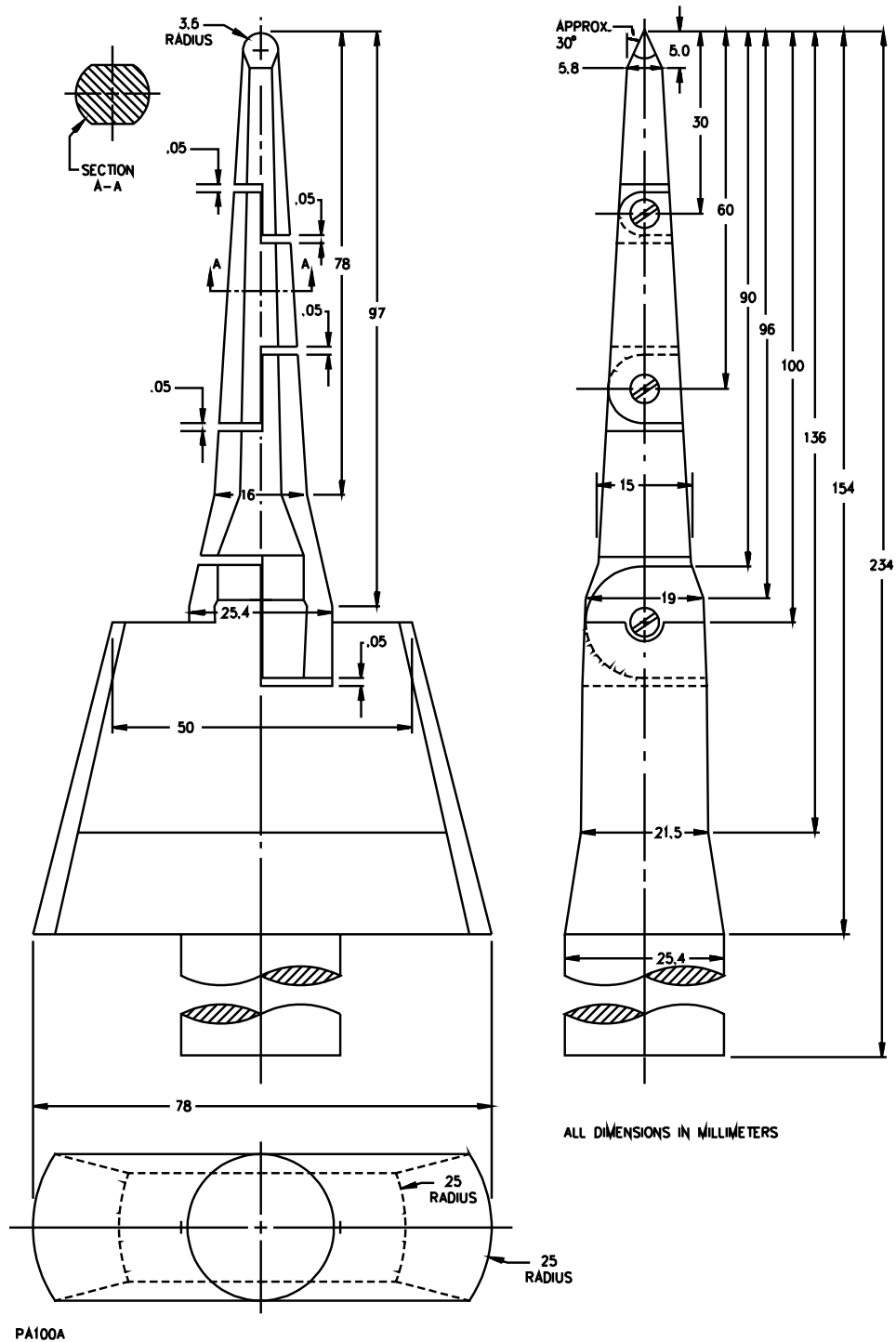
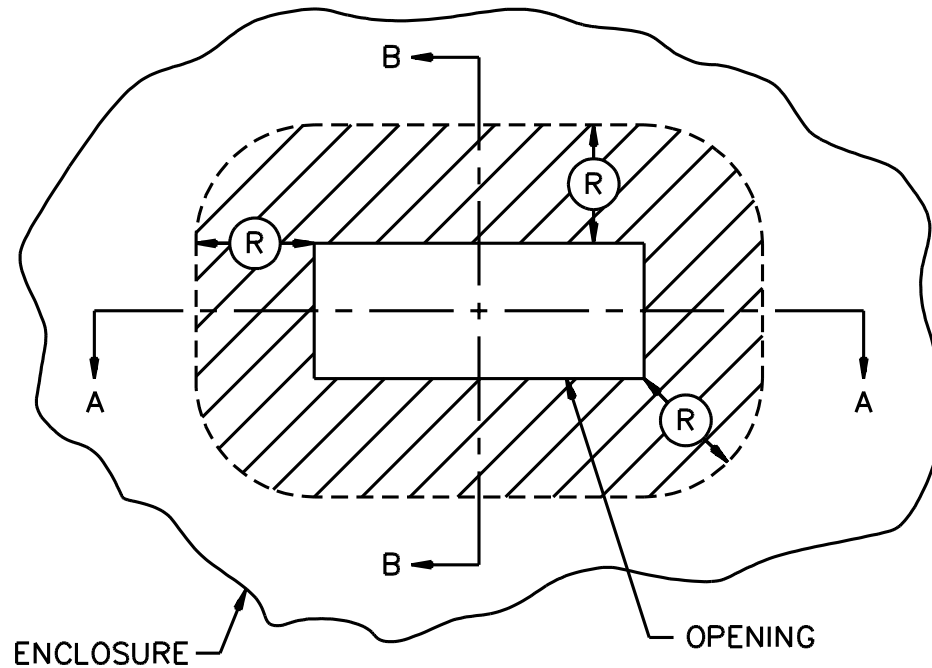
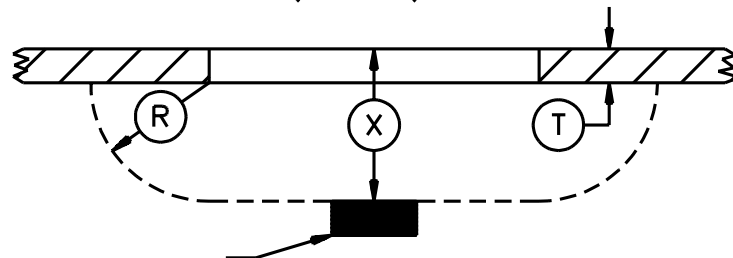


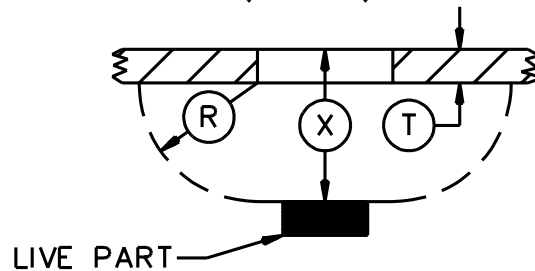
Figure 6.2
Opening in enclosure
 Proportions exaggerated for clarity



SECTION A-A
 $(X=R+T)$



SECTION B-B
 $(X=R+T)$



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6.5 In connection with the requirements in 6.1 – 6.4, a part of the outer enclosure that may be removed without the use of tools by the user of the appliance (for the attachment of accessories, to allow access to means for making operating adjustments, or for other reasons) is to be disregarded – that is, it is not to be assumed that the part in question affords protection against electric shock. A warning marking, such as that specified in 64.1.8 is not considered to eliminate this condition.

6.6 With reference to 6.7 and 6.8, the outer enclosure of a household counter-top appliance that requires removal for servicing is to be removed when determining compliance with the requirements.

6.7 A component (such as a lampholder, fuseholder, circuit breaker, or the like) intended to be user serviceable shall be so located that persons replacing or resetting the component in a line-voltage circuit cannot unintentionally touch an uninsulated live part.

Exception: The requirement does not apply to the screwshell or center contact of a screwshell lampholder or to the clips of a fuseholder that is associated with the component being replaced.

6.8 Uninsulated live parts of the line or high voltage circuits shall be individually insulated, guarded, or located such that the probe illustrated in Figure 6.3 cannot contact live parts with the outer enclosure removed.

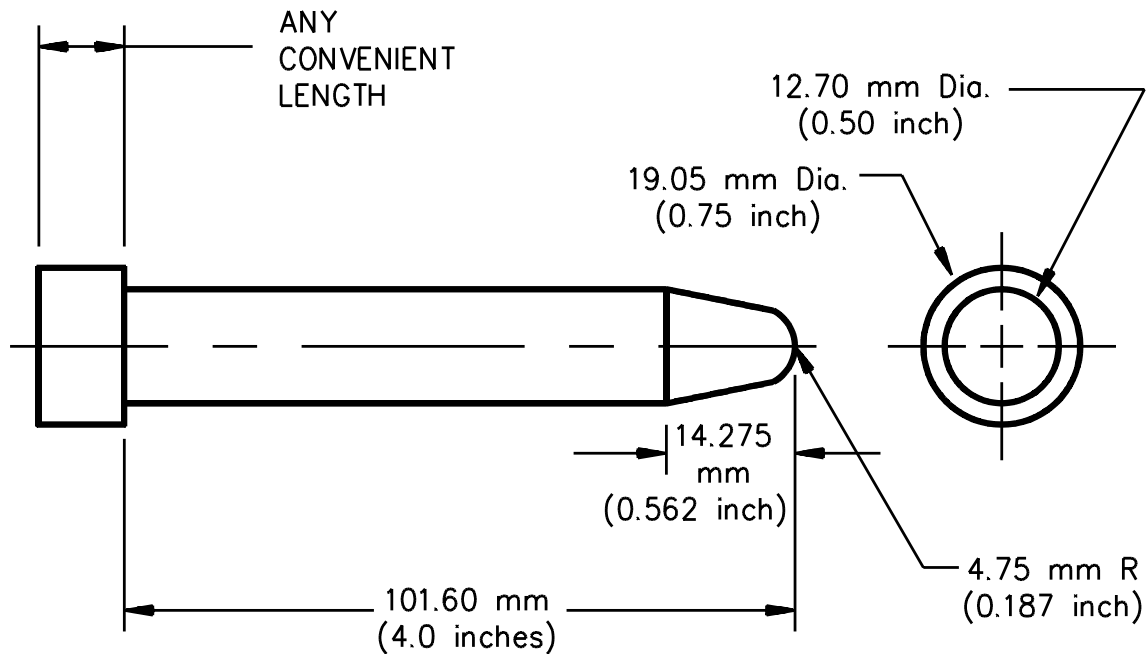
Exception No. 1: This requirement does not apply to enamel-coated line or low voltage connected coil windings. The secondary voltage coil of the magnetron transformer shall not be exempt from the requirement.

Exception No. 2: An interlock system may be provided in lieu of insulating, guarding, or locating the live parts if the system disconnects all poles of the power supply, and the live parts that can be contacted by the probe are reliably deenergized. The actuator for such an interlock shall be concealed and not obvious to the person servicing the microwave oven.

Exception No. 3: Non-removable type fasteners or other means of securing the outer enclosure to the oven may be provided in lieu of insulating guarding, locating or interlocking the live parts if:

- a) The securing means if determined through trial removal to be unlikely to be removed,*
- b) The securing means is provided with a tool interface that will not accommodate a slotted, a Phillips, a square, or torx driver, or wrench of any type for removal,*
- c) The securing means has a curved head that cannot be gripped by pliers. A securing means provided with a maximum 0.020-in (0.50-mm) radius curve above the exposed outer surface of the appliance to which the securing means is affixed is considered as not be capable of being gripped,*
- d) A minimum of two such securing means are provided, and*
- e) The appliance is marked in accordance with 66.23.*

Figure 6.3
Probe for uninsulated live parts



PA135A

7 Protection Against Injury

7.1 General

7.1.1 A moving part, such as the rotor of a motor, a chain, a pulley, a belt, or a gear, shall be enclosed or guarded to reduce the risk of injury to persons.

7.1.2 With reference to the requirement in 7.1.1, the degree of protection required of the enclosure depends upon the general construction and intended use of the appliance. The factors to be taken into consideration in determining the acceptability of an exposed moving part are:

- a) The degree of exposure;
- b) The sharpness of the moving part;
- c) The likelihood of unintentional contact with the moving part;
- d) The speed of movement of the part; and
- e) The likelihood of a finger, an arm, or clothing being drawn into the moving part (such as at points where gears mesh, where a belt travels onto a pulley, or where moving parts close in a pinching or shearing action).

7.1.3 A microwave cooking appliance, and any item furnished with the appliance, shall have no sharp edge, burr, point, or spike inside or outside the appliance that may cause injury during use, including a cleaning operation.

7.1.4 Materials employed in the construction of the appliance depended upon for protection against injury shall be acceptable for the particular use. See 5.1 and 5.3.

7.2 Strength of mounting

7.2.1 A support bracket, hanger, or the like, of a wall-mounted appliance, shall not weaken, crack, or break; and shall support the oven and mounting bracket assembly when subjected to the conditions described in Strength of Mounting Test, Section 58.

7.3 Fans

7.3.1 A removable filter that complies with the requirements in Filters, Section 28, is acceptable as a guard of a fan.

7.3.2 A side of a fan need not be guarded provided that:

- a) The appliance is marked as specified in 66.27; and
- b) The installation instructions are such that, when installed per the instructions, an opening allowing the user access to an unguarded side of a fan is at least 7 ft (2.13 m) above the floor.

8 Mechanical Assembly

8.1 A switch, a fuseholder, a lampholder, an attachment plug receptacle, a power inlet (motor attachment cap), or other component that is handled by the user shall be mounted securely and shall be prevented from turning. See 14.3.

Exception: The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

- a) The switch is of a plunger, slide, 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 operation of the switch;*
- b) The means of mounting the switch makes it unlikely that operation of the switch will loosen the switch;*
- c) Spacings are not reduced below the minimum acceptable values and there is no stress on internal wiring or terminals of internal wiring if the switch moves; and*
- d) Intended operation of the switch is by mechanical means rather than by direct contact by persons.*

8.2 The means by which the turning mentioned in 8.1 is prevented is to consist of more than friction between surfaces – for example, a lock washer, properly applied, is acceptable as the means to prevent turning of a device having a single-hole mounting means.

8.3 If a factory installed part of an appliance is normally removed from the appliance by the installer to convert the appliance from one type of installation to another, (for example, counter top installation to built-in), and the part is not replaced during such conversion, the appliance shall, with the part removed, comply with all requirements in this standard that apply to all types of installation for which the appliance is intended.

9 Protection Against Corrosion

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

Exception: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers or screws. The sheath of a heating element need not be protected against corrosion.

9.2 If the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors – surfaces of sheet steel and cast iron parts within an enclosure may not be required to be protected against corrosion.

10 Interlocks

10.1 Opening the door of a microwave cooking appliance shall operate a minimum of two door interlocks. At least one door interlock on a fully assembled microwave oven shall not be operable by any part of the human body, or any object with a straight insertable length of 3.9 in (99.6 mm). Such an interlock shall also be concealed (not within line-of-sight), unless its actuation is prevented when access to the interlock is possible. Any visible actuator or device to prevent actuation of this interlock shall not be removable without disassembly of the oven or its door. For magnetically operated interlocks see 50.1 and 50.2 also.

10.2 The interlocks designated as primary and secondary shall prevent microwave radiation emission in excess of the requirements in 34.1.1 for the primary and secondary interlocks under the normal operating conditions described in this standard.

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11 Interlock Monitors

11.1 An interlock monitor circuit shall be provided as part of the microwave cooking appliance and shall comply with the applicable constructional requirements of 11.2 – 11.4, and test requirements in Interlock Monitor Circuit Test, Section 43.

11.2 An interlock monitor circuit component or system shall not serve as one of the door interlocks. Door interlock malfunctions shall not disrupt the monitoring function of the interlock monitor circuit.

Exception: With reference to the first sentence of 11.2, a multiple circuit switch employing separate contact sets serving as door interlock and monitor switches may be acceptable provided:

- a) The presence of the interlock contact set does not increase the probability of malfunction of the monitoring function of the monitor contact set; and*
- b) There are no common-mode malfunctions that could lead to or result in malfunction of the monitoring function of the monitor contact set and an unacceptable operation of the interlock, unless there are at least two other operable door interlocks in the appliance.*

11.3 Any overcurrent device or fusible element necessary for proper operation of a monitor circuit, such as a crowbar circuit, shall be provided in the appliance and located where it is not accessible to the user without the use of tools.

11.4 The means of monitoring one or both of the required interlocks shall cause the microwave generator of a microwave cooking appliance to become inoperable until the appliance is serviced by qualified service personnel if any interlock being monitored fails to perform its required function with all other control devices in the monitor circuit set to the closed position. Instructions for servicing associated with the operation of the interlock monitor shall be provided for the serviceman, but shall not be provided for the user as part of the user operating instructions packaged with the product. See 69.2.

12 Polymeric Materials

12.1 Polymeric materials employed in the construction of gaskets, spacers, dielectric media of wave traps, or other structural parts of a microwave cooking appliance shall be investigated for the application if the partial or total deterioration of such parts could result in microwave radiation emission exceeding the limits specified in 34.1.1.

12.2 Compliance with 12.1 is determined by subjecting the specific construction to the test described in 40.1.1 – 40.5.7 and 42.1.1 – 42.4.1.

12.3 A polymeric material enclosure of electrical parts shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as applicable to polymeric enclosures.

Exception No. 1: A minimum impact of 5 ft-lbf (6.8 J) shall apply to all microwave cooking appliances when determining the impact resistance of a polymeric material enclosure of live parts.

Exception No. 2: An enclosure of Class 2 circuits – see Secondary Circuits, Section 31 – shall be treated as a decorative part, see 12.6.

Exception No. 3: For the abnormal operation and severe conditioning test of UL 746C, the appliance enclosure is to be evaluated under the abnormal operation tests specified in Abnormal Operation Tests, Section 47, and Cavity Fire Containment Test, Section 57, of this standard.

12.4 A polymeric material that limits access to microwave energy-containing spaces shall comply with the following:

- a) Impact Test – In accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. An impact of 2 ft-lbf (2.7 J) is to be applied. As a result of this test, the appliance shall comply with 5.8 and 5.9;
- b) Mold Stress-Relief Distortion – In accordance with UL 746C. As a result of this test, the appliance shall comply with 5.8 and 5.9;
- c) Abnormal Conditions – See Abnormal Operation Tests, Section 47; and
- d) Flammability – The material shall be classed as HB, V-0, V-1, V-2, 5VA, or 5VB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

12.5 When determining compliance with the enclosure requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C:

- a) A microwave cooking appliance is to be considered an unattended appliance;
- b) The stationary enclosure requirements shall apply to all permanently wired appliances, all floor-supported appliances, and any cord-connected appliance intended to be either fastened to or confined (totally or partially) by the building structure or other equipment;
- c) The portable enclosure requirements shall apply to all cord-connected counter top appliances, all cord-connected under-cabinet appliances, and all cord-connected appliances not covered by (b) above; and
- d) A microwave oven intended for indoor use shall be considered subject to normal room temperature environmental conditions.

12.6 Decorative parts of or on the electrical enclosure constructed of polymeric materials shall comply with the flammability requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as applicable to decorative parts of enclosures.

Exception No. 1: Polymeric materials that are located entirely external to a metallic enclosure of the appliance need not be classed HB minimum, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, provided:

- a) The metallic enclosure complies with the requirements in 5.5; and*
- b) The polymeric material does not cover any openings in the metallic enclosure.*

Exception No. 2: Polymeric parts not more than 0.010-in (0.25-mm) thick need not be classed HB, minimum.

12.7 Except where superseded by other requirements in this standard, polymeric materials shall have a flammability classification of HB minimum, when tested in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: Materials covered by one or more of the exceptions to 12.6 need not be classed HB, minimum.

Exception No. 2: Parts of a portable appliance are not required to be made of a material classed HB, minimum, provided the part does not occupy a volume greater than 0.122 in³ (2 cm³), does not have any dimension greater than 2.4 in (60.1 mm), and is located so it cannot propagate flame from one area to another or bridge between a possible source of ignition and other ignitable parts.

Exception No. 3: Parts of a fixed or stationary appliance are not required to be made of a material classed HB, minimum, provided the part does not occupy a volume greater than 0.24 in³ (4 cm³), does not have any dimension greater than 2.4 in (60.1 mm), and is located so it cannot propagate flame from one area to another or bridge between a possible source of ignition and other ignitable parts.

12.8 Polymeric materials that serve as direct or indirect support of live parts, or an electrical or mechanical barrier shall comply with the requirements for electric insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. An impact of 5 ft-lbf (6.8 J) is to be used for the applicable tests.

12.9 An adhesive material that is used to secure a portion of an enclosure, electrical or thermal insulation, an electrical component, an internal barrier (such as film, door screen, or the like), a mechanical component of a door interlock system, or a part that affects the routing of a cooling air stream shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: An adhesive need not comply with the requirements in UL 746C if the appliance complies with all of the requirements in this standard under all conditions of complete or partial failure of the adhesive.

12.10 With respect to 12.9, the as-received bond strength of the adhesive shall be not less than four times the strength necessary to perform its intended function, but in no case shall the as-received bond strength be less than 2 lbf/in². For an adhesive used with a flexible substrate, the as-received bond strength shall be not less than 2 lbf/in width.

12.11 With respect to 12.9, adhesive test samples shall be subjected to temperature, humidity, and cyclic conditioning. In addition, adhesive materials that may be exposed to food or cooking vapors during normal operation shall be subjected to corn oil exposure conditioning consisting of ten specimen samples immersed in corn oil for 7 days at the maximum adhesive temperature measured during the test specified in Temperature Test, Section 36.

12.12 A polymeric duct or grill that prevents exhaust air from venting into a concealed space of a building structure (see 5.7) shall comply with the following tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. As a result of these tests there shall not be cracking, warpage, or other distortion to the extent that a solid No. 18 AWG (0.82 mm²) uninsulated wire can be inserted into any opening in the duct or grill.

a) ENCLOSURE IMPACT – When conducting the Resistance to Impact test, an impact of 2 ft-lbf (2.7 J) is to be applied to any surface that is exposed to a blow during normal use (not including during installation). A grill, and a duct provided as part of a counter top appliance and intended to become part of the built-in ductwork, are examples of surfaces exposed to a blow during normal use.

b) **MOLD STRESS-RELIEF DISTORTION** – Mold stress-relief distortion tests are required for all applications. However, a repeated input test after the Mold Stress-Relief Distortion Test is not required.

c) **ABNORMAL OPERATION** – For the abnormal operation and severe conditions tests, the material is to be investigated for compliance with the Abnormal Operation Tests, Section 47.

d) **FLAMMABILITY** – The duct assembly shall be subjected to the 500 w (125 mm) Vertical Burning Test, or shall have a flammability classification of 5VA (as classed by the vertical burning rate test described in the Standard Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94). A duct or grill that only exhausts air other than oven cavity exhaust shall have a flammability classification of 5VA.

Exception: A polymeric duct or grill that exhausts air directly from the oven cavity is not prohibited from having a flammability classification of V-0 (as classed by the vertical burning rate test described in UL 94) when the appliance is provided with a manual reset temperature limiting control or a thermal cutoff that is located adjacent to the duct or grill, complies with the applicable requirements for appliance limit controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, or the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020, and functions to de-energize the entire appliance when subjected to the Cavity Fire Containment Test, Section 57, with the potato or potatoes located as close to the duct or grill as possible. See 52.1 for the applicable manual reset control endurance test.

12.13 A duct or grill as described in 12.12 may be part of the appliance or provided as a separately supplied accessory intended for field installation in or on the appliance to convert it from a counter top installation to a wall-mounted or built-in installation. The duct or grill, including a separately supplied accessory, is to be mounted as intended during the tests specified in 12.12.

13 Supply Connections

13.1 Permanently-connected appliances

13.1.1 General

13.1.1.1 A microwave appliance intended for permanent connection to the power supply shall be so constructed that it can be readily and permanently connected to one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, would be acceptable for the appliance.

13.1.1.2 An appliance intended to be built-in or recessed may be provided with 3 – 8 ft (0.91 – 2.44 m) of flexible metal conduit with leads and a grounding conductor installed to facilitate servicing and installation. The flexible conduit need not terminate in an outlet box at the free end but an antishort bushing is to be installed and retained reliably.

13.1.1.3 Sheet metal to which a wiring system is to be connected in the field, shall have a thickness of not less than that specified in Table 5.1.

13.1.1.4 A wiring compartment for field-wiring connections shall be of size to accommodate such connections.

13.1.1.5 If inspection indicates a compartment volume may not be large enough to accommodate the intended wiring, a trial installation is to be made using wires of the size indicated in 13.1.2.1 and conduit and fittings sized for the wire in accordance with the National Electrical Code, ANSI/NFPA 70.

13.1.1.6 The location of a terminal box or compartment in which branch-circuit connections to a permanently wired appliance are to be made shall be such that these connections can be readily inspected without disturbing the wiring or the appliance after the appliance has been installed as intended. See also 13.1.1.7.

13.1.1.7 An outlet or terminal box mounted integrally with a permanently connected, built-in or wall-mounted, microwave cooking appliance shall be so located that the power-supply connections can be inspected without the necessity of moving the appliance to the extent that it will not be supported by the building structure only.

13.1.1.8 No electrical component shall be mounted on a part that must be removed for the examination of field-wiring connections.

13.1.1.9 A terminal compartment intended for connection of a supply raceway shall be so attached to the appliance as to be prevented from turning with respect thereto.

13.1.2 Field wiring terminals and leads

13.1.2.1 A microwave cooking appliance intended for permanent connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors. Each terminal or lead shall be sized for connection of a branch-circuit conductor having an ampacity equal to or greater than the noncontinuous load plus 125 percent of the continuous load.

Revised 13.1.2.1 effective May 23, 2004

13.1.2.2 Pigtail leads provided for connection to the branch-circuit supply shall have an ampacity not less than that of the conductor of the next smaller size than that appropriate for the rating of the appliance. See 13.1.2.3.

13.1.2.3 For the purpose of these requirements it is assumed that 60°C (140°F) wire will be installed, unless the appliance is marked in accordance with 66.2, 66.3, and 66.4.

13.1.2.4 If terminals of unequal sizes are provided because of unbalanced loads, each terminal shall be sized to accept a conductor as in 13.1.2.1, but based on the total current that will be carried by the conductor connected to that terminal. See 64.1.6 and 66.3.

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

13.1.2.6 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the particular application, in accordance with the National Electrical Code, ANSI/NFPA 70. See 13.1.2.8.

13.1.2.7 The surface of an insulated lead intended for the 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.

13.1.2.8 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 the equipment grounding conductor shall be marked in accordance with 64.1.4. The wire-binding screw or pressure wire connector shall be so located that it does not require removal during the servicing of the appliance not involving the disconnecting of the supply conductors. Sheet-metal screws shall not be used for connection of equipment grounding conductors to enclosures at field wiring connections.

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

Exception: A lead may be less than 6 in (152 mm) in length if it is evident that the use of a longer lead might result in a risk of fire or electric shock.

13.1.2.10 A field-wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by some other equivalent method.

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

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm²) or smaller conductor if upturned lugs, cupped washers or the equivalent are provided to hold the wire in position.

13.1.2.12 Upturned lugs or a cupped washer shall retain a power-supply conductor corresponding in size to that mentioned in 13.1.2.1, but not smaller than No. 14 AWG (2.1 mm²), under the head of the screw or the washer.

13.1.2.13 A wire-binding screw at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter). The threads shall not be finer than that of the National Fine Thread Series for the screw size.

Exception: A No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm²) or smaller conductor, and a No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 16 or No. 18 AWG (1.3 or 0.82 mm²) control-circuit conductor.

13.1.2.14 No. 14 AWG (2.1 mm²) is the smallest conductor that can be used for branch-circuit wiring and thus is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

13.1.2.15 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050-in (1.27-mm) thick except that a plate not less than 0.030-in (0.76-mm) thick is acceptable if the tapped threads have equivalent mechanical strength. There shall not be less than two full threads in the metal of the plate.

13.1.2.16 A terminal plate formed from stock having the minimum acceptable thickness mentioned in 13.1.2.15 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

13.1.2.17 A field-wire connected appliance rated 125 or 125/250 V (3-wire) or less shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

13.1.2.18 A field-wiring terminal intended for the connection of a grounded-supply conductor shall be substantially white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided instead of terminals, the surface of the lead intended to be connected to the grounded supply circuit conductor shall be finished to show white or natural grey color and shall be easily distinguishable from the other leads.

13.2 Cord-connected appliances

13.2.1 General

13.2.1.1 A cord-connected microwave cooking appliance (an appliance intended to be connected to the power-supply circuit by means of a flexible cord) shall be provided with a length of attached flexible cord and an attachment plug for connection to the supply circuit. The type of flexible cord shall be as indicated in Table 13.1, or shall have such properties that it will be at least equally serviceable for the application. The length of attached cord shall be within the limits indicated in Table 13.2.

13.2.1.2 The current rating of the cord and fittings of an appliance shall not be less than the current rating of the appliance. For an appliance rated more than 15 A and which will operate continuously (3 h or more), the current rating of the attachment plug shall not be less than 125 percent of the current rating of the appliance.

Exception: An attachment plug rated 20 A is acceptable for an appliance rated at not more than 4000 W at 240 V.

Table 13.1
Acceptable types of cord and applicable limitations on their use

Revised Table 13.1 effective July 16, 2003

Appliance on which the cord is to be used	Cords acceptable where temperatures are more than 121°C (250°F) on any surface that the cord is likely to touch when the appliance is used as intended	Cords acceptable where temperatures are 121°C (250°F) or less on any surface that the cord is likely to touch when the appliance is used as intended
Household except built-in and wall mounted	HPN, HSJ, HSJO, or HSJOO	HPN, HSJ, HSJO, HSJOO, SP-2, SPE-2, SPE-3 ^a , SPT-2 ^a , SPT-3 ^a , SV, SVE, SVO, SVOO, SVT, SVTO, SVTOO, SJ, SJO, SJOO, SJT, SJTO, or SJTOO
All commercial and built-in and wall mounted household	HSJ, HSJO, or HSJOO	HSJ, HSJO, HSJOO, S, SE, SO, SOO, ST, STO, STOO, SJ, SJO, SJOO, SJT, SJTO, SJTOO
^a SPT-2, SPT-3, and SPE-3 cords are acceptable only for appliances not likely to be moved frequently. An SPT-2, SPT-3, or SPE-3 cord is not acceptable on microwave cooking appliances provided with rolling carts, or similar accessories that provide mobility, which are provided by the manufacturer, or described in the manufacturer's literature.		

Table 13.2
Lengths of cord connection

Type of microwave cooking appliance	Minimum acceptable length ^a		Maximum acceptable length ^a	
	ft	(m)	ft	(m)
Household, except appliances intended for only wall mounting	4.5 ^b	(1.37) ^b	7.0	(2.13)
Household, wall mounted	3.0 ^b	(0.91) ^b	7.0	(2.13)
Commercial except floor mounted	2.0	(0.61)	6.0	(1.83)
Commercial, floor mounted	3.0	(0.91)	6.0	(1.83)
^a Measured external to the appliance and including the fittings but excluding the blades on the attachment plug.				
^b The supply cord may be a minimum of 2 ft (610 mm) if a marking or instructions are provided in accordance with 66.13.				

13.2.1.3 The voltage rating of the cord shall not be less than the voltage rating of the appliance. The voltage rating and blade configuration of the fittings shall be such that the appliance can be connected to the proper supply source (voltage, phase, and the like).

13.2.1.4 Supplementary insulation employed on a flexible cord shall not extend more than 1/2 in (12.7 mm) outside the appliance (unless provided with additional mechanical protection), and shall be prevented from fraying or unraveling, and shall not affect adversely the means of providing strain relief.

13.2.2 Strain relief

13.2.2.1 Strain relief shall be provided so that a mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring. Means shall be provided for preventing the cord from being pushed into the appliance, if such displacement is likely to subject the cord to mechanical damage or to a temperature higher than that for which it is rated or can reduce spacings (such as to a metal strain-relief attachment) below the minimum acceptable values.

13.2.2.2 A knot shall not be employed to provide strain relief.

13.2.2.3 When tested in accordance with 13.2.2.4 the strain relief shall withstand for 1 min, without displacement, a direct pull of 35 lbf (156 N) applied to the cord with the connections within the appliance disconnected.

13.2.2.4 The specified force is to be applied to the cord so that the strain-relief means will be stressed from any angle that the construction of the appliance permits. The means of affording strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

13.2.3 Bushings

13.2.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be secured in place, and shall have a smooth, well-rounded surface against which the cord may bear. If Type SP-2, SPE-2, SPT-2, or other cord lighter than Type HSJ is employed, if the wall or barrier is of metal, and if the construction is such that the cord may be subjected to strain or motion, an insulating bushing shall be provided. The heat- and moisture-resistant properties of the bushing material shall be such that the bushing is acceptable for the particular application.

13.2.3.2 If the cord hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smooth, well-rounded surface is considered to be equivalent to a bushing.

13.2.3.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings, but a separate bushing of wood, hot-molded shellac and tar composition, or rubber material is not acceptable.

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

13.2.3.5 An insulated metal grommet may be accepted in place of an insulating bushing if the insulating material used is not less than 1/32-in (0.8-mm) thick, and completely fills the space between the grommet and the metal in which it is mounted.

14 Live Parts

14.1 Each current-carrying part shall be made of metal that is acceptable for the particular application.

14.2 A current-carrying part made of a corrosion-resistant ferrous alloy (for example, stainless steel) is acceptable regardless of temperature. A current-carrying part made of ordinary iron or steel is not acceptable unless it is rendered corrosion-resistant by an appropriate coating and, even then, it is acceptable only in the construction of the following parts:

- a) A part within a motor and its governor (if any),
- b) A part that operates at a temperature higher than 100°C (212°F) during the test in accordance with Temperature Test, Section 36,
- c) A coated iron or coated steel part of a component that the requirements referred to in 3.1.1 indicate as being acceptable,
- d) A part in a nonsafety isolated secondary circuit provided the coating consists of a copper underplate and tin or nickel overplate, or
- e) A part in a safety or line connected circuit that complies with the requirements in Salt Spray Corrosion Test, Section 56.

14.3 Uninsulated live parts shall be so secured to the base or surface that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacing below the minimum values specified in Spacings, Section 29, or stress internal wiring, or terminals of internal wiring.

14.4 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts; but a lock washer properly applied is acceptable.

15 Polarization

15.1 If an appliance is connected to a circuit that incorporates a grounded conductor, the screw shells of lampholders shall be connected:

- a) To the grounded circuit conductor or terminal of a permanently connected appliance, or
- b) To the grounded circuit conductor of the supply cord of a cord-connected appliance.

15.2 If there is no grounded conductor, as mentioned in 15.1 and if two lampholders are connected in series, the lampholder screw shells shall be common and the center contacts of the lampholders shall be connected toward the supply.

15.3 The following primary circuit components shall be connected to or cause the opening of an ungrounded conductor of the supply circuit:

- a) Fuseholder,
- b) Single-pole overcurrent protective device,
- c) Single-pole switch with a marked off position, and
- d) Automatic control with a marked off position.

15.4 The screw shell of a plug-type fuseholder and the accessible contact of an extractor-type fuseholder shall be connected toward the load.

16 Internal Wiring

16.1 General

16.1.1 Wire employed for the internal wiring of an appliance shall be acceptable for the particular application.

16.1.2 Among the factors considered when determining the acceptability of internal wiring are the temperature and voltage to which it may be subjected during normal operation.

16.1.3 There is no temperature limit applicable to glass fiber, beads of inorganic material, or the equivalent, employed as conductor insulation. Asbestos insulation may not be used where exposed to moisture produced by the appliance.

16.1.4 The wiring and electrical connections between parts of an appliance shall be protected or enclosed. Wiring and connections in circuits other than those covered in Secondary Circuits, Section 31, shall not be subject to handling during routine user servicing.

Exception: A length of flexible cord of a type specified in Table 13.1 shall be employed for external connections between parts if flexibility is essential.

16.1.5 With reference to exposure of internal wiring, the protection of wiring required in 16.1.4 is considered to exist, if, when considered as if it were enameled wire, the wiring would be acceptable according to 6.2 – 6.6.

16.1.6 Internal wiring not so protected may be accepted if it is so secured within the enclosure that neither it nor related electrical connections can be subjected to stress or mechanical damage. All wiring that is accessible to the operator is to be clamped or otherwise secured to prevent it from being unintentionally hooked, and the like.

16.1.7 No open wiring – that is wiring that is not separately and immediately enclosed in conduit, armored cable, metal raceway, or the like – shall be located where it is likely to be contacted during operator servicing or cleaning. For example, no wiring shall be located where it must be moved to replace fuses, operate a circuit-breaker handle, or adjust a manually reset control.

16.1.8 Wires within an enclosure, compartment, raceway, or the like shall be so disposed or protected that no damage to conductor insulation can result from contact with any rough, sharp, or movable part.

16.1.9 An appliance shall be so constructed that wires can be pulled through, or the appliance otherwise wired, without injuring the coverings or insulation on the conductors. A wireway shall be free from burrs and fins.

16.1.10 With reference to the requirement in 16.1.9, male screw threads shall not be exposed anywhere inside a raceway or wireway where wire is pulled.

16.1.11 Internal wiring, insulating tubing or sleeving, and electrical components shall be so located that they will not be exposed to the vapors from a vented oven cavity of the appliance.

Exception No. 1: This requirement does not apply to polyvinylchloride and similar moisture- and oil-resistant insulated wires and insulating tubing.

Exception No. 2: This requirement does not apply to the heater portion of an open-wire type heating element when the electrical spacings at the parts exposed to the vapors are at least twice the minimum specified in Table 29.2.

Exception No. 3: This requirement does not apply to electrical components, wiring, and the like employed in nonsafety Class 2 circuits as described in Secondary Circuits, Section 31.

Exception No. 4: Unenclosed live parts of components, such as terminals, connectors, and the like, need not comply with this requirement if electrical spacings of the unenclosed parts are at least twice the minimum specified in Table 29.2.

Exception No. 5: This requirement does not apply to unenclosed contacts of components not relied upon to comply with the performance requirements of this standard.

Exception No. 6: This requirement does not apply to electrical components when live parts, including film-coated wire, are enclosed and not adversely affected by moisture when the appliance is tested in accordance with Moisture Conditioning Test, Section 45.

Exception No. 7: Internal spacings within the enclosure of a component (such as within the case of a relay or switch) are to be evaluated in accordance with the requirements that cover that component.

16.1.12 A hole, through which insulated wires pass in a sheet-metal wall within the overall enclosure of the appliance, shall be provided with a smooth, rounded bushing or shall have smooth surfaces upon which the wires may bear to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 16.1.4 shall be provided with bushings and strain relief in accordance with 13.2.2.1 – 13.2.3.5 unless the construction is such that the cord will be protected from stress or motion.

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

16.2 Splices and connections

16.2.1 All splices and connections shall be mechanically secured and shall provide good electrical contact.

16.2.2 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in risk of fire, electric shock, or excessive radiation emission.

16.2.3 A wire inserted into a hole in a terminal is considered to be mechanically secure whether or not it is bent before soldering.

16.2.4 Any flexing or movement of internal wiring in an appliance that occurs during the normal cooking or a routine user-servicing function shall not result in stress on electrical connections.

16.2.5 A splice shall be provided with insulation unless permanence of spacing between the splice and other metal parts of the appliance is provided.

16.2.6 Stranded internal wiring shall be so connected to a wire-binding screw or stud-terminal that no loose strands result.

16.2.7 At a wire-binding screw, use of upturned ends or lugs, a cupped washer, barriers, or other equivalent means to hold the wires under the head of the screw is suitable for compliance as long as no loose strands are exposed. Other acceptable means of retaining the stranded internal wiring in position are use of a pressure terminal connector, soldering lug, or crimped eyelet.

16.2.7 revised January 16, 2003

17 Heating Elements

17.1 A heating element shall be supported in a reliable manner. It shall be protected against mechanical damage and contact with outside objects.

17.2 A movable heating element shall be protected against damage caused by contact with other parts of the appliance when the element is moved. See Mechanical Endurance Test, Section 44.

17.3 An exposed open-wire element in an appliance shall not be accessible to contact by the user. See 6.1.

17.4 An appliance in which the heating element is intended for use only in an air blast shall be so wired or controlled that the element can be operated only when under the cooling effect of the blast. An appliance in which the cooling effect of the motion of a part is necessary to prevent excessive temperature shall be so wired or controlled that the heating element cannot be operated in the absence of such motion.

17.5 A microwave cooking appliance employing resistance-type heating elements or similar auxiliary heating element shall be subjected to the tests specified in 47.5.1 and 47.5.2.

17.6 An appliance provided with a self-cleaning feature shall comply with the requirements in 27.7 – 27.10 and Sections 71 – 91.

17.7 An appliance employing resistance-type heating elements (sheathed or open-wire) shall be provided with a power-on indicator. The power-on indicator shall be readily visible in each intended installation configuration. The power-on indicator shall be readily distinguishable from any off position indicator and from all other control feature indicators by color, location, or the like.

17.8 The power-on indicator may be of an illuminated or nonilluminated type. The power-on indicator shall remain readily visible during any operating condition (including cycling of a thermostat) whenever the appliance is operated in a mode of operation where a resistance-type element may be energized.

18 Electrical Insulation

18.1 An insulating washer, a bushing, a lining, a barrier, and the like that is an integral part of an appliance and a base or a support for the mounting of live parts shall be of a moisture-resistant material that will not be adversely affected by the temperatures to which it will be subjected under conditions of actual use.

18.2 Insulating material is to be judged with respect to the particular application. Materials such as mica, some molded compounds, and certain refractory materials are usually acceptable for use as the sole support of live parts. Some other materials that are unacceptable for general use, such as magnesium oxide, may be acceptable if used in conjunction with other insulating materials or if so located and protected that mechanical damage is prevented and the absorption of moisture is minimized.

18.3 When it is necessary to investigate a material to determine whether it is acceptable, consideration is to be given to its mechanical strength, dielectric properties, insulation resistance, heat-resistant qualities, the degree that it is enclosed or protected, and any other features having a bearing on the risk of fire, electric shock, and injury to persons involved, in conjunction with conditions of actual service. All of these factors are to be considered with respect to thermal aging.

18.4 Screws or other fastenings used to mount or support small, fragile, insulating parts shall not be so tight as to crack or break such parts with expansion and contraction. Generally, such parts should be slightly loose.

19 Thermal Insulation

19.1 Combustible or electrically conductive thermal insulation shall not contact uninsulated live parts of the appliance.

19.2 With reference to 19.1, some types of mineral-wool thermal insulation contain conductive impurities in the form of slag that make their use unacceptable if they are in contact with uninsulated live parts.

20 Motors

20.1 A motor shall be capable of handling its maximum intended load without introducing a risk of fire or electrical shock.

20.2 A motor winding shall be such as to resist the absorption of moisture.

20.3 With reference to 20.2, film-coated wire need not be additionally treated to preclude absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorbent materials are to be impregnated or otherwise treated to preclude moisture absorption.

20.4 An appliance that is provided with a motor where the motor current is controlled by a triac or other solid-state device shall comply with the temperature test for motors used with solid-state controls, 36.7.1, and the Abnormal Operation Test on Motors Used With Solid-State Controls, Section 48.

20.5 A motor employed in a combination microwave oven vent hood fan shall either:

- a) Be located such that it will not be exposed to grease or cooking vapors;
- b) Be constructed so that accumulation of grease on the motor windings will be prevented – such as by use of a totally enclosed motor; or
- c) Comply with the requirements in Tests on Motors Exposed to Grease or Cooking Vapors, Section 59.

21 Motor Overload Protection

21.1 A continuous-duty motor in a permanently connected appliance, an automatically controlled fractional-horsepower motor in an appliance, the motor of an appliance intended to be operated unattended, a motor the operation of which or inability to operate will not be evident to the operator, and a continuous-duty integral-horsepower motor shall be provided with overload protection. The protection is to be as specified in 21.2. See 2.2.

Exception No. 1: A motor that is used for a direct drive blower or fan is considered to have overload protection if it is protected against locked-rotor conditions only.

Exception No. 2: A shaded-pole motor having a difference of 1 A or less between no-load and locked-rotor currents and having a 2:1 or smaller ratio between locked-rotor and no-load currents is to be considered to have overload protection if it is protected against locked-rotor conditions only.

21.2 Motor-overload protection required in 21.1 shall consist of one of the following:

- a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111.

Exception No. 1: When a product includes a control, such as a timer, that positively and reliably limits the length of time the product is able to operate, a shorter test duration for the Locked-Rotor Temperature and the Locked-Rotor Endurance tests meets the intent of the requirement. For this construction, the duration of these tests shall not be less than the time to which the control limits product operation.

Exception No. 2: When the time required to operate a manually reset protective device through 10 c of operation is longer than the time the product is intended to be operated during each use, less than 10 c of operation of the device for the Locked-Rotor Temperature Test meets the intent of the requirement. For this construction, the number of cycles shall be 4 c or the number of cycles required for maximum intended operating time of the product, whichever is longer.

Exception No. 3: A motor intended only for moving air and that has an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft is not required to have running overload protection.

- b) Impedance protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111, when the motor is tested as used in the product under stalled motor conditions.

- c) Other protection that is shown by tests to be equivalent to the protection specified in item (a).

21.2 revised January 16, 2003

21.2A Motor-overload protection provided for a product not required to have such protection shall:

- a) Comply with the requirements in 21.2, or
b) Be shown by test not to result in a risk of fire, electric shock, or injury to persons.

21.2A added January 16, 2003

21.3 Fuses may be used to provide the necessary overcurrent protection if compliance with the requirements will be provided by the largest ampere-rated fuse that can be mounted in the fuseholder or if a noninterchangeable fuse is used. The fuse used to provide this protection need not be of a type acceptable for branch-circuit protection.

22 Short-Circuit and Ground-Fault Protection

22.1 General

22.1.1 The overcurrent protection mentioned in 22.2.1 shall be of a type acceptable for branch-circuit protection.

22.1.2 A fuse, used as the overcurrent protection means referred to in 22.1.1, shall be Class CC, G, H, J, K, R, or T cartridge fuses or Type S or an Edison-base plug fuse.

22.1.3 It will be assumed that the rating of the branch-circuit overcurrent protective device will be 150 percent of the rating of the appliance unless the appliance is marked to specify the use of a protective device having a lower rating. Standard ampere ratings for overcurrent-protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, and 200. If 150 percent of the rating of the appliance does not equal one of the standard overcurrent-protective device ratings mentioned above, it will be assumed that the next lower rating or setting of overcurrent protective device will be employed.

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22.2 Motors and power transformers

22.2.1 A transformer and motor shall be protected by overcurrent protection:

- a) Rated 20 A or less,
- b) If the primary only is protected, the transformer protective device is rated or set at not more than 125 percent of the primary current, or
- c) If both primary and secondary circuits are protected, the transformer protective devices are rated or set at no more than 250 percent of the primary current and 125 percent of the secondary current.

Exception No. 1: The overcurrent protection need not be provided as part of the appliance if the overcurrent protection of the branch circuit with which the appliance will be connected will provide equal or better protection.

Exception No. 2: The overcurrent protection may be omitted from the primary of a transformer if there is no emission of flame or molten metal from the appliance enclosure when the transformer is operated under the conditions described in 22.2.3 and 22.2.4.

22.2.2 Ordinarily, a motor having an inherent thermal protector that complies with the requirements for such devices as acceptable with respect to the requirements in 22.2.1 if, in the appliance, it will be connected in series with a branch-circuit overcurrent-protective device of the same type and having a current rating equal to or less than that with which the motor-protector combination was tested during the investigation of the protector.

22.2.3 The transformer is to be operated continuously at the test voltage indicated in 35.2.1 and at rated frequency with the enclosure grounded. The load connected to the output terminals is to be a resistance of such value that three times the rated full-load current will be drawn from the secondary winding. Operation is to be continued until constant temperatures are indicated by a thermocouple on the transformer coil or until burnout, whichever occurs first. The circuit on which the transformer is tested is to be protected by fuses rated at not less than that required for the appliance. If accessible fuses are provided with the transformer, they are to be replaced by dummy fuses, but inaccessible fuses are to remain in the circuit.

Exception: The load may be connected to the output terminals as indicated in 22.2.4.

22.2.4 The burnout test is to be conducted with the output terminals of the transformer short circuited if such condition results in less than three times maximum normal current being drawn from the secondary. Otherwise, the test is to be conducted as follows:

- a) If the transformer controls a motor and the motor locked-rotor load plus the additional load on the transformer is equal to or greater than three times the full-load normal current, the test is to be conducted with output terminals connected to the motor with the rotor locked, and the other loads in parallel;
- b) If the transformer does not control a motor, the load imposed on the transformer by the coils of any solenoids, relays, or the like, with the armature of the largest such device blocked open, is determined, and the test is to be conducted with an equal resistance load substituted for the coils if this load is equal to or greater than three times the full-load normal current; or

- c) If under the conditions specified in (a) and (b) the current is less than three times the full-load normal current, the transformer is to be loaded in a manner such that the current is equal to three times the full-load normal current.

22.3 Receptacles

22.3.1 Attachment plug receptacles intended for general use shall have overcurrent protection rated not more than 20 A in the appliance unless the appliance would be properly connected, in accordance with 22.1.3 to a branch circuit rated 20 A or less.

23 Thermostats

23.1 A manually reset thermostat intended to be operated by the user shall be capable of being reset:

- a) From outside the appliance, or
- b) After opening a hinged door or the equivalent that does not give access to uninsulated live parts.

23.2 The reset button of a manually reset thermostat shall be protected from mechanical abuse and the construction shall provide for trip-free operation.

23.3 If a thermostat in a microwave cooking appliance has a marked off position, when the thermostat is set to the off position lowering of temperature or loss of capillary tube pressure shall not cause the contacts to close and the heating element or microwave generating circuits shall not produce heat. "No heat," "Cold," or the like are considered to be off markings.

23.4 A malfunction such as short-circuiting or changing of impedance of a pilot light or indicating lamp shall not affect the proper functioning of a temperature control system.

23.5 For the test required in 23.4, the series resistor of a gaseous discharge lamp is to be left in the circuit.

24 Thermal Cutoffs

24.1 A thermal cutoff shall be secured in place and shall be so located that it will be accessible for replacement without damaging other connections or internal wiring.

Exception: Thermal cutoffs that are an integral part of a component that necessitates replacement of the entire component, for example, thermal cutoffs embedded in the windings of motors, transformers, and the like are not required to be located so that it will be accessible for replacement without damaging or displacing other connections or internal wiring.

24.2 Wiring connected to a thermal cutoff shall be so secured that replacement of the cutoff will not result in displacement of internal wiring other than leads to the cutoff itself.

Exception: As noted in the Exception to 24.1.

24.3 A thermal cutoff shall comply with the requirements in the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020.

Exception: A thermal cutoff that is not relied upon to preclude a risk of fire, electric shock, injury to persons, or excessive radiation emission need not comply with the calibration requirements in UL 1020.

24.4 A thermal cutoff shall open the circuit in the intended manner without causing the short-circuiting of live parts and without causing live parts to become grounded to the enclosure when the appliance is connected to a circuit of voltage in accordance with 35.2.1 and operated to cause abnormal heating. See 24.5.

24.5 To determine whether a thermal cutoff complies with the requirement in 24.4 the appliance is to be operated with separate thermal cutoffs five times as described in 24.3 and 24.4 and with any other thermally operated control devices in the appliance short-circuited. Each thermal cutoff is required to perform acceptably. During the test, the enclosure is to be connected through a fuse rated 3 A, other than the time-delay type, to ground.

Exception No. 1: A thermal cutoff incorporated in an interlock monitor circuit shall be tested as specified in 43.1 and 43.2.

Exception No. 2: A completely encapsulated-type thermal cutoff that is not incorporated in an interlock circuit need not be subjected to this test.

25 Attachment-Plug Receptacles

25.1 An attachment-plug receptacle rated 15 or 20 A intended for general use shall be of the grounding type. The grounding contact of the receptacle shall be electrically conductively connected to the point of connection of the equipment-grounding conductor to the appliance.

26 Lampholders

26.1 A lampholder intended to be connected to a power-supply circuit without a grounded conductor shall be located so that a tool is required to change the lamp.

26.2 A screw-shell lampholder for an infrared lamp shall be of the unswitched medium-base type, and for use with a lamp rated 300 W or less.

Exception: A lamp-and-lampholder combination need not comply if an unacceptable temperature is not produced on any of the components in the temperature test, and if the switching mechanism of a switched lampholder is capable of performing acceptably without undue burning, pitting, and the like.

26.3 A lampholder screw shell of a cord-connected appliance shall not operate at a potential of more than 150 V to ground.

Exception: This requirement does not apply to a lampholder for a pilot light or indicating lamp.

26.4 A female screw shell used as a holder for a heating element shall be of copper or a copper base alloy and shall be plated with nickel or equivalent oxidation-resistant metal.

26.5 A lampholder shall not employ a paper liner if the lampholder is likely to be exposed to moist vapors during the operation of the appliance.

26.6 A lampholder constructed with a cavity depth less than that specified by the Standard for Edison-Base Lampholders, UL 496, may be used provided:

- a) The lamp is not user serviceable; or
- b) The lamp is user serviceable, and the appliance is marked in accordance with 64.1.9.

27 Switches and Controls

27.1 A switch shall be of a type intended for the particular application and shall have a current and voltage rating not less than that of the circuit (load) that it controls when the appliance is operated as described in Power Input Test, Section 35.

27.2 The current rating of a switch or other control device that controls a solenoid, a magnet, a transformer, an electric-discharge-lamp ballast, or another inductive load shall be at least twice the rated full-load current of the component that it controls unless the switch is rated for the particular application.

27.3 Any switch is acceptable for controlling a tungsten-filament load if its rating is more than six (for alternating current) or ten (for direct current) times the rating of the load, or if it is provided with a tungsten-filament load rating equal to or greater than the load it controls.

27.4 A switch shall be evaluated with respect to the temperature limitations of the materials employed.

27.5 A switch or other means of control intended to limit the number of heating elements used at one time shall be so located or of such type that the user cannot readily change the connections to use more elements than intended.

27.6 An appliance control containing solid-state components shall comply with the applicable requirements in the Standard for Solid-State Controls for Appliances, UL 244A.

27.7 An oven employing a temperature-regulating control, the malfunction or breakdown of which would result in a risk of fire, as determined by the Abnormal Operation Test, Section 47, and 78.1 and 78.2, during any operation including self-clean operation, shall be provided with a temperature-limiting control. The control shall open a sufficient number of ungrounded conductors to the heating elements to limit the oven temperature and shall be:

- a) A thermal cutoff;
- b) A manually reset control not capable of being reset from outside the appliance without using a tool to gain access to the reset mechanism; or
- c) An automatically reset control if a means, such as an indicator light or audible signal, is provided to alert the user that the oven is not operating normally when in the self-cleaning mode. See 27.9 and 27.10.