UL 201

STANDARD FOR SAFETY

Garage Equipment

UL Standard for Safety for Garage Equipment, UL 201

Third Edition, Dated March 31, 2015

Summary of Topics

This revision of ANSI/UL 201 dated April 7, 2023 includes added language to include electronic and web-based instruction manuals; 85.1, 85.1A, 85.1B, 85.5 and 85.6.

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 revised requirements are substantially in accordance with Proposal(s) on this subject dated December 2, 2022 and March 3, 2023.

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UL 201

Standard for Garage Equipment

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This ANSI/UL Standard for Safety consists of the Third edition including revisions through April 7, 2023.

The most recent designation of ANSI/UL 201 as an American National Standard (ANSI) occurred on April 7, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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 ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover equipment intended for use indoors in an automotive repair facility. Products covered by this standard are as indicated in 1.2. This equipment is intended to be installed and used in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 These requirements cover the following:

a) Equipment used in servicing and repairing automobiles, such as dynamometers, battery testers, roll-up brake lathes, distributor testers, driveway signals, engine analyzers, exhaust emissions testers, generator-alternator-regulator testers, growlers, ignition testers, rectifier diode testers, timing lights, fluid changing equipment, tire changers, tune-up testers, wheel alignment and balance equipment, and other similar equipment primarily for use in garages and service stations. These devices may be provided as a system of devices, including a console that houses control and utilization equipment for the system.

b) Powered and nonpowered tool cabinets, which may or may not be provided with a work surface. These products are intended to store tools in a repair facility or residential location.

c) Electrical requirements for equipment and systems used to provide power or control for automotive lifts.

1.3 With reference to 1.2(b), powered cabinets shall be powered by an electrical source not exceeding 240 Vac, and shall be cord connected. All other equipment covered by this standard is intended to be supplied by a power source not exceeding 600 Vac, and may be cord connected or permanently wired.

1.4 With reference to 1.2(c), the electrical system of electrically powered or controlled automotive lifts shall be shown to comply with UL 201. Automotive lifts as a complete system are not covered by this Standard and shall comply with the Standard for Automotive Lifts – Safety Requirements for Construction, Testing and Validation, ANSI/ALIALCTV, which contains additional requirements for automotive lifts, including such additional electrical requirements for automotive lifts that are intended to be installed out-of-doors.

1.5 Equipment intended for use in Class I, Division 1, and Class I, Division 2 hazardous locations as defined in the National Electrical Code, ANSI/NFPA 70, is investigated under these requirements, and, in addition, is investigated with respect to its acceptability for the particular application.

1.6 These requirements do not cover arc-welders, automotive battery chargers, electric or pneumatic tools, vacuum cleaners, equipment using refrigerants, or other equipment that is used in an automotive service or repair facility, but is covered by individual requirements.

1.7 These requirements do not cover portable tool chests or toolboxes intended to be transported by hand.

1.8 These requirements do not cover flammable liquid storage cabinets.

1.9 These requirements do not cover battery chargers, battery testers, or other equipment intended for the servicing of electric vehicles or electric vehicle battery packs.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirements 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.

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

2.4 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 Units of Measurement

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

3.2 Values of voltage and current are rms values, unless otherwise indicated.

4 Undated References

4.1 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.

5 Glossary

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

5.2 ACCESSIBLE PART – A part located so that it is able to be contacted by a person, either directly or by means of a probe.

5.3 AUTOMATICALLY CONTROLLED EQUIPMENT – Equipment is considered to be automatically controlled if:

a) The repeated starting of the equipment, beyond one complete predetermined cycle of operation to the point where some form of limit switch opens a circuit, is independent of any manual control;

b) During any single predetermined cycle of operation, the motor is caused to stop and restart one or more times;

c) Upon energizing the equipment, the initial starting of the motor may be intentionally delayed beyond normal conventional starting; or

d) During any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

5.4 BARRIER – A part providing protection against direct contact from any usual direction of access.

5.5 BONDED (BONDING) – The permanent joining of metallic parts to form an electrically conductive path that provides electrical continuity and the capacity to conduct any current likely to be imposed without a risk of electric shock, fire, or injury to persons.

5.6 BONDING JUMPER – A conductor, including a strap or similar part that is used to provide the required electrical conductivity between metal parts required to be electrically connected.

5.7 CABINET – Equipment that is provided with shelves and/or drawers intended to house hand tools or similar devices for permanent or temporary storage. This equipment may be provided with an electrical connection such that power can be made available within the cabinet and provide power to systems within the cabinet, such as convenience receptacles.

5.8 CLASS 2 SOURCE – A source having a limited voltage and energy capacity. Requirements for voltage and energy are as indicated in 29.4. See the Low-Voltage, Limited-Energy Measurements, Section 68.

5.9 CONSOLE – Equipment that is intended to house electrical or electronic equipment for the purpose of control, utilization, or diagnostic functions and is associated with an overall system, such as a wheel alignment system, automotive lift, or similar equipment.

5.10 DECORATIVE PARTS – A part of the equipment, outside the fire enclosure, which has no safety function.

5.11 ELECTRICAL ENCLOSURE – A part of the equipment intended to reduce the risk of contact with parts at potentials other than low-voltage, limited-energy circuits.

5.12 ENCLOSURE – A part of the equipment providing one or more of the functions described in 5.11, 5.14, or 5.23.

5.13 EQUIPMENT GROUNDING CONDUCTOR – The conductor used to connect the non-current carrying metal parts of equipment, raceways, and other enclosures, to the system grounded conductor, the grounding electrode, or both, at the service equipment or at the source of a separately derived system.

5.14 FIRE ENCLOSURE – A part of the equipment intended to minimize the spread of fire or flames from within.

5.15 GROUND – A conducting connection, whether intentional or not, between an electrical circuit and the earth.

5.16 GROUNDED – Connected to earth.

5.17 GROUNDED CONDUCTOR – A system or circuit conductor that is intentionally grounded.

5.18 HIGH VOLTAGE CIRCUIT – A circuit having a potential in excess of 2500 volts peak.

5.19 IN-SERIES MOTOR – A motor connected directly to the line voltage supply.

5.20 ISOLATING TRANSFORMER – A device that consists of a primary winding electrically connected to the supply wiring, and one or more secondary windings which are not conductively connected to the primary windings, and as such are isolated from the supply wiring.

5.21 LEAKAGE CURRENT – Any currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of equipment and ground or other conductive surfaces of equipment.

5.22 LOW-VOLTAGE, LIMITED-ENERGY CIRCUIT – A circuit involving a potential of not more than 30 volts rms (42.4 volts peak) or a direct voltage of not more than 60 volts and supplied by a battery, a Class 2 source, or a combination of an isolating transformer and a fixed impedance that, as a unit, limits the available energy as described in 29.4.

5.23 MECHANICAL ENCLOSURE – A part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards.

5.24 OPERATOR ACCESS AREA – An area in which, under normal operating conditions, one of the following applies:

a) Access can be gained without the use of a tool;

b) The means of access is deliberately provided to the operator; or

c) The operator is instructed to enter regardless of whether or not a tool is needed to gain access.

5.25 PORTABLE EQUIPMENT – Equipment that is moved to the workpiece or other location in order to perform the function for which it is intended. Generally, portable equipment is hand-held or hand-supported.

5.26 PRESSURE-RELIEF DEVICE – A pressure-actuated valve or rupture member designed to relieve excessive pressures automatically.

5.27 PRIMARY CIRCUIT – A circuit involving a potential of not more than 600 volts that is directly connected to the supply circuit.

5.28 PROTECTIVE GROUNDING – A system for connecting noncurrent carrying conductive parts of the equipment to ground.

5.29 RACEWAY – A completely enclosed channel intended specifically for the holding and routing of wiring, excluding communication and low voltage wiring unless provisions for such are provided. A raceway provides mechanical protection to the enclosed wiring.

5.30 RATED CURRENT – The input current of the equipment as declared by the manufacturer.

5.31 RATED FREQUENCY – The primary power frequency as declared by the manufacturer.

5.32 RATED FREQUENCY RANGE – The primary power frequency range as declared by the manufacturer, expressed by its lower and upper rated frequencies.

5.33 RATED VOLTAGE – The primary power voltage as declared by the manufacturer.

5.34 RATED VOLTAGE RANGE – The primary power voltage range as declared by the manufacturer, expressed by its lower and upper rated voltages.

5.35 REMOTELY CONTROLLED EQUIPMENT – Equipment that is not within the sight of the operator at the location of the starting device.

5.35.1 REPAIR GARAGE, MAJOR – A building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, and repairs that require draining of the motor vehicle fuel tank are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms.

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5.35.2 REPAIR GARAGE, MINOR – A building or portion of a building used for lubrication, inspection and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., oil, antifreeze, transmission fluid, brake fluid, air-conditioning refrigerants), brake system repairs, tire rotation, and similar routine maintenance work, including associated floor space used for offices, parking, or showrooms.

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5.36 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, or injury to persons.

5.37 SECONDARY CIRCUIT – A circuit supplied from a secondary winding of an isolating transformer.

5.38 SERVICE ACCESS AREA – An area, other than an operator access area, where it is necessary for service personnel to have access even with the equipment switched on.

5.39 SUPPLY CIRCUIT – The branch circuit supplying electrical energy to the equipment.

5.40 TOOL – A screwdriver or any other object which may be used to operate a latch, screw, or similar fixing means.

5.41 TRADE SIZE – A term used to distinguish between actual sizes and industry standard approximations for that size.

5.42 UNINSULATED LIVE PART – A part involving a risk of fire or electric shock that is bare or has insulation that is not rated for the end use operating conditions, such as voltage, temperature, or the like.

5.43 USER SERVICING – The replacing, cleaning, or adjusting done by the user as described in Servicing, Section 41.

CONSTRUCTION

6 General

6.1 All equipment shall be investigated for use indoors, with an operating ambient range of 5 – 40°C (41 – 104°F). Other environmental conditions specified by the manufacturer in the user manual shall also be considered.

6.2 Each electrical device provided as part of the overall equipment (e.g. printers, docking stations) shall have an appropriate electrical rating for the application.

6.3 Unless otherwise noted, all equipment is intended for use in a non-classified (ordinary) location. This can be accomplished by the physical location of installation where the equipment is intended to be used within a repair facility, or by integral construction features that allow the equipment to be used outside of the classified area as defined by the National Electrical Code, NFPA 70. For equipment that is intended to

be used within the classified area as defined by NFPA 70, additional hazardous location requirements shall be applied to verify the safe operation within that classified (hazardous) location. The area classification that applies is as defined for either a major repair garage or a minor repair garage. The area classification for a minor repair garage is less stringent than for a major repair garage and may include ordinary locations within the minor repair garage. All equipment intended for use within a minor repair garage shall be marked in accordance with 83.12.1. Equipment that is not marked in this manner can be installed in either a major or minor repair garage.

7 Assembly

7.1 Equipment shall be completely wired with all internal splices and electrical connections made before the equipment leaves the factory. Equipment may be shipped unassembled provided no internal wiring connections are to be made in the field, unless these connections are made by connectors or appliance couplers.

Exception: This requirement does not apply to field wiring connections for permanently connected products.

7.2 Any equipment that requires assembly in the field to any degree shall be provided with installation instructions detailing all assembly steps. See Instruction Manual, Section 84.

7.3 Equipment shall be so assembled that it will not be affected adversely by the vibration of normal operation. Brush caps in motors shall be tightly threaded or otherwise designed to prevent loosening.

7.4 All uninsulated live parts shall be enclosed in the final assembly.

7.5 An uninsulated live part shall be secured so that it will be prevented from turning or shifting in position, if such motion would result in a reduction of spacings below the minimum acceptable values.

7.6 A switch, lampholder, attachment plug receptacle, motor attachment plug, or similar component shall be mounted securely and shall be prevented from turning, see 7.7.

Exception: A lampholder for a non-replaceable lamp, such as a neon pilot or indicator light in which the lamp is sealed in a non-removable enclosure, need not be prevented from turning if rotation cannot reduce spacings below the minimum required.

7.7 A means for preventing the turning mentioned in 7.6 shall consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as the means for preventing turning of a small stem mounted switch or other device having a single hole mounting means.

7.8 Means shall be provided to reduce the risk of contact between the enclosure of equipment and a light fixture, other than at the intended mounting means. The means provided shall have the strength and rigidity to reduce the risk of distortion which facilitates installation in a manner other than as intended.

8 Frame and Enclosure Construction

8.1 General

8.1.1 The enclosure of garage equipment shall be formed and assembled so that it has the strength and rigidity required to resist the abuses to which it may be subjected without resulting in a risk of fire, electrical shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other defects.

8.1.2 Materials used to form an enclosure shall be metallic or nonmetallic. Metallic and nonmetallic materials shall comply with the applicable requirements in this standard. Additionally, nonmetallic materials shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.1.3 Nonpowered cabinets are not required to comply with the enclosure requirements in this section.

8.2 Fire enclosures

8.2.1 The fire enclosure of all equipment shall prevent molten metal, burning insulation, flaming particles, or similar materials from falling on combustible materials outside the enclosure.

8.2.2 A fire enclosure is required to cover all parts that are not contained within a low-voltage, limited-energy circuit. This includes components, wiring, motors, transformers, and the like.

8.2.3 Openings provided in the top of a fire enclosure shall comply with one of the following:

a) Not exceed 5 mm (1/5 inch) in any dimension;

b) Not exceed 1 mm (1/25 inch) in width regardless of length; or

c) Be so constructed that direct, vertical entry of a falling object is prevented from reaching such bare parts by means of a trap or restriction.

8.2.4 Openings provided in the sides of a fire enclosure shall comply with one of the following:

a) Not exceed 5 mm (1/5 inch) in any dimension;

b) Not exceed 1 mm (1/25 inch) in width regardless of length;

c) Be provided with louvers that are shaped to deflect outwards an external vertically falling object (see Figure 8.1 for details); or

d) Be so located that an object, upon entering the enclosure, is unlikely to fall on bare parts which are not considered low-voltage, limited energy (see Figure 8.2 for details).

Where a portion of the side of a fire enclosure falls within the area traced out by the 5 degree angle in Figure 8.3, the limitation in 8.2.5 on sizes of openings in bottoms of fire enclosures also apply to this portion of the side openings.

Figure 8.1

Example of louver design

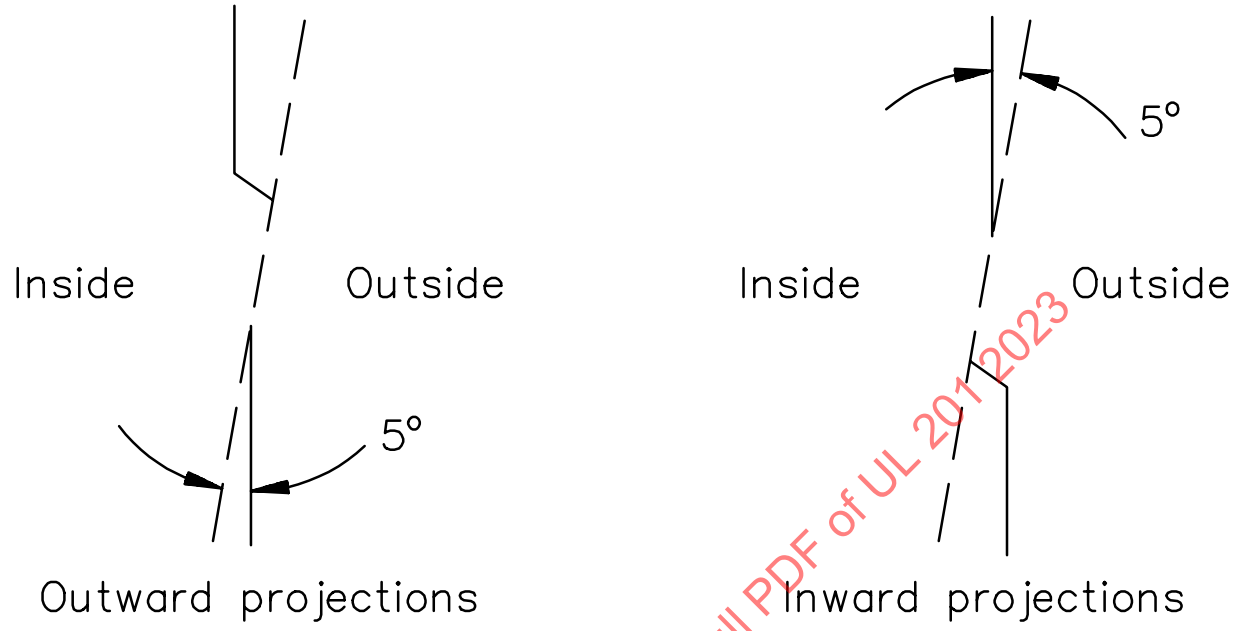

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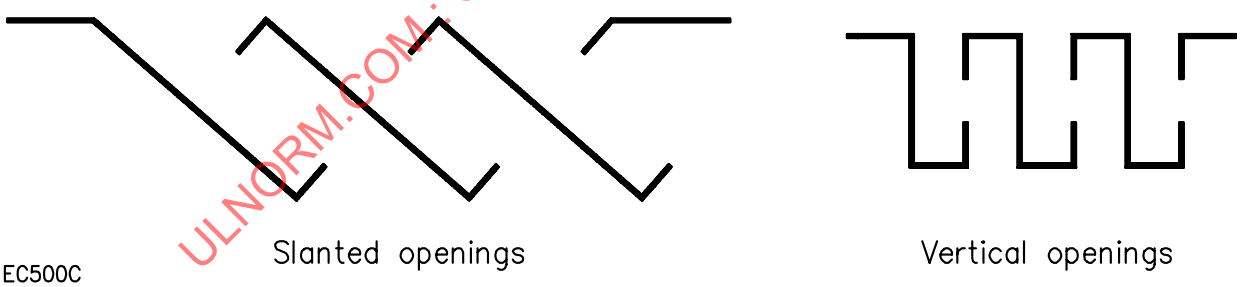
Figure 8.2

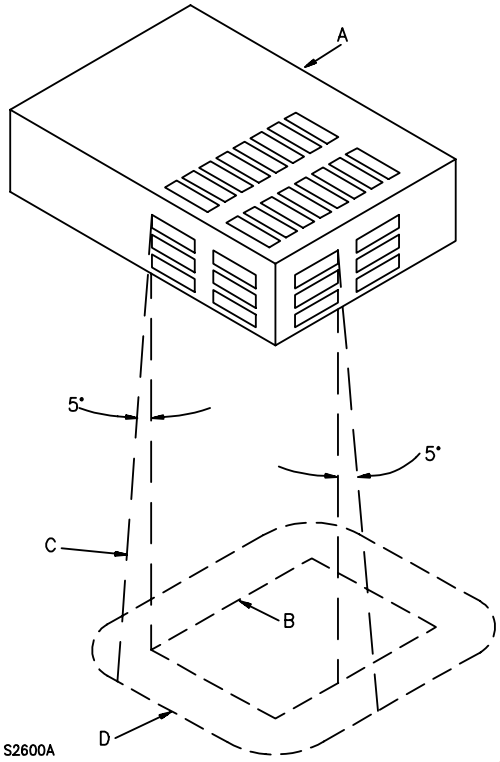
Examples of enclosure side openings



EC500C

Figure 8.3

Typical bottom of fire enclosure for partially enclosed components



A The portion of a component under which a FIRE ENCLOSURE is required, for example, under those openings in a component or assembly through which flaming particles might be emitted. If the component or assembly does not have its own FIRE ENCLOSURE, the area to be protected is the entire area occupied by the component or assembly.

B The outline of the area A projected vertically downward onto the horizontal plane of the lowest point of the FIRE ENCLOSURE.

C Inclined line that traces an outline D on the same plane as B. Moving around the perimeter of the outline B, this line projects at a 5° angle from the vertical at every point round the perimeter of the openings in A and is oriented to trace out the largest area.

D Minimum outline of the bottom of the FIRE ENCLOSURE. A portion of the side of a FIRE ENCLOSURE which is within the area traced out by the 5° angle is also considered to be part of the bottom of the FIRE ENCLOSURE.

8.2.5 Openings in the bottom of a fire enclosure shall comply with one of the following:

a) No openings in the bottom of a fire enclosure;

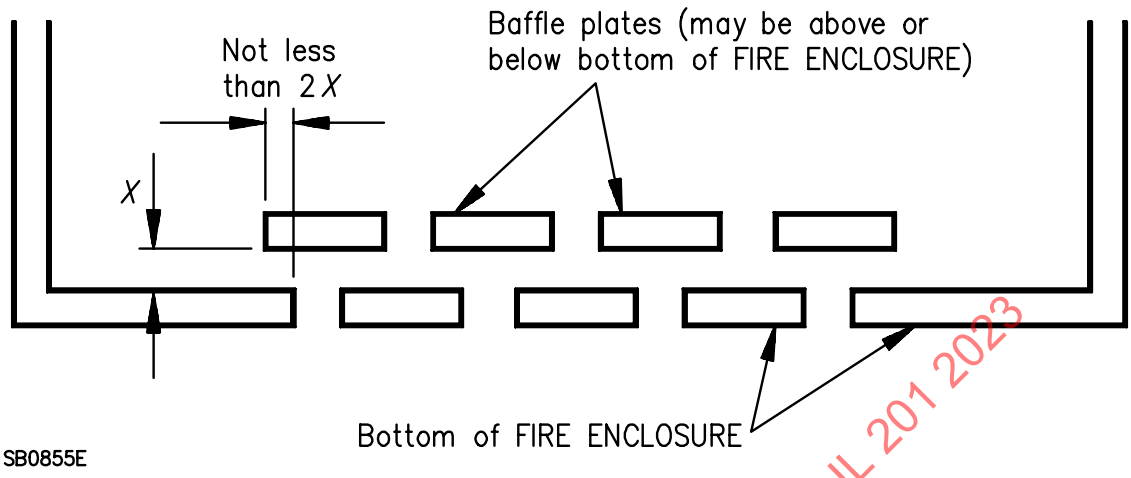
b) Openings in the bottom, each not larger than 40 mm^2 (0.06 $inch^2$) under components of flammability class V-1 or better, or parts made of material with flammability class V-1 better;

c) Baffle plate construction as illustrated in Figure 8.4;

d) Metal bottom screens having a mesh not greater than 2 mm by 2 mm (0.08 inch by 0.08 inch) and a wire diameter of not less than 0.45 mm (0.02 inch).

Figure 8.4

Baffle plate construction



8.2.6 If part of the fire enclosure consists of a door or cover leading to an operator access area, one of the following requirements shall apply:

a) The door or cover shall be interlocked to comply with the requirements in Interlocks, Section 25.

b) A door or cover, intended to be routinely opened by the operator, shall not be removable from the fire enclosure by the operator, and it shall be provided with a means to keep it closed during normal operation; or

c) A door or cover intended only for occasional use by the operator, such as for the installation of accessories, shall be permitted to be removable provided the equipment instructions include directions for correct removal and replacement for the door or cover.

8.3 Electrical enclosures

8.3.1 An electrical enclosure of equipment shall prevent the operator from contacting circuits other than low-voltage, limited-energy circuits. An electrical enclosure shall not provide access after being tested in accordance with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10.

8.3.2 Openings in the electric enclosure can be of any size provided the openings do not allow access to any hazardous circuits when tested in accordance with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10.

8.4 Mechanical enclosures

8.4.1 A mechanical enclosure shall prevent access to any hazardous moving part within the enclosure from operator contact. A mechanical enclosure shall not provide access after being tested in accordance with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10.

8.4.2 Openings in the mechanical enclosure can be of any size provided the openings do not allow access to any moving parts or pinch points when tested in accordance with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10.

8.5 Metallic enclosures

8.5.1 A metallic enclosure shall comply with the Strength of Enclosure Tests, Section 69.

8.5.2 For an unreinforced, flat surface in general, cast metal shall not be less than 3.2 mm (1/8 inch) thick, malleable iron shall not be less than 2.4 mm (3/32 inch) thick, and die-cast metal shall not be less than 2.0 mm (5/64 inch) thick.

Exception: Metal of lesser thickness but not less than 2.4 mm (3/32 inch), 1.6 mm (1/16 inch) and 1.2 mm (3/64 inch), respectively for cast metal, malleable iron, and die-cast metal, is acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape and size, or both of the surface is such that its mechanical strength is equivalent to that of a metal of the specified minimum thickness.

8.5.3 An enclosure of sheet metal shall be investigated with respect to its size, shape, thickness of metal, and its suitability for the particular application, considering the intended use of the complete equipment. Sheet steel having a thickness of less than 0.66 mm (0.026 inch) if uncoated or 0.74 mm (0.029 inch) if galvanized or of nonferrous sheet metal having a thickness of less than 0.91 mm (0.036 inch) shall not be used, except for relatively small areas or of surfaces that are curved or otherwise reinforced.

8.5.4 A metallic fire enclosure shall be considered to comply with flammability requirements without test.

8.6 Non-metallic enclosures

8.6.1 A polymeric enclosure shall comply with the Strength of Enclosure Tests, Section 69.

8.6.2 The minimum thickness for the polymeric material used shall be determined by its component recognition or by test.

8.6.3 The flammability of a nonmetallic enclosure shall comply with the appropriate requirement below:

a) For equipment with a total mass not exceeding 18 kg (40 lbs), the fire enclosure material shall have a flammability rating of V-1 minimum at the smallest thickness used: or

b) For equipment with a total mass exceeding 18 kg (40 lbs), the fire enclosure material shall have a flammability rating of 5-V at the smallest thickness used.

8.6.4 Enclosures of molded or formed thermoplastic material shall be constructed so that any shrinkage or distortion of the material over time will not allow for the user to be exposed to hazardous parts.

8.6.5 Non-metallic enclosures shall be subjected to the Stress Relief Test, 69.2.

9 Flammability of Materials and Components

9.1 General

9.1.1 Components and parts inside a fire enclosure shall be so constructed, or shall make use of such materials, that the propagation of fire is minimized.

9.1.2 In considering how to minimize the propagation of fire, and what are "small parts", account shall be taken of the cumulative effect of small parts when they are adjacent to each other, and also of the possible effect of propagating fire from one part to another.

9.2 Flammability

9.2.1 Except as specified elsewhere in this standard, all materials shall comply with one of the following:

a) They shall have a flammability rating of V-2 or better; or

b) They shall have a flammability rating of HF-2 or better.

Exception: This requirement does not apply to:

a) Components meeting the flammability requirements of a relevant component standard which includes such requirements;

b) Meter cases, meter faces, and indicator lamps that are part of a separate and distinct accessory;

c) Gears, cams, belts, bearings, and other small parts which would contribute negligible fuel to a fire provided they are separated from electrical parts, that under a fault condition would be likely to produce temperatures that could cause ignition, by 13 mm (1/2 inch) of air;

d) Tubing for air or fluid systems provided they are of flammability class HB or HBF or better;

e) Integrated circuit packages, transistor packages, optocoupler packages, capacitors, and other small parts mounted on a material of flammability class V-1 or better; and

f) Inflatable air bags used in dynamometers for raising and lowering the automobile onto the dynamometer, provided they are of flammability class HB or HBF or better and they are separated from electrical parts, that under a fault condition would be likely to produce temperatures that could cause ignition, by 13 mm (1/2 inch) of air.

9.2.2 Printed wiring board material for use in garage equipment shall have a flammability rating of V-1 minimum.

9.2.3 Air filter assemblies shall be constructed of materials of flammability class V-2 or better, or of HF-2 or better, except that the following constructions need not comply with this requirement:

a) Air filter assemblies in air circulating systems that are not intended to be vented outside the fire enclosure; or

b) Air filter assemblies located externally to the fire enclosure, constructed of materials of flammability class HB or HBF or better.

9.2.4 Parts of the equipment which are located external to the fire enclosure shall be constructed of materials of flammability class HB or better. This requirement also applies to mechanical and electrical enclosures provided they are located external to the fire enclosure.

9.2.5 Wood used as a frame or supporting part within an enclosure shall comply with the Wood Flammability Test, Section 80.

10 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

10.1 To reduce the likelihood of unintentional contact with an uninsulated live part, a film-coated wire, or a moving part, an opening in an electrical or mechanical enclosure shall comply with either of the following:

a) For an opening that has a minor dimension less than 25 mm (1 inch), such a part or wire shall not be contacted by the probe illustrated in Figure 10.1;

b) For an opening that has a minor dimension greater than 25 mm (1 inch), such a part or wire shall be spaced from the opening as specified in Table 10.1.

The minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

Exception No. 1: A motor other than one used in either a hand-held or hand-supported equipment, need not comply with these requirements if it complies with 10.2.

Exception No. 2: Insulated brush caps on motors are not required to be additionally enclosed.

Exception No. 3: A moving part or portion of a part that is necessarily exposed to perform the intended work function need not comply with this requirement.

Figure 10.1

Articulate probe

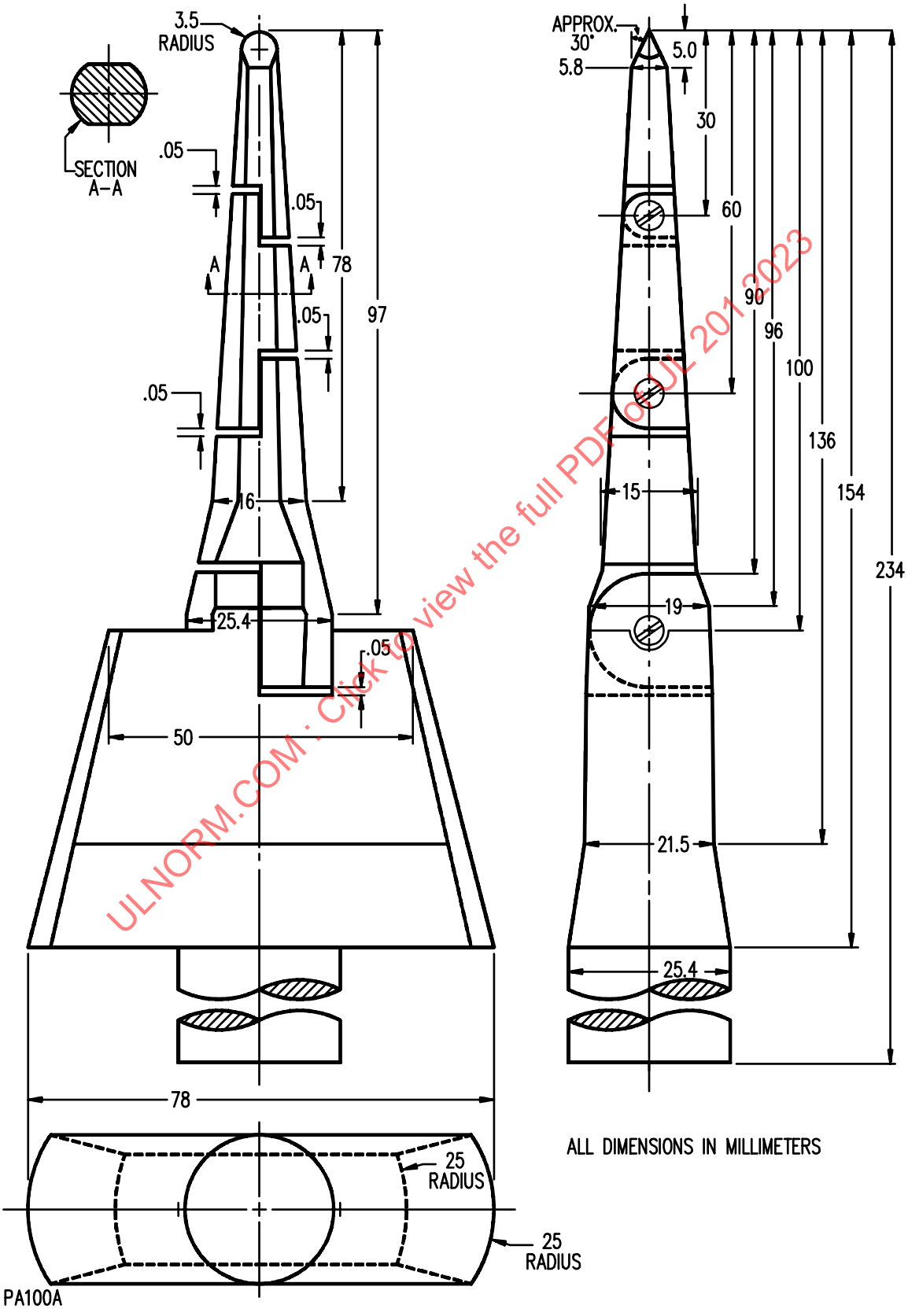


Table 10.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minimum dimension[a] of opening,		Minimum distance from opening to part,	
mm	(inches)[b]	mm	(inches)[b]
19[c]	(3/4)	110	(4-1/2)
25[c]	(1)	165	(6-1/2)
32	(1-1/4)	190	(7-1/2)
38	(1-1/2)	320	(12-1/2)
48	(1-7/8)	400	(15-1/2)
54	(2-1/8)	440	(17-1/2)
d		760	(30)

[a] See 10.1.

[b] Between 19 and 54 mm (3/4 and 2–1/8 inches) interpolation is to be used to determine a value between values specified in the table.

[c] Any dimension less than 25 mm applies to a motor only.

[d] More than 54 mm, but not more than 152.0 mm (6 inches).

10.2 For a part or wire specified in 10.1 that is an integral enclosure of a motor specified in Exception No. 1 to 10.1:

a) An opening that has a minor dimension less than 19 mm (3/4 inch) is acceptable if:

1) A moving part can not be contacted by the probe illustrated in Figure 10.4;

2) Film-coated wire can not be contacted by the probe illustrated in Figure 10.2;

3) In a directly accessible motor (see 10.5), an uninsulated live part can not be contacted by the probe illustrated in Figure 10.3; and

4) In an indirectly accessible motor (see 10.5), an uninsulated live part can not be contacted by the probe illustrated in Figure 10.4.

b) An opening that has a minor dimension of 19 mm (3/4 inch) or more is acceptable if a part or wire is spaced from the opening as specified in Table 10.1.

Figure 10.2

Probe for film-coated wire

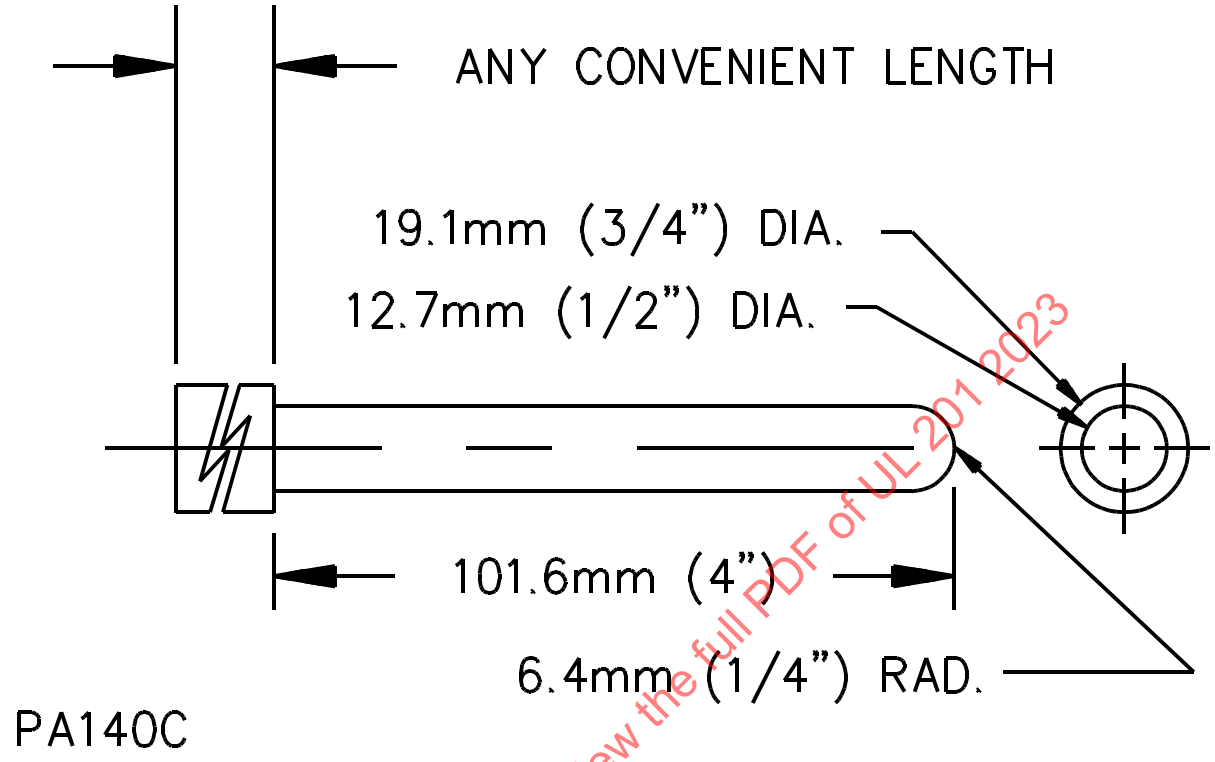


Figure 10.3

International Electrotechnical Commission (IEC) articulate accessibility probe with stop plate

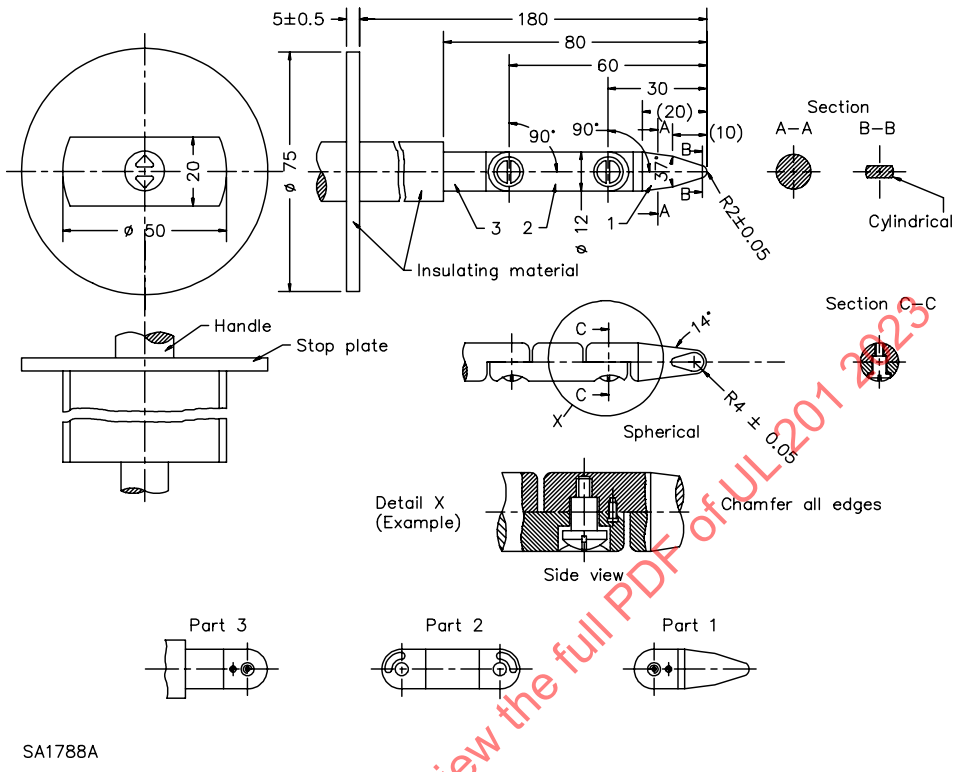
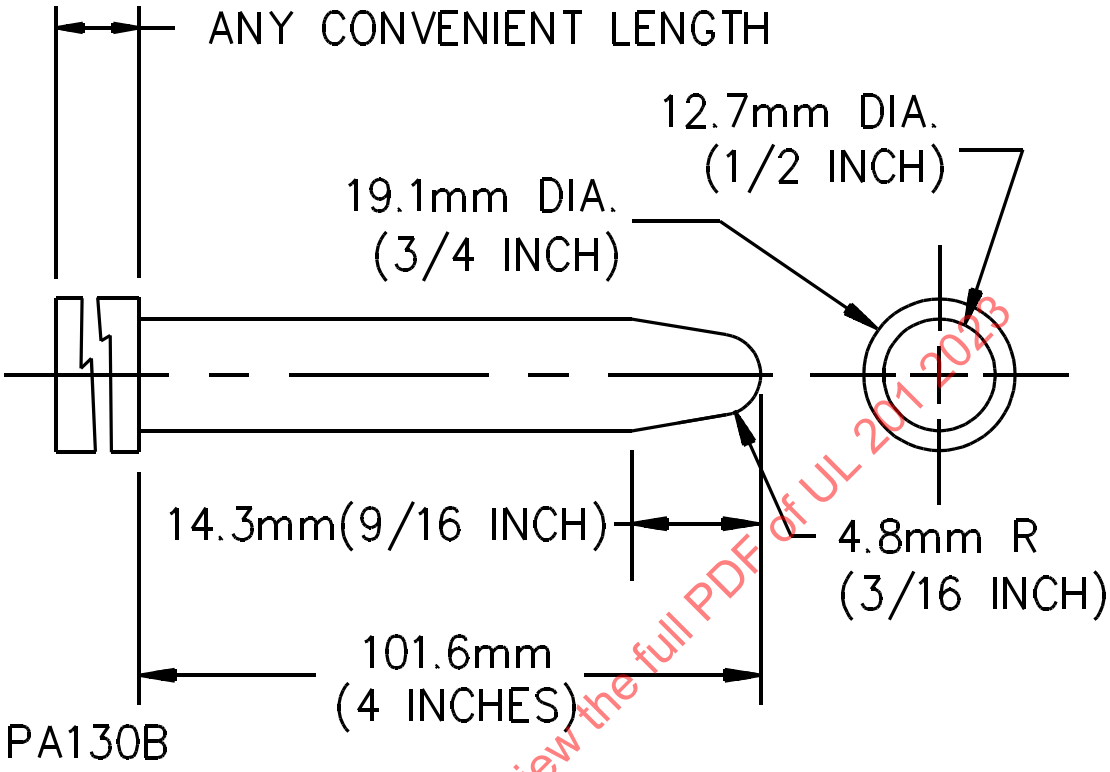


Figure 10.4

Straight probe



10.3 The probes specified in 10.1 and 10.2 and illustrated in Figure 10.1 – Figure 10.4, shall be applied to any depth that the opening will permit, and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figure 10.1 and Figure 10.3 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

10.4 The probed specified in 10.1 and 10.2 shall be used as measuring instruments to determine the accessibility provided by an opening, and not as instruments to determine the strength of material; they shall be applied with the minimum force necessary to determine accessibility.

10.5 With reference to 10.2:

a) An indirectly accessible motor is a motor that is accessible only by opening or removing a part of the enclosure, such as a guard or panel that can be removed without the use of a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted; and

b) A directly accessible motor is a motor that can be contacted without opening or removing any part or is so located as to be accessible to contact.

10.6 During the examination of equipment to determine compliance with 10.1 or 10.2, a part of the enclosure that can be opened or removed by the operator – either without the use of a tool or with instructions given to the user to open or remove the part of the enclosure – is to be opened or removed.

11 Protection Against Corrosion

11.1 An iron or steel part shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, if the deterioration or breakage of the part is likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: For constructions where 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 need not be protected against corrosion.

Exception No. 2: This requirement does not apply to bearings, laminations, or to minor parts of iron or steel, such as washers, screws, and the like.

11.2 If the failure of a gasket, seal, or liquid container provided as a part of the equipment is likely to result in a risk of fire, electric shock, or injury to persons; the gasket, seal or container shall be of a material that is resistant to corrosion by the liquid intended to be used therein.

12 Supply Connections

12.1 Cord connected equipment

12.1.1 Cord connected equipment shall be provided with a flexible cord and a grounding type attachment plug for connection to the supply circuit.

Exception No. 1: Plugs need not be furnished on non-detachable power cords provided with equipment when the equipment is marked in accordance with 82.4, and the instruction manual contains instructions as described in 85.7 concerning the proper selection of the plug.

Exception No. 2: Equipment intended to be used with a detachable power supply cord is acceptable without provision of the supply cord if the equipment is marked in accordance with 82.4, and the instruction manual contains instructions as described in 85.7 concerning the proper selection of the supply cord.

12.1.2 A flexible cord shall be rated for a voltage not less than the rated voltage of the equipment, and shall have a current rating not less than the current rating of the equipment.

12.1.3 A flexible cord for use on movable or stationary floor supported equipment, where the cord is in contact with the floor and could be subjected to abuse, shall be Type G, SO, STO, or W.

12.1.4 A flexible cord for use on equipment other than specified in 12.1.3 shall be Type G, SO, SJO, SJEO, SJOO, SJTO, SJTOO, SO, STO, or W, or a type at least equally serviceable for the particular application.

12.1.5 A flexible cord shall be attached permanently to the equipment or shall be in the form of a separate cord set with means for connection to the equipment, such as an attachment plug.

12.1.6 The length of an attached flexible cord, including the attachment plug, shall not be less than 1.8 m (6 feet).

Exception: A supply cord provided for use for other than direct connection to the branch circuit, such as a power supply cord for cabinet to cabinet power, may have an overall length less than 1.8 m (6 feet).

12.1.7 An attachment plug, provided with equipment with provision for use on two or more different values of voltage, either by field alteration of internal connections or by a voltage selector switch, shall be rated for the highest voltage rating on the equipment.

12.1.8 The equipment grounding conductor of a non-detachable power supply cord shall be green with or without one or more yellow stripes.

12.2 Strain relief

12.2.1 Strain relief shall be provided on a non-detachable flexible cord to reduce the risk of mechanical stress being transmitted to terminals, splices, or interior wiring. See Strain Relief Test, Section 65. A knot in the flexible cord is not considered an acceptable form of strain relief.

12.2.2 A metal strain relief clamp or band provided in accordance with 12.2.1 shall be provided with auxiliary insulation over the cord if damage to the cord insulation results when the strain relief test is conducted without auxiliary insulation.

12.2.3 Means shall be provided to prevent a flexible cord from being pushed into the equipment through the cord entry hole if such displacement would:

a) Result in mechanical damage to the cord;

b) Expose the cord to a temperature higher than that for which it is rated; or

c) Reduce spacings, such as to a metal strain relief clamp, below the acceptable minimum values.

To determine compliance, the supply cord or lead shall be tested in accordance with Push-back relief test, 65.3.

12.3 Bushings

12.3.1 At the point where a non-detachable flexible cord passes through an opening in a wall, barrier, or the enclosure, there shall be a bushing or the equivalent that is secured in place, and that has a smooth, well rounded surface against which the cord may bear. An insulating bushing shall be provided, if the wall or barrier is of metal, or if the construction is such that the cord may be subjected to strain or motion.

12.3.2 A hole in porcelain, phenolic composition, or other non-conducting material, having a smooth, rounded surface, is considered to be equivalent to a bushing.

12.3.3 In the frame of a motor or in the enclosure of a capacitor attached to a motor (but not elsewhere in the equipment), a separate soft-rubber, neoprene, or polyvinyl chloride bushing is acceptable if:

a) The bushing is not less than 1.2 mm (3/64 inch) thick; and

b) The bushing is located that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound employed.

12.3.4 A bushing of the same material as, and molded integrally with, a supply cord is acceptable if the built-up section is not less than 1.6 mm (1/16 inch) thick at the point where the cord passes through the enclosure.

12.3.5 At a point of flexure, no additional flexible cords or wires shall be routed through a bushing or opening with the power supply cord.

12.4 Permanently connected equipment

12.4.1 Permanently connected equipment shall have provision for connection to a wiring system for the supply circuit.

12.4.2 Sheet metal to which a supply circuit wiring system is to be connected shall not have a thickness less than 0.81 mm (0.032 inch) if uncoated steel, not less than 0.86 mm (0.034 inch) if galvanized steel, and not less than 1.14 mm (0.045 inch) if nonferrous.

12.5 Wiring compartments

12.5.1 A terminal box or compartment in which supply circuit connections are to be made shall be located so that wire connections therein are accessible for inspection after the equipment is installed as intended.

12.5.2 A terminal box or compartment attached to the equipment and intended for connection of a supply circuit wiring system shall be prevented from turning.

12.6 Wiring terminals and leads

12.6.1 Garage equipment shall be provided with wiring terminals for the connection of supply circuit conductors having an ampacity acceptable for the equipment; or the terminals shall be provided with leads rated for such connection.

12.6.2 The free length of lead inside an outlet box or wiring compartment shall be 156 mm (6 inches) or more if the lead is intended for connection to the supply circuit conductors.

Exception: A lead less than 156 mm in length is acceptable if the use of a longer lead is likely to result in a risk of fire or electric shock.

12.6.3 A wiring terminal shall be provided with a soldering lug or pressure terminal connector. The lug or connector shall be securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A wire binding screw or stud and nut combination may be employed at a wiring terminal intended for connection of a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

12.6.4 A wiring terminal shall be prevented from turning.

12.6.5 A wire binding screw or stud at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception: A No. 8 (4.2 mm diameter) screw or stud is acceptable at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

12.6.6 In accordance with the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest size conductor that shall be used for branch circuit wiring, and thus is the smallest conductor that is to be anticipated at a terminal for connection of a supply circuit wire.

12.6.7 A wire binding screw shall thread into metal. The screw shall engage to a depth of at least two full threads into the metal, which shall be a minimum of 1.27 mm (0.050 inch) thick. Extrusion of the metal at a tapped hole to provide at least two full threads is acceptable.

12.6.8 Permanently connected equipment rated 125 volts or 125/250 volts (3 wire) or less and employing a lampholder of the Edison screw shell type, or a single-pole switch or overcurrent protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be the one that is electrically connected to screw shells of lampholders and to which no switch or overcurrent protective device of the single-pole type, other than automatic control without a marked off position, is connected.

12.6.9 A terminal intended for the connection of a grounded supply circuit conductor shall be of, or plated with, metal that is substantially white in color and shall be readily distinguishable from other terminals, or the terminal shall be clearly identified in some other manner, such as an attached wiring diagram.

12.6.10 A lead intended for the connection of a grounded supply circuit conductor shall be finished white, gray, or white with a colored stripe other than green, and shall be readily distinguishable from the other leads.

13 Internal Wiring

13.1 Mechanical protection

13.1.1 Wiring and connections between parts of equipment shall be protected or enclosed so that the conductor insulation is not exposed to contact with any rough, sharp, or moving part.

13.1.2 Insulated wiring accessible through an opening in an electrical enclosure is considered to be protected as required in 13.1.1 if the accessibility complies with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10. Internal wiring not so protected may be acceptable if it is so secured within the enclosure that it is not likely to be subjected to stress or mechanical damage.

13.1.3 An opening in the frame or enclosure of the equipment through which insulated wires pass shall be provided with a smooth, well rounded bushing or shall have smooth, well rounded surfaces upon which the wires may lie.

13.1.4 Insulated wires, complying with the requirements of Separation of Circuits, Section 17, may be bunched and passed through a single smooth opening in a wall within the enclosure of the equipment.

13.2 Wiring insulation

13.2.1 The internal wiring of garage equipment shall be of a type rated for the application, when considered with respect to the temperature and voltage involved, with respect to its exposure to oil and grease, and with respect to other conditions of service to which it is subjected.

13.2.2 The insulation of wiring used in a high voltage circuit shall have a flame retardant rating of VW-1 in accordance with the requirements in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

13.2.3 Sleeving, tape, and tubing used for insulation on wires shall be rated for the voltage and temperature involved.

13.3 Splices and connections

13.3.1 Splices and connections shall be mechanically secure and provide electrical contact. A soldered connection shall be made mechanically secure before being soldered.

13.3.2 Equipment subject to vibration shall be provided with lock washers or other means to mechanically secure wire binding screws and nuts. A twist on type connector shall be additionally secured to the wires by means of at least two layers of tape. Tape used for this means shall be suitable for use and comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510.

13.3.3 A splice shall be provided with insulation equivalent to that of the wires connected if spacing between the splice and other metal parts is not maintained.

13.3.4 Insulation consisting of two layers of tape is acceptable on a splice if the voltage involved is less than 250 volts. In determining if splice insulation is acceptable, consideration is given to such factors as its dielectric properties, heat resistance, and moisture resistance. Tape shall not be wrapped over a sharp edge.

13.3.5 If internal wiring is stranded, loose strands of wire shall not contact other uninsulated live parts of opposite polarity, or dead metal parts. At a wire binding screw, this may be accomplished by using upturned lugs, a cupped washer, barriers, or other equivalent means to hold the wires under the head of the screw. Other acceptable means of retaining the loose stranded internal wiring in position are use of a pressure terminal connector, soldering lug, or crimped eyelet.

13.3.6 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 that is acceptable for the combination of metals involved at the connection point.

13.3.7 With reference to 13.3.6, a wire binding screw or a pressure terminal connector used as a terminating device shall be rated for use with aluminum under the condition involved – for example, temperature, heat cycling, vibration, and the like.

13.3.8 For floor-supported garage equipment that is located within the area defined as classified by the National Electrical Code, ANSI/NFPA 70, the external connectors shall be located not less than 460 mm (18 inches) above the floor level, and the product shall be marked in accordance with 83.11. For all garage equipment that is intended for use only within the non-classified (ordinary) location of a minor repair garage, the equipment shall be marked in accordance with 83.12.1.

Exception: Garage equipment with external connectors which are not inherently located above 460 mm (such as in table top or wall mounted equipment) and are marked in accordance with 83.12 need not comply with this requirement.

14 Interconnecting Cords and Cables

14.1 For external interconnection between individually enclosed sections of the same equipment or between individual equipment, a flexible cord shall be of a type specified in 12.1.3 or 12.1.4 based on the type of equipment, or an equivalent flexible cable assembly shall be used.

Exception No. 1: A type of flexible cord or flexible cable assembly other than specified is acceptable for connection of a low-voltage, limited-energy circuit.

Exception No. 2: A type of flexible cord or flexible cable assembly other than specified is acceptable if the equipment complies with the Cable Arcing Test, Section 71.

14.2 A permanently attached cord or cable shall be provided with a bushing, strain relief, and means to reduce the risk of the cord or cable from being pushed through the cord entry hole into the equipment, or from experiencing any undue stress on internal connections.

14.3 When inserting a male connector in a female connector, misalignment of male and female connectors and other manipulations of parts that are accessible to the operator shall not result in a risk of fire, electric shock, or injury to persons.

14.4 External cables shall not terminate in an exposed contact, unless the exposed contact is at ground potential and provides no energy source.

15 Grounding and Bonding

15.1 Grounding

15.1.1 A product shall have provision for grounding all exposed non-current carrying conductive parts that may become energized. There shall also be provision for grounding all internal, uninsulated non-current carrying parts that can become energized and that can be contacted during servicing by the user or service personnel. A part shall be considered capable of becoming energized if failure of electrical spacing or insulation or both can result in conductive connection to a current carrying part.

Exception: Equipment provided with a system of double insulation in lieu of grounding need not comply. See 15.1.2.

15.1.2 Equipment marked as double insulated shall not be provided with a means for grounding and shall comply with the requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

15.1.3 Double insulated equipment shall bear the marking indicating this fact. The square in a square marking (IEC 417, No. 5172) ⧈ shall be indicated adjacent to the ratings on the device.

15.1.4 With reference to 15.1.1, the following dead metal parts are not considered likely to become energized:

a) Small metal parts such as adhesive-attached foil markings, a screw, a handle, and the like, that is on the exterior and separated from all electrical components by grounded metal or is otherwise electrically isolated from all electrical components;

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

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

d) A door or the like that can only become energized through a grounded part; or

e) Cores and assembly screws of relays, solenoids, and the like.

15.1.5 All non-current carrying conductive parts shall be bonded together and to the electrical supply equipment grounding means in accordance with Bonding, 15.2.

15.1.6 Connection to the electrical supply equipment grounding means shall be accomplished by connection to the equipment grounding conductor of the power supply cord.

15.1.7 An equipment grounding conductor of a power supply cord shall be connected to the grounding blade of the attachment plug.

15.1.8 The grounding conductor of a supply cord, or the grounding terminal of the appliance inlet, shall be secured to the frame or enclosure of the equipment by means of a screw or a dedicated stud and nut, that is not to be removed during servicing purposes other than servicing the cord. Solder alone shall not be used for securing the grounding conductor.

Exception: A quick connect that complies with the requirements in 15.1.11 meets the intent of this requirement.

15.1.9 A screw used to secure the grounding conductor to the frame shall engage the metal by at least two full threads. The metal thickness shall not be less than 1.27 mm (0.050 inch) thick. Extrusion of the metal is acceptable to increase the effective thickness. Only the supply cord grounding conductor shall be secured by the grounding screw. The screw shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent means, as needed to retain a 10 AWG conductor under the head of the screw. A sheet metal screw shall not be used.

15.1.10 A stud and nut combination used to secure the grounding conductor to the frame shall be secured to the frame by welding the stud in place. The ground conductor shall be connected first and be in contact with the frame and secured in place by a dedicated nut and lock washer. Other bonding jumpers may be connected to the stud, but they shall be connected above the main ground connection and secured by separate nut and lock washers.

15.1.11 A quick connect used in accordance with the Exception to 15.1.8 shall comply with the following:

a) The quick connect terminal connection shall not be in an area subject to mechanical stresses that affect the continuity of the connection;

b) The terminal shall be in a location that is not subject to disturbance during servicing; and

c) The male and female connections shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

15.1.12 The grounding conductor of cord connected equipment shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

15.1.13 A separable connection, such as that provided by an attachment plug and a mating connector or receptacle, shall be such that the equipment grounding connection is made before connection to and broken after disconnection from the supply conductors.

15.1.14 For equipment intended to be grounded and that is provided with a means for separate connection to more than one power supply source, each such connection shall be provided with a means for grounding.

15.1.15 The principal equipment grounding conductor or path shall not include a trace of a printed wiring board.

15.1.16 Grounding conductors shall be either bare or insulated. When insulated, the surface of the insulation shall be green with one or more yellow stripes.

15.1.17 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal shaped, slotted or both.

15.1.18 Any connection intended for connection of an equipment grounding conductor shall be plainly identified with the ground symbol in a circle (IEC 417, No. 5019) ⏚. This mark shall not be used for any other bonding terminals.

15.1.19 The voltage drop between the point of connection of the equipment grounding conductor, at or within the equipment, and any other point in the grounding circuit shall not be more than 4 volts when measured as described in the Grounding Circuit Reliability Test, Section 57.

15.2 Bonding

15.2.1 A conductor, including a strap, jumper, or similar part, that is used only for bonding shall:

a) Be of copper, copper alloy, aluminum, or other material that has been investigated and found acceptable for use as an electrical conductor;

b) Be protected from mechanical damage;

c) Not be secured by a removable fastener used for any other purpose other than bonding unless the bonding conductor is not likely to be omitted after removal and replacement of the fastener; and

d) Have the flexibility needed to withstand mechanical stress due to vibration of flexing during use.

15.2.2 Metal parts in a bonding path shall be galvanically compatible so as to reduce electrolytic action between dissimilar metals.

15.2.3 Bonding shall be by a positive means, such as by a clamp, rivet, bolt, screw, welded joint, or a soldered or brazed joint using materials having a softening or melting point higher than 454°C (850°F). Terminals complying with the requirements in the Standard for Electrical Quick-Connect Terminals, UL 310, are acceptable to connect bonding conductors in sizes 19 – 14 AWG under the following conditions:

a) For conductor sizes 18 – 16 AWG, the minimum connector and tab width shall be 2.8 mm (0.110 inch).

b) For conductor size 14 AWG, the minimum connector and tab width shall be 6.4 mm (0.250 inch).

c) Quick connect tabs shall not be less than 0.8 mm (0.032 inch) thick.

15.2.4 A bonding screw shall engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining a 10 AWG conductor under the head of the screw.

15.2.5 A bonding connection means shall penetrate nonconductive coatings, such as paint or vitreous enamel.

15.2.6 A metal-to-metal hinge bearing member of a door or cover used as a means for binding the door or cover shall be of the multiple-bearing –pin (piano) type.

15.2.7 In a product provided with a power supply cord and an attachment plug:

a) A copper bonding jumper, including a clamp or strap, shall have a cross sectional area not less than that of the equipment grounding conductor of the power supply cord.

b) An aluminum bonding jumper, including a clamp or strap, shall have a cross sectional area not less than that of a conductor two AWG sizes larger than the circuit equipment grounding conductor of the power supply cords.

Exception: A conductor, including a strap, jumper, or similar part, for a component or electrical enclosure, need not be larger than the largest conductors supplying power to the component or component adjacent to the dead metal parts.

16 Current Carrying Parts

16.1 A current carrying part shall be silver, copper, a copper alloy, stainless steel, or other material rated for the particular application.

16.2 Ordinary iron or steel shall not be used for a current carrying part unless it is within a motor or associated governor.

17 Separation of Circuits

17.1 Conductors of different circuits operating at different potentials shall be separated or segregated from each other unless each conductor is provided with insulation acceptable for the highest potential involved.

17.2 An insulated conductor shall be positioned so that it cannot contact an uninsulated live part of a different circuit.

17.3 In a compartment that is intended for field installation of conductors, and that contains provision for connection of Class 2 or Class 3 circuit conductors, and Class 1, power or lighting circuits; a barrier shall be provided to separate the conductors of the different circuits, or the arrangement of the compartment shall be such that a minimum of 6.4 mm (1/4 inch) is maintained between the conductors of different circuits including the conductors to be field installed.

18 Insulating Material

18.1 Insulating materials, used in circuits other than low-voltage, limited-energy circuits, shall be porcelain, phenolic composition, or other similar material, and shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

18.2 Ordinary vulcanized fiber is acceptable for insulating bushings, washers, separators, and barriers, but shall not be used as the sole support for uninsulated live parts if shrinkage, current leakage, or warpage is likely to result in a risk of fire, electric shock, or injury to persons.

18.3 A thermoplastic material shall not be used for the sole support of live parts unless it complies with all of the following:

a) Adequate mechanical strength;

b) Adequate rigidity;

c) Resistance to heat;

d) Resistance to flame propagation;

e) Dielectric withstand; and

f) Resistance to abnormal heat.

18.4 Small molded parts, such as brush caps, shall be constructed to have adequate mechanical strength and rigidity to withstand the stresses of service. Brush caps shall be secured or located to be protected from mechanical damage that may result during normal use.

19 Motors

19.1 Construction

19.1.1 A motor used in garage equipment shall comply with the relevant requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

19.1.2 A motor shall be rated for the particular application and shall operate under the maximum normal load as described in 57.2 without resulting in a risk of fire, electric shock, or injury to persons.

19.1.3 A motor winding shall resist the absorption of moisture as determined by Humidity Conditioning, Section 55.

19.1.4 With reference to 19.1.3, film coated wire is not required to be additionally treated to resist absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture absorptive materials shall be provided with impregnation or otherwise treated to resist moisture absorption.

19.2 Location

19.2.1 For floor-supported garage equipment that is located within the area defined as classified by the National Electrical Code, ANSI/NFPA 70, the motor shall be installed not less than 460 mm (18 inches) above floor level and the product shall be marked in accordance with 83.11. For all garage equipment that is intended for use only within the non-classified (ordinary) location in a minor repair garage, the equipment shall be marked in accordance with 83.12.1.

Exception No. 1: Garage equipment provided with a motor evaluated for use in Class I, Division 1, or Class I, Division 2, or Class I, Zone 0, or Class I, Zone 1, or Class I, Zone 2, Hazardous Location, as appropriate, as defined in the National Electrical Code, ANSI/NFPA 70, is not required to comply with this requirement.

Exception No. 2: Garage equipment with motors which are not inherently located above 460 mm above the floor level (such as in table-top or wall mounted equipment) that is marked in accordance with 83.12, is not required to comply with this requirement.

19.3 Brush wear out

19.3.1 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 shall be retained to the degree required so as not to result in accessible dead metal parts to become energized or live parts to become accessible.

19.4 Motor overload protection

19.4.1 Continuous duty motors used in garage equipment shall incorporate thermal or overload protection to protect the equipment under a locked rotor or overload condition, by means of:

a) Thermal and impedance protection complying with the applicable requirements in the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3 when the motor is tested as used in the equipment under stalled rotor conditions or overload conditions; or

b) An appropriately sized magnetic motor starter (motor contactor and motor overload relay combination) complying with the applicable requirements of Part II of the Standard for Industrial Control Equipment, UL 508; or

c) An appropriately sized manual motor starter (motor contactor and motor overload relay combination) complying with applicable requirements of Part III of the Standard for Industrial Control Equipment, UL 508; or

d) Other protection that is shown by test to be equivalent to the product specified in (a). Testing shall be conducted in accordance with Motor Tests, Section 60.

Exception: Motor overload protection need not be provided with the equipment where the equipment is marked according to Section 83.22.

19.4.2 The functioning of a motor protective device provided as part of garage equipment shall not result in a risk of fire, electric shock, or injury to persons.

19.4.3 Overload devices and fuses employed for running overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single phase supply system and in each ungrounded conductor of a three phase supply system.

19.4.4 In reference to 19.4.3, an overload protective device is one that is responsive to motor current and is rated or set as specified in column A of Table 19.1. If the rating of the motor running overload protection determined in accordance with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal trip motor switch, the next higher size, rating or setting may be used, but shall not be more than that specified in column B of Table 19.1. For a multispeed motor, each winding connection is to be considered separately.

Table 19.1
Maximum rating or setting of overload-protective device

Type of motor	Ampere rating of device as a percentage of motor full-load current rating	
	A	B
Motor with marked service factor of 1.15 or more	125	140
Motor with marked temperature rise of 40°C or less	125	140
Any other motor	115	130

19.4.5 A motor intended to move air only by means of an air moving fan that is integrally attached to the motor shaft is not required to have running overload protection, but it shall have locked rotor protection.

19.4.6 For a multispeed motor that employs a separate overload protective device to provide running overload protection, the requirements in 19.4.1 applies at all speeds at which the motor is intended to operate.

20 Capacitors

20.1 A capacitor, provided as part of a capacitor motor, shall be housed within an enclosure that will protect the plates against mechanical damage and that will reduce the risk of the emission of flame or molten material as a result of malfunction of the breakdown of the capacitor. Compliance with this requirement shall not rely on the body of the capacitor alone.

20.2 A capacitor that is connected across the supply circuit shall comply with Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains, IEC 60384-14, subclass X1 or X2. A capacitor that is connected between the supply circuit and exposed metal parts shall comply with IEC 60384-14, subclass Y1, Y2, or Y4.

20.3 A capacitor employing a liquid or wax dielectric medium more combustible than askarel shall comply with the requirements in the Standard for Capacitors, UL 810.

20.4 A capacitor shall have a marked voltage rating that is equal to, or exceeds, its operating voltage in the equipment.

21 Lampholders

21.1 A screw shell or screw shell contact of an Edison-screw lampholder shall be wired so that the screw shell is connected to the grounded conductor of the power supply circuit or the grounded conductor of the supply cord.

Exception: A screw shell lampholder installed in a low-voltage, limited-energy circuit need not comply with this requirement.

21.2 A medium based screw shell lampholder shall not be used in a circuit operating at more than 150 volts.

21.3 Lampholders shall have all wiring terminations and connections enclosed within the insulating body of the lampholder or they shall be enclosed is a suitable manner.

22 Printed Wiring Boards

22.1 A printed wiring board shall comply with the requirements in the Standard for Printed Wiring Boards, UL 796 and shall have a minimum flammability rating of V-1 minimum.

22.2 Printed wiring boards, consisting of multiple populated layers, shall have a minimum thickness of 0.4 mm (1/64 inch) for each layer of the board.

23 Receptacles

23.1 A 15 or 20 ampere general use attachment plug receptacle shall be of the grounding type and shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498. The grounding contact of the receptacle shall be connected to dead metal intended to be grounded when the equipment is in use.

23.2 Each receptacle circuit in equipment having one or more attachment plug receptacles intended for general use shall have overcurrent protection rated not more than 20 amperes provided as a part of the equipment when the overcurrent protection of the branch circuit to which the equipment is connected in accordance with the National Electrical Code, ANSI/NFPA 70, exceeds that intended for the receptacle.

23.3 For floor-supported garage equipment that is located within the area defined as classified by the National Electrical Code, ANSI/NFPA 70, the receptacles shall be located not less than 460 mm (18 inches) above the floor level and the product shall be marked in accordance with 83.11. For all garage equipment that is intended for use only within the non-classified (ordinary) location in a minor repair garage, the equipment shall be marked in accordance with 83.12.1.

Exception: Garage equipment with receptacles which are not inherently located 460 mm above the floor level (such as in table top or wall mounted equipment) that is marked in accordance with 83.12, is not required to comply with this requirement.

23.4 Powered cabinets provided with a general-purpose receptacle shall be marked in accordance with 84.1 at the receptacle so that the combined ampacity of the product operated under maximum normal load

and the equipment connected to the receptacle does not exceed the rating of the product. A general purpose receptacle shall not increase the risk of fire, electric shock, or other injury to the user.

23.5 The face of a general-purpose receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface, or

b) Project at least 0.4 mm (0.015 inch) beyond a conductive surrounding surface.

23.6 In a powered cabinet, the face of a receptacle mounted on the work surface shall be vertical or the receptacle shall comply with the Spill Test, Section 72.

24 Switches and Controls

24.1 General

24.1.1 A switch, or other control device, shall have a current and voltage rating not less than that of the load it controls.

24.1.2 With reference to 24.1.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric discharge lamp ballast, shall not be less than twice the rated full-load current of the transformer or ballast unless the switch has been investigated and found acceptable for the application.

24.1.3 A line connected, single-pole switch or an overload protective device of the single-pole type, other than an automatic control without a marked off position, shall be connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

24.2 Location

24.2.1 For floor-supported garage equipment that is located within the area defined as classified by the National Electrical Code, ANSI/NFPA 70, a switch, relay, solenoid, or other control device shall be installed not less than 460 mm (18 inches) above floor level, and the product shall be marked in accordance with 83.11. For all garage equipment that is intended for use only within the non-classified (ordinary) location in a minor repair garage, the equipment shall be marked in accordance with 83.12.1.

Exception No. 1: Garage equipment provided with a switch, solenoid, relay, or other control device, evaluated for use in a Class I, Division 1 or Class I, Division 2, or Class I, Zone 0, or Class I, Zone 1, or Class I, Zone 2, Hazardous Location, as appropriate, as defined by the National Electrical Code, ANSI/NFPA 70, is not required to comply with this requirement.

Exception No. 2: Garage equipment provided with control devices that are not inherently located 460 mm above the floor level (such as in table top or wall mounted equipment) that is marked in accordance with 83.12, is not required to comply with this requirement.

24.3 Controls for solenoids, relay coils, and the like

24.3.1 A switch or other control device which controls a solenoid, relay coil, or the like, and that is not rated for the application shall perform acceptably when subjected to the overvoltage test described in 66.1.2.

24.4 Controls for motors

24.4.1 A switch or other device that controls a motor shall comply with 66.2.2.

24.5 Controls for medium base lampholders

24.5.1 A switch that controls a lampholder for an incandescent lamp other than a 15 watt or smaller pilot or indicating lamp:

a) Shall be suitable for use with tungsten filament lamps;

b) Shall have a current rating greater than or equal to six times the steady state tungsten load for alternating current or ten times the steady state load for direct current; or

c) Shall comply with the test prescribed in 66.3.1.

24.6 Actuation of switches and controls

24.6.1 Devices shall be constructed such that unexpected operation of a part shall not result in a risk of injury to persons.

24.6.2 Each function of multiple-function equipment is to be taken into consideration in determining compliance with 24.6.1.

24.6.3 A motor control switch, other than a momentary contact switch, shall have a plainly marked off position, if when energized the equipment has a moving part and the switch is relied upon to reduce the risk of injury to persons.

24.6.4 The actuator of a switch shall be located or guarded so as to reduce the risk of unintentional operation of the switch, when said operation may result in a risk of injury to persons.

24.6.5 Guarding of the actuator of a switch shall be by means of recessing, ribs, barriers, or the like.

24.6.6 A device that automatically starts equipment, such as a timer, an automatically reset overload protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

25 Interlocks

25.1 An interlock required to reduce the risk of electric shock or injury to persons shall comply with 25.2 – 25.9.

25.2 The interlock device shall not be defeated readily without:

a) Damaging the equipment;

b) Making wiring connections or alterations;

c) Using other than ordinary tools; or

d) Using materials other than those readily available. Adhesive tape, string, or conventional extension cord sets are identified as readily available.

25.3 The interlock device shall be such that during normal operation and user servicing:

a) The interlock is not defeated by improper disassembly, for example, removal of the wrong screws during removal of the cover;

b) The cover in which the interlock is mounted shall not be rotated by its own weight about the interlock axis perpendicular to the cover during any stage of its removal or replacement, if such rotation gives access to a live part, or damages the interlock or cover;

c) The act of removal or replacement of the interlocked cover shall not subject the user to unintentional contact with live parts;

d) The interlocked cover is not capable of being readily misapplied to result in a risk of electric shock; and

e) The equipment is marked in accordance with 83.10.

25.4 If two momentary contact switches must be operated to energize the equipment, the arrangement shall be spaced from each other and from live parts so that, if the means are operated simultaneously by one individual, contact with live parts shall not occur.

25.5 With reference to 25.2(c), parts that are recessed more than 64 mm (2-1/2 inches) from the edge of the opening, normally in the plane of the cover, are excluded when determining that the act of removal or replacement of a cover will subject the user to unintentional contact with live parts.

25.6 An interlock shall comply with the Interlocks, 66.4.

25.7 An actuator of an interlock switch shall be so located so as to reduce the risk of unintentional operation. See 24.6.5.

25.8 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

25.9 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the open position that permits operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirements in 25.7.

26 Overload Protection

26.1 An overcurrent or thermal protective device shall be acceptable for the particular application.

26.2 An automatic reset device used to comply with 26.1 shall be cycled through 200 operations. At the end of 200 operations, the device shall be able to perform its intended function with no additional risk of fire, electric shock, or injury to persons. See Overload protective devices, 66.7.

26.3 A fuse involving a risk of electric shock shall be inaccessible:

a) To the user from outside the electrical enclosure; and

b) To the user during servicing as defined in Servicing, Section 40.

26.4 A fuse that can be serviced by the user shall be secured in a fuseholder that is constructed and installed such that no uninsulated live parts will be exposed to contact by persons removing or replacing the fuse.

26.5 The screw shell of a plug fuseholder and the accessible contact of an extractor type fuseholder shall be connected to the load.

27 Information Technology Equipment

27.1 Power supplies complying with either the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, or with the Standard for Audio/Visual, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, shall be considered to comply with the requirements of this Standard.

27.2 Information Technology Equipment such as computers, monitors, printers, drives, modems, and the like, employed in garage equipment, shall comply with either the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, or with the Standard for Audio/Visual, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

27.3 A liquid crystal display that is not covered by 27.2 shall comply with the Test for Liquid Crystal Displays, Section 74.

28 Transformers

28.1 General

28.1.1 A transformer used for isolation of primary and secondary circuits in garage equipment shall comply with both 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; or the transformer shall comply with the requirements in 28.2 – 28.5.

28.2 Bobbin

28.2.1 The bobbin of the transformer shall have a flammability class of V-1 minimum.

28.2.2 The bobbin of the transformer shall comply with Abnormal Heat, Section 77.

28.3 Coil insulation

28.3.1 The coil of the transformer shall be constructed to provide insulation between:

a) Primary and secondary windings, as specified in 28.3.2;

b) Primary windings and the core, as specified in 28.3.3;

c) Primary windings and end bells, when provided, as specified in 28.3.4; and

d) Crossover leads and adjacent windings, as specified in 28.3.6.

28.3.2 Insulation between the primary and secondary windings shall be electrical grade paper, polyester tape, or an equivalent material having a total thickness of not less than 0.3 mm (0.012 inches). Two or more layers shall be provided. The insulation system used shall comply with the requirements in 28.4.

28.3.3 Insulation between the primary winding and the core shall be electrical grade paper, polyester tape, or an equivalent material having a total thickness of not less than 0.3 mm (0.012 inches). The insulation system used shall comply with the requirements in 28.4.

28.3.4 Insulation between the primary winding and the end bells of the transformer shall be electrical grade paper, polyester tape, or an equivalent material having a total thickness of not less than 0.6 mm (0.023 inch) when the insulation is in contact with the end bell. The insulation system used shall comply with the requirements in 28.4.

28.3.5 The insulation specified in 28.3.4 is not required if the spacings in Table 28.1 are met between the primary windings and the end bells. If one half of the spacing is provided, the insulation may have a total thickness of 0.3 mm (0.012 inch). If the entire spacing is provided, then no insulation is required.

Table 28.1
Minimum spacings for transformers

Potential involved, volts (rms)	Through air,		Over surface			
			Protected against deposition of dirt,		Not protected against deposition of dirt,	
	mm	(inch)	mm	(inch)	mm	(inch)
0 – 50	1.6	(1/16)	1.6	(1/16)	1.6	(1/16)
51 – 150	1.6	(1/16)	1.6	(1/16)	3.2	(1/8)
151 – 250	3.2	(1/8)	3.2	(1/8)	6.4	(1/4)

NOTE – The spacings apply to coils, crossover leads, splices, uninsulated lead wires, and any turn of the primary winding to any turn of the secondary winding. The spacings do not apply to turn-to-turn spacings of a coil.

28.3.6 Insulation between the crossover leads and the adjacent windings shall be electrical grade paper, polyester tape, or an equivalent material having a total thickness not less then 0.3 mm (0.012 inch). The insulation system used shall comply with the requirements in 28.4.

28.3.7 A total thickness of 0.15 mm (0.006 inch) shall be provided if one half of the spacing in Table 28.1 is provided. No insulation is required if the entire spacing is provided.

28.4 Margin tape

28.4.1 The end windings for each layer on the transformer shall be retained by positive means to prevent displacement of the end windings.

28.4.2 Individual insulating materials used to comply with 28.3.2 – 28.3.7 shall consist of two or more layers. The electric strength of the materials shall comply after the simulated failure of one layer of insulation. If two layers are provided, one layer shall comply with the Dielectric Voltage Withstand Test, Section 54. If three or more layers are provided, two layers shall comply with the Dielectric Voltage Withstand Test, Section 54.

28.5 Testing

28.5.1 Humidity conditioning shall be performed on all transformers used in garage equipment as described under Humidity Conditioning, Section 55.

28.5.2 Dielectric strength testing shall be performed, before and after the conditioning described in 28.5.1, on all transformers. In reference to 28.3.3, the insulation system employed by the transformer shall also comply with the Dielectric Voltage Withstand Test, Section 54.

28.5.3 Insulation resistance measurements, as described in the Insulation Resistance Test, Section 79, shall be performed after the conditioning of 28.5.1 on all transformers used in garage equipment.

28.5.4 Overload tests shall be performed on all transformers used in garage equipment. Transformers shall have each secondary loaded in turn, with all other secondary circuits loaded to normal load in order to produce the maximum heating effect. The maximum temperatures allowed are shown in Table 28.2.

Table 28.2
Permitted temperature limits for transformer windings under overload conditions

Maximum temperature °C					
Protection method	**Class A**	**Class E**	**Class B**	**Class F**	**Class H**
Protection by inherent or external impedance	150	165	175	190	210
Protection by protective device which operates during the first hour	200	215	225	240	260
Protection by any protective device:					
– maximum after first hour	175	190	200	215	235
– arithmetic average during the 2nd hour and during the 72nd hour	150	165	175	190	210

29 Secondary and Battery Circuits

29.1 Any circuit supplied by an internal or external battery pack, alkaline cells, or other types of internal batteries, are covered by the following requirements. For any circuit connected to the automobile battery, see Automobile Battery Circuits, Section 30.

29.2 If any secondary circuit of more than 30 volts rms (42.4 volts peak), or 60 volts dc, is connected to the frame of the equipment, all exposed dead metal parts that may become energized, and all dead metal parts within the enclosure that can be contacted by a person during user servicing and that may become energized, shall be connected together.

29.3 A circuit supplied from a Class 2 source, as described by the National Electrical Code, ANSI/NFPA 70, need not be investigated.

29.4 A circuit supplied by a single source of supply, consisting of a battery or power supply with an isolating transformer, need not be investigated if:

a) The open circuit potential or no-load output of the source is not more than 30 volts (42.4 volts peak) or 60 volts DC;

b) The current available to the circuit is limited so that the current under any condition of load, including short circuit, is not more than 8 amperes after 1 minute of operation; and

c) The power available is not more than 250 VA.

See the Low-Voltage, Limited-Energy Measurements, Section 68.

29.5 If the available short circuit current of the power supply mentioned in 29.4 is not limited by design of the source, but the circuit includes either a fixed impedance, a fuse, a nonadjustable manual reset circuit protective device, or a regulating network – the circuit in which the current is limited in accordance with 29.7 need not be investigated.

29.6 In a circuit of the type described in 29.5, the battery or secondary winding of the transformer, the fuse, circuit protective device, or regulating network, and all wiring up to the point at which the current and voltage are connected to the circuits shall comply with the requirements in the standard for other than low-voltage, limited-energy circuits.

29.7 A fuse or circuit protective device used to limit the current in accordance with 29.5 shall be rated or set at not more than the values specified in Table 29.1.

Table 29.1
Rating for fuse or circuit protector

Open-circuit potential, peak volts	Current rating, amperes
0 – 21.2	5
21.3 – 42.4	3.2

29.8 If a regulating network is used to limit the voltage or current in accordance with 29.4 – 29.7, and the performance may be affected by short circuit or open circuit malfunction of any single component in the network, the likelihood of such malfunction occurring is to be determined by investigation of that component.

30 Automobile Battery Circuits

30.1 An automobile battery is considered an unlimited source. All circuits and wiring connected to an automobile battery shall comply with the requirements for primary circuits.

30.2 Equipment comprising of an option or accessory which may connect to the automobile battery (12 V adapter) shall have the connecting means evaluated for primary circuits.

30.3 If protection components are incorporated into the adapter or accessory, the circuits after the protection shall comply with secondary circuit requirements. The protection shall comply with Overload Protection, Section 26.

31 Safety Circuits

31.1 A safety circuit shall comply with the requirements for primary circuits.

32 Adhesives

32.1 An adhesive that is relied upon to reduce the risk of fire, electric shock, or injury to persons, shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

33 Spacings

33.1 The spacings specified in (a), (b), and (c) shall not be less than the values indicated in Table 33.1 – Table 33.3, as applicable:

a) Between uninsulated live parts of opposite polarity;

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

c) Between an uninsulated live part and a low-voltage, limited-energy circuit.

Exception: The spacing requirements do not apply to the inherent spacings within a component of the equipment, such as a snap switch, rated for the application. Such spacings shall comply with the requirements for the component.

Table 33.1
Minimum acceptable spacings other than at field wiring terminals and in motor circuits

Potential involved, volts	Minimum spacings, mm (inch)			
	Over surface		Through air	
0 – 50	1.2	(3/64)	1.2	(3/64)
51 – 125	1.5	(1/16)	1.5	(1/16)
126 – 250	2.5	(3/32)	2.5	(3/32)
251 – 600	13[a]	(1/2)	9.5[a]	(3/8)

[a] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 2.5 mm over surface and through air is acceptable between a dead metal part and film-coated wire that is rigidly supported and held in place on a coil.

Table 33.2
Spacings at field wiring terminals

Potential involved, volts	Minimum spacings, mm (inch)					
	Between terminals, through air or over surface		Between terminals and other uninsulated metal parts not always of the same polarity[a]			
			Over surface		Through air	
250 or less	6.4	(1/4)	6.4	(1/4)	6.4	(1/4)
More than 250	13[b]	(1/2)	13[b]	(1/2)	9.5	(3/8)

[a] Applies to the sum of the spacings involved where an isolated dead part is interposed. See 33.7.

[b] A spacing of not less than 9.5 mm, through air and over surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

Table 33.3
Spacings in motor circuits

Potential involved, volts	Diameter of motor used in equipment[a]							
	178 mm (7 inches) or less[b]				More than 178 mm (7 inches)[b]			
	Over surface,		Through air,		Over surface,		Through air,	
	mm	(inch)	mm	(inch)	mm	(inch)	mm	(inch)
0 – 125	2.5	(3/32)[c]	2.5	(3/32)[c]	6.4	(1/4)	3.2	(1/8)
126 – 250	2.5	(3/32)[c]	2.5	(3/32)[c]	6.4	(1/4)	6.4	(1/4)
251 – 600	13.0	(1/2)[c]	9.5	(3/8)[c]	13.0	(1/2)	9.5	(3/8)

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

[b] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 2.5 mm over surface and through air is acceptable between a dead metal part and film-coated wire that is rigidly supported and held in place on a coil.

[c] For equipment employing a motor rated 249 W output (1/3 horsepower) or less, these spacings may not be less than 1.6 mm (1/16 inch).

33.2 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 required minimum spacing will be maintained.

33.3 In applying Table 33.3 to a circuit incorporating two or more motors of different sizes, the required spacings in the circuit are to be based on the size of the largest motor in the circuit.

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

33.5 At terminal screws and studs to which connection may be made in the field by means of wire connectors, eyelets, or the like, the spacings shall not be less than those shown in Table 33.1 when such connectors, eyelets, or the like, are in a position such that minimum spacings (opposite polarity and to dead metal) exists.

33.6 If an isolated dead metal part is interposed between or is in close proximity to:

a) Live parts of opposite polarity;

b) A live part and an exposed dead metal part; or

c) A live part and a dead metal part that may be grounded;

the spacing may be not less than 1.2 mm (3/64 inch) between the isolated dead metal part and any one of the other parts mentioned, if the total spacing between the isolated dead metal part and the other parts is not less than the minimum acceptable value specified in Table 33.1 – Table 33.3, whichever applies.

33.7 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 be located or shall be of such material so that it will not be affected adversely by arcing, and shall not be less than 0.8 mm (1/32 inch) thick.

Exception No. 1: An insulating liner or barrier less than 0.8 mm thick but not less than 0.4 mm thick is acceptable when used in conjunction with an air spacing of not less than 50 percent of the minimum acceptable through air spacing.

Exception No. 2: A barrier of other than vulcanized fiber having a thickness less than that specified may be used if investigation shows it to be acceptable for the particular application.

33.8 The spacings in secondary and battery circuits shall comply with the dielectric strength requirements in the Dielectric Voltage-Withstand Test, Section 54.

Exception: Low-voltage, limited-energy circuits need not be investigated.

PROTECTION AGAINST INJURY TO PERSONS

34 General

34.1 If the operation, including reasonably foreseeable misuse of the equipment, or maintenance of the equipment, by the user involves a risk of injury to persons, means shall be provided to reduce the risk.

34.2 A functional attachment that is made available or recommended by the manufacturer for use with the basic equipment is to be included in the evaluation of the equipment. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be evaluated with the equipment.

34.3 A guard, a safety release, an interlock, or the like, if such a device is required, is to be investigated with respect to the complete equipment, its operating characteristics, and the likelihood of a risk of injury to persons. The investigation is to include consideration of the results of breakdown or malfunction of any one component; but not more than one component at a time, unless one event contributes to another.

35 Sharp Edges

35.1 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons during normal use and maintenance.

Exception: This requirement does not apply to a part or portion of a part needed to perform a working function.

35.2 Whenever referee measurements are necessary to determine that a part as mentioned in 35.1 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the Sharp Edge Test, Section 73 is to be employed.

36 Guards

36.1 A rotor of a motor, a pulley, a belt, a gear, a fan, or other moving part that results in a risk of injury to persons shall be enclosed or provided with other means to reduce the risk on unintentional contact therewith.

Exception No. 1: A part or portion of a part that is necessarily exposed to perform the work function is not required to be enclosed and guarding shall be provided. See 36.4.

Exception No. 2: The rollers of a dynamometer are not required to comply with this requirement.

36.2 With reference to 36.1, a part of the enclosure that may be opened or removed without the use of tools (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

36.3 A moving part that involves a risk of injury to persons shall comply with the requirements specified in Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10, and shall be considered with respect to:

a) The degree of exposure necessary to perform the intended function;

b) The sharpness of the moving part;

c) The risk of unintentional contact therewith;

d) The speed of the moving part; and

e) The risk that a part of the body would be endangered or that clothing could be entangled by the moving part resulting in a risk of injury to persons.

These factors are to be considered with respect to both intended operation of the equipment and any reasonably foreseeable misuse.

36.4 With reference to Exception 1 to 36.1, a guard shall be considered with respect to the following:

a) Removability without the use of a tool;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness;

e) Creation of a risk of injury to persons such as a pinch point, and the necessity for additional handling because of the increased need for servicing, such as cleaning, unjamming, and the like; and

f) Self-restoring.

36.5 An enclosure or guard over a rotating part shall:

a) Retain a part that, because of breaking or other reasons, may become loose or may separate from a rotating part; and

b) Retain a foreign object that may be struck and propelled by the rotating part.

36.6 If complete guarding of a moving part that could obviously cause injury to persons would defeat the utility of the equipment:

a) A control, such as a momentary contact switch, shall be provided; and

b) An appropriate statement shall be provided in the instruction manual warning the user of the potential risk.

36.7 The material of those portions of a part adjacent to a moving part considered to involve a risk of injury to persons, the 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 use conditions.

37 Rotating or Moving Parts

37.1 A rotating or moving part, which if it should become disengaged may result in a risk of injury to persons, shall be provided with a means to retain the part in place under conditions of use.

37.2 A rotating or moving part, the breakage of which may result in a risk of injury to persons, shall be constructed to reduce the likelihood of its breakage, or the release or loosening of the part, that may result in a risk of injury to persons.

37.3 To determine if equipment employing a series motor complies with 37.2, it is to be tested as described in the Overspeed Test, Section 59.

38 Parts Subject to Pressure

38.1 A pressure vessel having an inside diameter more than 152 mm (6 inches), subjected to a gauge pressure more than 102 kPa (15 psig), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors, shall be marked in accordance with the appropriate boiler and pressure vessel code symbol of the American Society of Mechanical Engineers for a working pressure not less than the pressure determined in accordance with 38.3.

38.2 A pressure vessel, that because of its application is not covered by the scope of the inspection procedure of the American Society of Mechanical Engineers code, shall comply with the requirements in 38.3.

38.3 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, shall during normal or abnormal operation comply with the Hydrostatic Pressure Device, Section 67. The test pressure shall be a pressure equal to the highest of the following that is applicable:

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as part of the assembly;

b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with (a);

c) Five times the pressure setting of a required pressure-relief device;

d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly unless the pressure is limited by a pressure-relief device in accordance with (a);

e) Five times the working pressure marked on the part.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or lengths of tubing connected by hard soldered, brazed, or welded joints if the wall thickness of tubing is not less than the value specified in Table 38.1.

Exception No. 2: This requirement does not apply to a pressure vessel bearing the American Society of Mechanical Engineers code inspection symbol – other than the UM symbol – if the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Table 38.1
Wall thickness for copper and steel tubing

Outside diameter,		Minimum wall thickness,		Maximum gauge pressure to which tubing is subjected, MPa (psi)					
mm	(inch)	mm	(inch)	Seamless copper		Butt-welded steel		Seamless steel	
9.5 or smaller	(3/8)	0.41	(0.016)	3.45	(500)	4.14	(600)	6.89	(1000)
12.7	(1/2)	0.41	(0.016)	2.76	(400)	3.31	(480)	5.52	(800)
15.9	(5/8)	0.41	(0.016)	2.21	(320)	2.65	(384)	4.41	(640)
15.9	(5/8)	0.53	(0.021)	2.90	(420)	3.48	(504)	5.79	(840)
19.1	(3/4)	0.53	(0.021)	2.48	(360)	2.98	(432)	4.86	(720)
19.1	(3/4)	0.64	(0.025)	2.90	(420)	3.48	(504)	5.79	(840)
25.4	(1)	0.53	(0.021)	1.79	(260)	2.15	(312)	3.59	(520)
25.4	(1)	0.64	(0.025)	2.21	(320)	2.65	(384)	4.41	(640)

38.4 A part supported or actuated hydraulically that due to pressure loss may result in a risk of injury to persons shall comply with the Hydrostatic Pressure Device, Section 67, when tested at a pressure equal to five times the maximum pressure that can be developed in the system.

39 Pressure Relief Devices

39.1 A means for relieving pressure shall be provided for a part in which pressure may be generated by an external source of heat.

39.2 A pressure relief device, a fusible plug, a soldered joint, nonmetallic tubing, or equivalent pressure relief means shall comply with the requirement in 39.1.

39.3 A shut-off valve shall not be provided between the pressure relief device and the parts that it is intended to protect.

39.4 A vessel having an inside diameter of more than 76 mm (3 inches) and subject to air or steam pressure generated or stored within the equipment shall be protected by a pressure relief device.

39.5 The start to discharge pressure setting of a pressure relief device shall not be higher than the working pressure marked on the vessel. The discharge rate of the device shall be adequate to relieve the pressure.

39.6 A pressure relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect:

b) Be installed so that it is accessible for inspection and repair, and cannot be rendered inoperative so that it will not perform its intended function; and

c) Have its discharge opening located and directed so that:

1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture; and

2) The likelihood of scalding persons is reduced.

39.7 A required control that limits the pressure in a vessel shall function as intended so that the pressure does not exceed 90 percent of the highest pressure setting of the pressure relief device when tested as prescribed in the Pressure Relief Test, Section 75.

40 Servicing

40.1 User servicing includes the following:

a) Replacement of a replaceable battery;

b) Replacement of a fuse;

c) Replacement of lamps;

d) The cleaning of a display tube, if access to the parts to be cleaned can be gained using ordinary tools and without removing the chassis or the display tube from the enclosure;

e) Adjustment of a marked adjustable control or adjustable component, when the adjustment can be accomplished with the equipment in operation and without defeating any interlock;

f) Adjustment of an unmarked adjustable control when the adjustment can be accomplished without a tool, with the equipment in operation and without defeating any interlock; and

g) Any other act that is described to the user in the user service manual.

40.2 Any handling, disconnection, or displacement, either intentional or unintentional, of a component of a printed wiring assembly, a connector lead, cover, or similar part, that is likely during user servicing shall not result in a risk of fire, electric shock, or injury to persons.

41 Stability

41.1 Under all conditions of servicing and normal use, garage equipment shall not become physically unstable to the degree that it becomes a risk of injury to operators and service personnel. A risk of injury to persons shall not result when equipment is tested in accordance with the Stability Tests, Section 61.

Exception No. 1: Equipment that is intended to be hand supported or hand held need not be tested.

Exception No. 2: Equipment that is intended to be permanently mounted to the floor need not be tested.

42 Mounting

42.1 Units that are intended to be mounted to the wall, ceiling, or other permanent structure, are to be tested in accordance with Mounting Tests, Section 63.

43 Strength of Handles

43.1 A handle intended for lifting and carrying equipment shall be subjected to the Handle Test, Section 64.

SPECIFIC REQUIREMENTS FOR EQUIPMENT

44 General

44.1 The following cover specific requirements for different types of equipment covered by this standard.

44.2 For each type of equipment shown, the specific requirements will outline additional points of investigation in regard to use, safety, and features only inherent to the particular piece of garage equipment.

45 Wheel Balancers

45.1 A wheel balancer shall be provided with a guard over the wheel. The guard shall be of a large enough size to:

a) Reduce the risk of an object in the tire tread from being thrown at the user: and

b) Reduce the risk of the user becoming entangled in the moving parts.

45.2 The requirements of 45.1 shall be verified for compliance by performing the Maximum Angular Momentum Test, Section 76. When the angular momentum of the wheel is found to exceed the limits specified in 76.3, the guard is required to completely cover the top 50 percent of the wheel.

45.3 A wheel balancer which requires a hood in accordance with 45.2, shall be provided with an interlock, in accordance with Interlocks, Section 25, such that the wheel will not spin unless the wheel guard is in position over the wheel.

45.4 Wheel balancers which do not exceed the limits specified in the Maximum Angular Momentum Test, Section 76, are not required to have the guard interlocked.

45.5 A wheel balancer shall be marked in accordance with 83.19.

45.6 A wheel balancer, which is automatically controlled, shall be marked in accordance with 83.8.

45.7 A wheel balancer shall be provided with a means to prevent the wheel from loosening during the wheel balancing operation.

46 Dynamometers

46.1 Dynamometers intended to be installed at floor level (below 45.7 cm [18 inches]) shall be investigated for use in a Class I, Division 2 area, as defined by the National Electrical Code, ANSI/NFPA 70, unless the product is intended for use only within the non-classified (ordinary) location in a minor repair garage and the product is marked in accordance with 83.12.1.

46.2 Dynamometers intended to be installed below grade shall be investigated for use in a Class I, Division 1 area as defined by the National Electrical Code, ANSI/NFPA 70.

47 Battery Testers

47.1 Battery testers that include a charging function in the device, shall be investigated in accordance with the Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236.

47.2 Battery Testers that include a crank assist function in the device, shall comply with the crank assist test outlined in the Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236.

48 Fluid Changing Equipment

48.1 Fluid Changing Equipment shall be investigated to determine compatibility between the fluid and the materials it will contact, such as the reservoir material and hoses.

49 Powered and Non-Powered Cabinets

49.1 A cabinet that has multiple sections that are intended to be mechanically connected together shall be subjected to the Loading Tests, Section 62.

49.2 The cabinet shall be provided with all parts required to mechanically connect the sections together and shall be provided with installation instructions. See Instruction Manual, Section 85.

50 Automotive Lifts

50.1 Only the electrical requirements of the lift are tested in accordance with this Standard. The mechanical requirements for automotive lifts must also comply with the Standard for Automotive Lifts – Safety Requirements for the Construction, Testing, and Validation, ANSI/ALI ALCTV.

PERFORMANCE

51 General

51.1 Garage equipment having both alternating current (ac) and direct current (dc) ratings is to be tested with the equipment connected to an alternating current supply and again to a direct current supply, unless it can be established that one test will result in the most severe operating conditions.

51.2 A lead, connector, or component that is accessible during normal operation or user servicing is to be connected for normal operation and is to be arranged in any position likely after user servicing.

51.3 Cheesecloth used in tests is to be bleached cheesecloth having an area of approximately 26 – 28 m^2/kg mass (14 – 15 square yards per pound mass) and having what is known in the trade as a "count of

32 by 28", that is, for any square centimeter, 13 threads in one direction and 11 in the other direction (for any square inch, 32 threads in one direction and 28 threads in the other direction).

51.4 All tests are to be conducted in a room free of drafts.

51.5 Equipment intended for connection to an ac mains supply shall be tested over a tolerance of plus 6 percent and minus 10 percent, unless:

a) The rated voltage is 230 V single phase or 400 V three phase, in which case the tolerance shall be taken as plus 10 percent and minus 10 percent;

b) A wider tolerance is declared by the manufacturer, in which case the manufacturer's declared tolerance shall be used.

51.6 When testing equipment designed for dc connections, the possible influence of polarity shall be taken into account.

51.7 Garage equipment rated 50 – 60 hertz or 50/60 Hz, is to be tested at 50 and 60 hertz.

52 Input Test

52.1 The current or power input to garage equipment shall not exceed more than 110 percent of the rated value when the equipment is operated under the condition of maximum normal load as described in Maximum load, 57.2, and measured with a suitable device.

52.2 Garage equipment with a measured input rating of less than 1 ampere may be marked in accordance with 82.2.

53 Leakage Current Test

53.1 Cord connected garage equipment, excluding cabinets, rated 240 V or less, and employing a grounding conductor, is to be tested for leakage current in accordance with 53.2 – 53.4. The leakage current shall not be more than 3.5 mA. Systems of interconnected equipment with individual connections to primary power shall have each piece of equipment tested separately. Systems of interconnected equipment with one common connection to primary power shall be treated as a single piece of equipment. The tests specified in 53.2 – 53.6 are to be performed using the measuring instrument described in Appendix A, or any other circuit giving the same results, and using an isolating supply transformer as shown. When the use of an isolating transformer does not meet the intent of this requirement, the equipment is to be mounted on an insulating stand, not earthed, and precautions are to be taken in view of the possibility of the body of the equipment being at a primary voltage.

53.2 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible, and from one surface to another if simultaneously accessible. A part is considered to be exposed unless it is guarded by an enclosure that is acceptable for protection against the risk of electric shock in accordance with Accessiblility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 10. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to involve a risk of electric shock, see 29.4. If all accessible surfaces are bonded together and connected to the grounding conductor of the supply circuit cord, the leakage current may be measured between the grounding conductor and the grounded supply conductor. If exposed dead metal parts of a product are connected to the neutral supply conductor, this connection is to be open during the test.

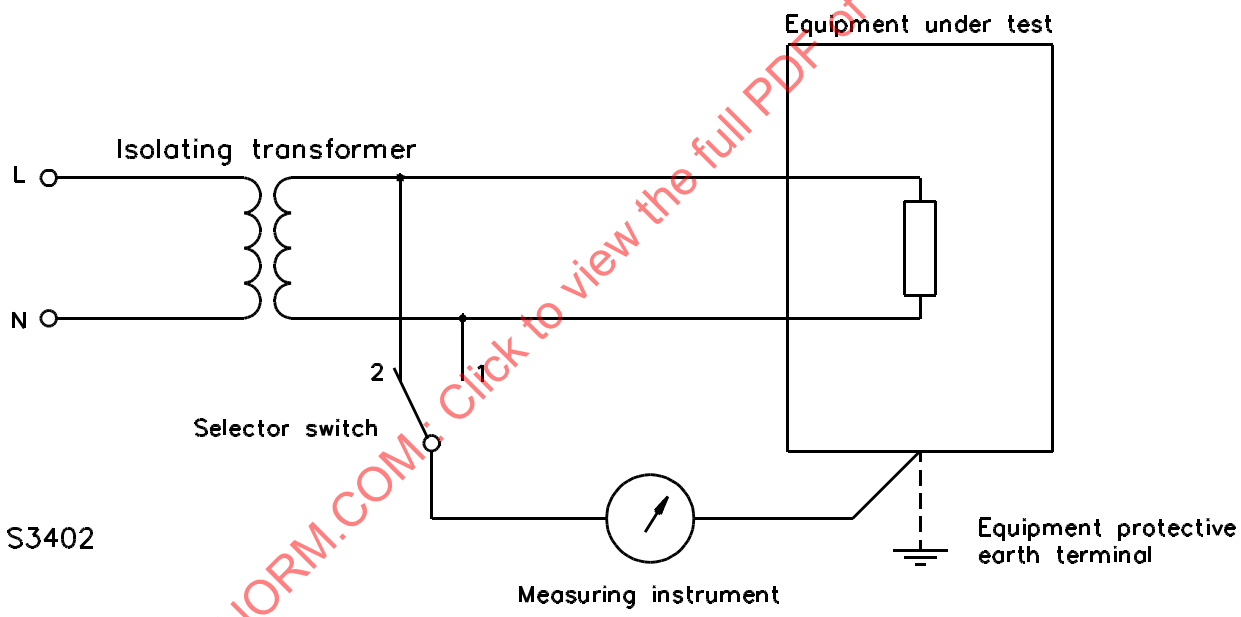
53.3 If a conductive surface other than metal is used for an enclosure or part of the enclosure, leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters (4 by 8 inches) in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface.

53.4 Unless the meter is being used to measure leakage from one part of the equipment to another part of the equipment, the meter is to be connected between accessible parts and the grounded supply conductor.

53.5 Single phase equipment intended for operation between one phase conductor and neutral is to be tested using the circuit of Figure 53.1 with the selector switch in each of the positions 1 and 2. For each position of the selector switch, any switches within the equipment, controlling primary power and operated in normal use, are to be opened and closed in all possible combinations. None of the current values shall exceed the limit.

Figure 53.1

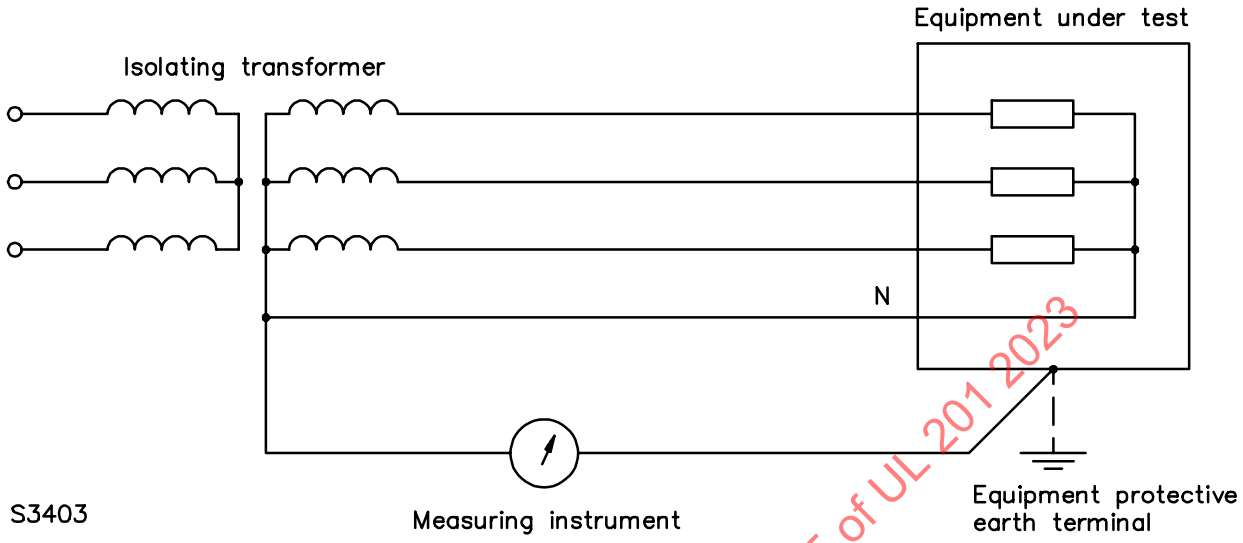
Test circuit for leakage current on single-phase equipment



53.6 Three phase equipment and equipment intended for operation between two phase conductors are to be tested using the circuit in Figure 53.2, with the selector switch in each of the positions 1 and 2. For each position of the selector switch, any switches within the equipment, controlling primary power and operated in normal use, are to be opened and closed in all possible combinations. Any components used for EMI suppression and connected between phase and earth are to be disconnected one at a time; for this purpose, groups of components in parallel connected through a single connection are to be treated as single components. None of the current values shall exceed the limit.

Figure 53.2

Test circuit for leakage current on three-phase equipment



53.7 Normally a sample will be subjected to the complete leakage current test, as specified in 53.5 and 53.6, without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted to conduct other nondestructive tests.

54 Dielectric Voltage Withstand Test

54.1 General

54.1.1 The insulation and spacings of garage equipment shall withstand, without dielectric breakdown for a period of 1 minute, the application of the test potentials prescribed in 54.2 – 54.4.

54.1.2 The test is to be performed when the equipment is complete – fully assembled – and with the power switch or any other primary switching device in the "on" position. It is not intended that the equipment be unwired, modified, or disassembled for the test.

54.2 Primary circuits

54.2.1 A 60 Hz essentially sinusoidal potential is to be applied between any live metal part conductively connected to the supply circuit and any dead metal parts. The test potential shall be:

a) 1000 V for equipment employing a motor rated 375 watts (1/2 horsepower) or less and 250 V or less; or

b) 1000 V plus twice the rated voltage for equipment employing a motor rated at more than 375 watts or more than 250 V.

c) 1000 V for cabinets rated 120 V; or

d) 1500 V for cabinets rated 240 V.

54.2.2 If an isolating transformer is employed, the test described in 54.2.1 is to be conducted with both sides of the supply circuit connected together.

54.2.3 If an isolating transformer is employed, a 1000 V, 60 Hz potential is to be applied between any live or current-carrying part of the primary circuit and any live or current-carrying part of the secondary circuit.

Exception: In the secondary circuit of an isolating transformer, a 1000 V, 60 Hz potential is to be applied across each capacitor, winding separation, or other insulation employed to reduce the risk of electric shock, or, which, if short-circuited, would involve a risk of fire either directly or indirectly.

54.2.4 The test potentials specified in 54.2.1 – 54.2.3 are to be obtained from a 500 volt-ampere or larger testing transformer, the output voltage of which is essentially sinusoidal and can be regulated. Starting at zero, the applied potential is to be increased gradually until the required test value is reached or until breakdown occurs. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter.

Exception: The test potentials specified in 54.2.1 – 54.2.3 may be replaced be a dc voltage potential which is equal to 1.414 times the required ac potential.

54.3 Secondary circuits

54.3.1 A dc potential of 3 times the maximum voltage determined in accordance with 54.3.2 – 54.3.6, but not less than 500 V, is to be applied between live parts of opposite polarity in the secondary circuit and between such live parts and accessible metal parts.

Exception: A low-voltage, limited-energy circuit need not comply with this requirement.

54.3.2 The maximum voltage used as a basis for the calculation of the dielectric withstand potentials specified in 54.3.1, is to be determined in accordance with 54.3.3 and 54.3.4.

54.3.3 To obtain the maximum voltage, any combination of tubes and fuses may be removed.

54.3.4 An automatic voltage regulating device is to be rendered inoperative unless, upon investigation, it is found that it can be relied upon to prevent an increase in voltage. The investigation is to take into consideration any likely breakdowns in either the regulating device or the equipment, and the possibility of the device being disconnected if it is not permanently connected to the circuit.

54.3.5 A connector or comparable part that is likely to be disconnected during operation or user servicing is to be both connected and disconnected during the test to determine the maximum voltage.

54.3.6 If a complex voltage is present, the peak value of the voltage is to be measured.

54.4 Automobile ignition circuits

54.4.1 An equipment test lead that is intended to be directly connected to a high voltage source within an automobile, such as a timing light trigger lead, shall withstand for a period of 1 minute a direct current potential of 35 kilovolts applied between the test lead and the reference lead unless the reference lead is connected to earth ground through the grounding means. The resistance between the point of connection

for the reference lead and the equipment grounding means shall not be more than 0.1 ohms when measured as described in the Grounding Circuit Reliability Test, Section 58.

54.4.2 An inductive (clamp on) type test lead that is intended to measure the high voltage source within an automobile shall withstand for a period of 1 minute, a direct current potential of 35 kilovolts applied between metal foil placed inside the clamp and external metal surfaces accessible to the user.

Exception No. 1: The 35 kilovolt dielectric test is not required to be conducted when the resistance between the point of connection of the internal connectors inside the clamp and the equipment grounding means to the supply circuit is no more than 0.1 ohm when measured as described in the Grounding Circuit Reliability Test, Section 58.

Exception No. 2: A timing light is not required to meet this requirement when it is marked in accordance with 83.20.

55 Humidity Conditioning

55.1 Garage equipment, excluding cabinets, shall comply with the requirements in Leakage Current Test, Section 53, and in the Dielectric Voltage Withstand Test, Section 54, following this exposure. Cabinets shall comply with the Dielectric Voltage Withstand Test following this exposure. The test is performed with each sample subjected to an exposure for 48 hours to air having a relative humidity of 92.5 ±2.5 percent relative humidity at a temperature of 42 ±2°C (107.6 ±4°F).

55.2 To determine if equipment complies with the requirement in 55.1, the equipment is to be heated to a temperature just above 34°C (93°F) to reduce condensation of moisture during conditioning. The heated equipment is to be placed in the humidity chamber and conditioned for 48 hours under the conditions specified in 55.1. Following the conditioning, the equipment is to be subjected to the Leakage Current Test, Section 53, and/or the Dielectric Voltage Withstand Test, Section 54, as indicated in 55.1.

56 Starting Current Test

56.1 Garage equipment tested in accordance with 56.2 shall start and operate as intended on a branch circuit protected by a fuse, that:

a) Is of other than the time-delay type; and

b) Has a current rating corresponding to that of the branch circuit to which the equipment is intended to be connected in accordance with the National Electrical Code, ANSI/NFPA 70.

Tripping of an overload protective device provided as part of the equipment or opening of the fuse is unacceptable.

Exception: This requirement does not apply if:

a) The construction of the equipment or the nature of its usage is such that the equipment will be used only on a branch circuit dedicated solely to the equipment at the time of installation;

b) The equipment will only start and operate as intended on a circuit protected by a time-delay fuse; and

c) The equipment is marked in accordance with 83.13.

56.2 To determine if equipment complies with the requirement in 56.1, the equipment is to be started three times with the equipment at room temperature at the beginning of each test. Each start of a motor is to be made under conditions representing the beginning of normal operation – the beginning of the normal

operating cycle, in the case of automatic equipment – and the motor is to be allowed to come to rest between successive starts.

57 Normal Temperature Test

57.1 General

57.1.1 Garage equipment is to be tested as described in Maximum load, 57.2 and shall not:

a) Reach a temperature at any point high enough to result in a risk of fire;

b) Damage any material in the equipment; or

c) Exceed the temperature rises specified in Table 57.1.

Table 57.1
Maximum temperature rises

	Materials and component parts	°C	(°F)
1.	Any point within a terminal box or wiring compartment of a permanently connected equipment in which power-supply conductors are to be connected, including such conductors themselves, unless the equipment is marked in accordance with 83.14.	35	(63)
2.	A surface upon which stationary equipment may be mounted in service, and surfaces that may be adjacent to the equipment when so mounted	65	(117)
3.	Exterior surfaces of an overall enclosure	65	(117)
4.	Capacitors:		
	a) Electrolytic[a]	40	(72)
	b) Other types[b]	65	(117)
5.	Fuses	65	(117)
6.	Fiber employed as electrical insulation	65	(117)
7.	Wood and other combustible material	65	(117)
8.	Class 105 insulation systems in windings of a relay, a solenoid, or the like[c]:		
	a) Thermocouple method	65	(117)
	b) Resistance method	85	(153)
9.	Class 130 insulation systems on windings of a relay, solenoid, or the like:		
	a) Thermocouple method	85	(153)
	b) Resistance method	105	(189)
10.	Class 105 insulation system in coil windings in an ac motor having a diameter of more than 178 mm (7 inches), in a dc motor, and in a universal motor[c,d]:		
	a) In an open motor:		
	1) Thermocouple method	65	(117)
	2) Resistance method	75	(135)
	b) In a totally enclosed motor:		
	1) Thermocouple method	70	(126)
	2) Resistance method	80	(144)
11.	Class 105 insulation systems in coil windings in an ac motor having a diameter of 178 mm or less, not including a universal motor, and in a vibrator coil[c,d]:		

Table 57.1 Continued on Next Page

Table 57.1 Continued

	Materials and component parts	°C	(°F)
	a) In an open motor and in a vibrator coil:		
	Thermocouple or resistance method	75	(135)
	b) In a totally enclosed motor:		
	Thermocouple or resistance method	80	(144)
12.	Class 130 insulation system in coil windings of an ac motor having a frame diameter of more than 178 mm (7 inches), in a dc motor, and in a universal motor[c,d]:		
	a) In an open motor:		
	1) Thermocouple method	85	(153)
	2) Resistance method	95	(171)
	b) In a totally enclosed motor:		
	1) Thermocouple method	90	(162)
	2) Resistance method	100	(180)
13.	Class 130 insulation systems in coil windings of an ac motor having a diameter of 178 mm (7 inches) or less, not including a universal motor[c,d]:		
	a) In an open motor:		
	Thermocouple or resistance method	95	(171)
	b) In a totally enclosed motor:		
	Thermocouple or resistance method	100	(180)
14.	Class 155 insulation systems in coil windings in an ac motor having a diameter of more than 178 mm (7 inches), in a dc motor, and in a universal motor[c,d]:		
	a) In an open motor:		
	1) Thermocouple method	110	(198)
	2) Resistance method	120	(216)
	b) In a totally enclosed motor:		
	1) Thermocouple method	115	(207)
	2) Resistance method	125	(225)
15.	Class 155 insulation systems in coil windings in an ac motor having a diameter of 178 mm (7 inches) or less, not including a universal motor, and in a vibrator coil:		
	a) In an open motor and on vibrator coils (thermocouple or resistance method)	120	(216)
	b) In a totally enclosed motor (thermocouple or resistance method)	125	(225)
16.	Class 180 insulation system in coil windings in an ac motor having a diameter of more than 178 mm (7 inches), in a dc motor, and in a universal motor[d]:		
	a) In an open motor:		
	1) Thermocouple method	125	(225)
	2) Resistance method	135	(243)
	b) In a totally enclosed motor:		
	1) Thermocouple method	130	(234)
	2) Resistance method	140	(252)
17.	Class 180 insulation system in coil windings in an ac motor having a diameter of 178 mm (7 inches) or less, not including a universal motor, and in a vibrator coil[d]:		
	a) In an open motor and on vibrator coils (thermocouple or resistance method)	135	(243)

Table 57.1 Continued on Next Page

Table 57.1 Continued

	Materials and component parts	°C	(°F)
	b) In a totally enclosed motor (thermocouple or resistance method)	140	(252)
18.	Transformers with Class 105 insulation systems		
	a) Thermocouple method	65	(117)
	b) Resistance method	75	(135)
19.	Transformers with Class 130 insulation systems		
	a) Thermocouple method	85	(153)
	b) Resistance method	95	(171)
20.	Transformers with Class 155 insulation systems		
	a) Thermocouple method	110	(198)
	b) Resistance method	120	(216)
21.	Transformers with Class 180 insulation systems		
	a) Thermocouple method	125	(225)
	b) Resistance method	135	(243)
22.	Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock[e]	125	(225)
23.	Rubber- or thermoplastic-insulated wire and cord[e,f,g]	35	(63)
24.	Sealing compound	40[j]	(104)[j]
25.	Laminated phenolic composition[e]	100	(180)
26.	Selenium rectifiers[i]	50	(90)
27.	Silicon rectifiers[h,i]	75	(135)
28.	Varnished-cloth insulation	60	(108)

[a] A capacitor operating at a temperature rise higher than 40°C (104°F) may be investigated on the basis of its marked temperature rating, or if not marked with a temperature rating, may be investigated to determine its acceptability at the higher temperature rise.

[b] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.

[c] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher than the maximum temperature specified in this table if the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple may be higher than the specified value by the following amount:

	Additional temperature rise	
Item	°C	°F
Items 8 and 10, subitem a	15	(27)
Item 11, subitem a	5	(9)
Item 12, subitem a	20	(36)
Item 13, subitem a	10	(18)

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

[e] The maximum temperature requirements for phenolic composition and for rubber and thermoplastic insulation do not apply to compounds that have been investigated and found acceptable for use at higher temperatures.

[f] Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may obtain a temperature rise of more than 35°C (63°F), if a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[g] A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord.

Table 57.1 Continued on Next Page

Table 57.1 Continued

Materials and component parts	°C	(°F)
[h] A rectifier operating at a temperature rise higher than 75°C (135°F) is to be judged on the basis of its case temperature at the actual current compared with the case temperature at rated current (derating curves). [i] This requirement does not apply to a rectifier which has been investigated and found suitable for a higher temperature rise. [j] Values are maximum acceptable temperatures (not temperature rises) less than the melting point. The sealing compound shall not melt at a temperature less than 65°C (149°F).		

57.1.2 All values for temperature rises in Table 57.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

57.1.3 If the equipment incorporates a reel for the supply circuit cord, one-third of the length of the cord is to be unreeled for the temperature test.

57.1.4 Temperature tests are to be performed under the conditions of continuous operation until thermal stabilization is obtained.

Exception: If the equipment is obviously not intended for continuous operation, the temperature test may be conducted so that it will take into consideration the probable intermittent or short time operation of the equipment. See 57.1.11.

57.1.5 Small, cord connected garage equipment of the hand-supported type (such as a timing light) shall not attain a temperature of more than 125°C (257°F) on any exterior surface which may be laid on combustible materials, and there shall be no emission of smoke or molten metal.

57.1.6 To determine if the equipment complies with the requirement in 57.1.5, the equipment is to be operated at the conditions indicated in 57.2.3 until thermal stabilization is attained. The equipment may be stationary during the test, and simulation of actual service conditions need not be attempted.

57.1.7 With reference to those tests which are to be continued until thermal stabilization is attained, thermal stabilization is considered to exist when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5 minute intervals, indicate no change.

57.1.8 In reference to the Exception to 57.1.4, garage equipment that is obviously intended for intermittent or short time operation may be cycled during the test. Consideration shall be given to the time it would take to exchange parts and begin a new operation cycle. The equipment shall then be cycled continuously taking into account the downtime due to the nature of operation of the equipment. The test shall still be continued until thermal stabilization.

57.1.9 For equipment that is capable of continuous operation, but is declared by the manufacturer to operate intermittently, a duty cycle shall be imposed. If a duty cycle is imposed on the equipment, the temperature test shall be performed using the on and off times specified by the manufacturer, until thermal stabilization, when the unit is marked in accordance with 81.7.

57.1.10 Coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of thermocouples, such as a coil immersed in sealing compound, or unless the coil wrap includes thermal insulation or more than two layers (1/32 inch maximum) of cotton, paper, rayon, or the like. For a thermocouple measured temperature of a coil of an alternating current motor, other than a universal motor, having a diameter of 178 mm (7 inches) or less (11 and 13 in Table 57.1), the thermocouple is to be mounted on the integrally applied insulation on the conductor.

57.1.11 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouple wire is to conform with the requirements listed in the Initial Calibration Tolerances for Thermocouples table in Temperature-Measurement Thermocouples, ANSI/ISA MC96.1.

57.2 Maximum load

57.2.1 General

57.2.1.1 In tests on garage equipment, maximum normal load is considered to be that load which approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions which are recommended by the manufacturer of the equipment. Test loads which have been found to be close approximations of the most severe conditions of normal use are indicated in 57.2.2 – 57.2.8 for some common forms of equipment. However, equipment having features not contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

57.2.1.2 A receptacle and an accessory connector that is not utilized for the connection of a part of the equipment, is to be loaded to the ratings specified by the manufacturer during the test.

57.2.2 Tune-up testers, ignition testers, engine analyzers

57.2.2.1 Garage equipment intended to be connected to the ignition system of an automobile is to be connected to an ignition simulator supplying 4800 ignition sparks per minute (representing 1200 rpm for an eight-cylinder four-cycle engine). The equipment is to be operated until thermal stabilization is attained.

57.2.3 Timing lights

57.2.3.1 A timing light is to be connected to an ignition simulator supplying 600 ignition sparks per minute (representing 1200 rpm for an eight-cylinder four-cycle engine). The equipment is to be operated with a 2 minute on and 5 minute off operation cycle (to simulate the moving of the equipment to a new vehicle) until thermal stabilization is attained.

57.2.4 Wheel balancers

57.2.4.1 A wheel of the largest mass indicated in the marking on the balancer is to be used for this test.

57.2.4.2 A wheel balancer is to be cycled continuously until thermal stabilization is attained. Each cycle of operation is to consist of one complete rotational balancing cycle (prescribed by the design of the equipment) followed by a 1 minute "off" period to simulate wheel exchange.

57.2.5 Tire changers

57.2.5.1 A tire is to be removed from its rim and replaced continuously with a 10 second "off" time between cycles to simulate wheel exchange. The test is continued until thermal stabilization has been attained.

57.2.6 Roll-up brake lathes

57.2.6.1 A brake lathe is to be operated continuously at the manufacturer's maximum specified speed and cutting depth, with a 30 second "off" time to simulate parts exchange. The test shall be continued until thermal stabilization is attained.

57.2.7 Dynamometers

57.2.7.1 A dynamometer is to be operated at the maximum time and rotation resistance (such as hill simulation) recommended by the manufacturer, followed by a 2 minute "off" period to simulate vehicle exchange. If no maximum time is recommended by the manufacturer, the cycle is to consist of 4 minutes on with rollers at maximum rotation resistance, followed by 2 minutes off. The test shall be continued until thermal stabilization is attained.

57.2.8 Powered cabinets

57.2.8.1 All receptacles are loaded to their normally rated load. All accessories, light fixtures, and the like, are operated in a manner to create the maximum normal load on the cabinet.

57.2.9 Automotive lifts

57.2.9.1 Automotive lifts shall be tested at the maximum load for which the lifting system is designed.

58 Grounding Circuit Reliability Test

58.1 The voltage drop across the point of connection of the equipment grounding means, at or within the equipment, and any other point in the grounding circuit, shall not be more than 4 volts when measured as described in 58.2.

58.2 An alternating current, derived from a power supply of not more than 12 volts, is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit. The value of the alternating current used for this test shall be equal to twice the rating of the overcurrent protective device in the building. The duration for the test is also based on the rating of the overcurrent protective device in the building. See Table 58.1 for the proper duration of the test. The resulting drop in potential is to be measured across the two points tested. The grounding conductor of a supply circuit cord is not to be included in the test.

Table 58.1
Grounding reliability duration

Current rating of circuit, A	Time, minutes
≤ 30	2
> 30 ≤ 60	4
> 60 ≤ 100	6
> 100 ≤ 200	8
> 200	10

59 Overspeed Test

59.1 With reference to 37.3 for equipment employing a series motor, a part that may result in a risk of injury to persons shall not work loose as a result of the test described in 59.2.

59.2 The equipment employing a series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times the rated voltage. Equipment in which the rotating load may be varied is to be tested for each condition of loading that can occur.

60 Motor Tests

60.1 General requirements

60.1.1 Motors, both ac and dc, located in either primary or secondary circuits, are required to comply with the applicable tests in 60.3 – 60.6.

60.1.2 Air handling motors, such as fans, do not need to comply with running overload tests.

60.1.3 Stepper motors are not required to be tested.

60.2 Maximum temperature

60.2.1 For the tests covered by 60.3 – 60.6, the temperature limits specified in Table 60.1 and Table 60.2, as applicable, shall not be exceeded.

Table 60.1
Permitted temperature limits for motor winding during locked rotor tests

Maximum temperature °C					
Method of protection	Class A	Class E	Class B	Class F	Class H
Protection by inherent or external impedance	150	165	175	190	210
Protection by protective device which operates during the first hour	200	215	225	240	260
Protection by any protective device:					
– Maximum after first hour	175	190	200	215	235
– Arithmetic average during the second hour and during the seventy-second hour	150	165	175	190	210

Table 60.2
Permitted temperature limits for motor winding during running overload tests

Maximum temperature °C				
Class A	Class E	Class B	Class F	Class H
140	155	165	180	200

60.3 Running overload test for primary motors

60.3.1 The motor is operated under normal load. The load is increased in gradual steps, allowing for the motor temperatures to stabilize before each increase. The load is increased until the overload protection device operates. The load on the motor shall not induce a locked rotor condition at any time during this test.

60.3.2 The motor winding temperatures are determined during each steady period. The maximum temperature is recorded and shall not exceed the limits specified in Table 60.2.

60.4 Locked rotor test for primary motors

60.4.1 A locked rotor test is carried out starting at room temperature, and continued for a duration as follows:

a) A motor protected by inherent or external impedance is operated with its rotor locked for 15 days except that testing may be discontinued when the windings of the motor reach a constant temperature, provided the temperature does not exceed the limits specified in Table 60.1;

b) A motor with an automatic reset protection device is cycled with its rotor locked for 18 days;

c) A motor with a manual reset protection device is cycled with its rotor locked for 60 cycles, the protection device being reset after each operation as soon as possible for it to remain closed, but after not less than 30 seconds; and

d) A motor with a non-resettable protection device is operated with its rotor locked until the device operates.

60.4.2 Temperatures shall be recorded for the first three days for a motor with inherent or external impedance, or with an automatic reset protection device, or for the first ten cycles for a manual reset protection device, or at the time of operation of a non-resettable device. Maximum temperatures shall not exceed the limits specified in Table 60.1.

60.5 Running overload tests for secondary motors

60.5.1 The motor is operated under normal load. The load is increased in gradual steps, allowing for the motor temperatures to stabilize before each increase. The load is increased until the overload protection device operates or the windings open. The load on the motor shall not induce a locked rotor condition at any time during this test.

60.5.2 Compliance is checked by one of the following methods:

a) Temperatures are recorded during each steady period during the test of 60.5.1. The maximum temperatures shall not exceed the limits specified in Table 60.2; or

b) The motor is covered with a single layer of bleached cheesecloth having an area of approximately 26 – 28 m^2/kg mass (14 – 15 square yards per pound mass) and having what is known in the trade as a "count of 32 by 28", that is, for any square centimeter, 13 threads in one direction and 11 in the other direction (for any square inch, 32 threads in one direction and 28 threads in the other direction). There shall be no ignition of the cheesecloth during the test.

60.6 Locked rotor tests for secondary motors

60.6.1 The same test durations as outlined in 60.4.1 apply to secondary motors.

60.6.2 Compliance is checked by one of the following methods:

a) Temperatures are recorded during each steady period during the test of 60.6.1. The maximum temperatures shall not exceed the limits specified in Table 60.1; or

b) The motor is covered with a single layer of bleached cheesecloth having an area of approximately 26 – 28 m^2/kg mass (14 – 15 square yards per pound mass) and having what is known in the trade as a "count of 32 by 28", that is, for any square centimeter, 13 threads in one direction and 11 in the other direction (for any square inch, 32 threads in one direction and 28 threads in the other direction). There shall be no ignition of the cheesecloth during the test.

60.7 Electric strength

60.7.1 If the motor voltage exceeds 42.4 V peak or 60 Vdc, the motor shall pass the electric strength test as outlined in the Dielectric Voltage Withstand Test, Section 54.

61 Stability Tests

61.1 General

61.1.1 The tests are to be performed with the equipment loaded to approximate as closely as possible the most severe conditions of normal use. An accessory – such as a wheel rotor – is to be installed as intended in use. For tests on a wheel balancer, the tire used for the test is to be one having the largest mass indicated in the marking on the balancer.

61.1.2 If units are designed to be fixed together on site and not used individually, the stability of each individual unit is exempt from the requirements of 61.3 – 61.5.

61.1.3 Units are not to be powered during these tests.

61.1.4 Each test described in 61.3 – 61.5 is carried out separately. During the tests, containers are to contain the amount of substance within their rated capacity producing the most unfavorable condition. All casters and jacks, if used in normal operation, are placed in the most unfavorable position, with wheels and the like locked or blocked. However, if the casters are intended only to transport the unit, and if the installation instructions require jacks to be lowered after installation, then the jacks (and not the casters) are used in these tests.

61.2 Stabilizing means

61.2.1 Under conditions of operator use, a stabilizing means, if needed, shall be automatic in operation when drawers, doors, etc., are opened.

61.2.2 During operations performed by service personnel, the stabilizing means, if needed, shall be automatic in operation, or a marking shall be provided to instruct service personnel to deploy the stabilizing means.

61.3 Ten degree tilt test

61.3.1 A unit shall not overbalance when tilted to an angle of 10 degrees from its normal upright position. Doors, drawers, etc., are closed during this test.

61.3.2 If a part of surface of the product not normally in contact with the horizontal supporting surface touches the supporting surface before the product has been tipped through an angle of 10 degrees, the tipping is to be continued until the surface or place of the surface of the product originally in contact with the horizontal supporting surface is at an angle of 10 degrees from the horizontal supporting surface.

61.4 Horizontal force test

61.4.1 A floor-standing unit, excluding cabinets, having a mass of 22 kg (50 lbs) or more, shall not tip over when the force indicated in Table 61.1 is applied in any direction at the point of maximum moment.

61.4.2 A cabinet shall not tip over when the force indicated in Table 61.1 is applied in any direction, except upward, at any point on a cabinet including the highest point not exceeding 1 meter (3 feet) from

the floor. Doors, drawers, and the like are placed in their most unfavorable position, consistent with the manufacturer's instruction manual.

Table 61.1
Force applied in stability test

Weight of equipment,		Force to be applied,	
kg	(lbs)	N	(lbs·f)
22 – 45	(50 – 100)	67	(15)
46 – 68	(101 – 150)	110	(25)
69 – 90	(151 – 200)	180	(40)
91 – 159	(201 – 350)	222	(50)
160 – 227	(351 – 500)	267	(60)
228 – 295	(501 – 650)	311	(70)
296 – 363	(651 – 800)	356	(80)
364 – 453	(801 – 1000)	445	(100)
454 – 544	(1001 – 1200)	534	(120)
545 – 725	(1201 – 1600)	623	(140)
726 – 907	(1601 – 2000)	712	(160)
908+	2001+	800	(180)

61.5 Downward force test

61.5.1 A floor-standing unit shall not overbalance when a constant downward force of 800 N (180 lbf) is applied at the point of maximum moment to any horizontal surface of at least 12.5 cm (5 inches) by at least 20 cm (9 inches), at a height up to 1 m (3 ft) above the floor. The 800 N force is applied by a suitable test tool having a flat surface of approximately 12.5 cm by at least 20 cm. Doors, drawers, and the like are closed during this test.

62 Loading Tests

62.1 General

62.1.1 For cabinets that are provided with shelves or drawers, the test of 62.2 shall apply.

62.1.2 For cabinets that are provided with sections that are connected together, the test of 62.3 shall apply.

62.2 Shelf and drawer loading test

62.2.1 This test is performed on cabinets that are provided with shelves and drawers.

62.2.2 The drawers and shelves shall be installed as intended. If the position of shelves or drawers is adjustable either by the manufacturer or the user, the most disadvantageous positioning should be used. If drawers are provided, the loading is to be performed with the drawer fully extended.

62.2.3 Each load is to be uniformly applied along the entire width of the shelf or drawer, centered on the line at mid-depth of the shelf or drawer or at a line 0.1 m (4-1/4 inches) from the front edge of the shelf or drawer, whichever is furthest from the rear edge of the shelf or drawer. The loads are gradually increased from zero to the specified value and maintained for 5 minutes after full loading is attained. If the

manufacturer does not specify a maximum load for each shelf or drawer, then each shelf or drawer is subjected to a load as shown in Table 62.1 based on the drawer depth. If the manufacturer specifies a maximum load for each shelf or drawer, then each shelf or drawer is subjected to a load equal to 4 times the manufacturers specified load.

Table 62.1
Loading values for shelves and drawers

Drawer or shelf width[a]		Load based on depth (d) of shelf or drawer					
		d < 0.2 m (8 in)		0.2 m < d < 0.4 m (16 in)		0.4 m (16 in) < d	
m	(in)	kg	(lbs)	kg	(lbs)	kg	(lbs)
0.15	(6)	8.2	(18)	13.6	(30)	19.0	(42)
0.30	(12)	16.4	(36)	27.2	(60)	38.1	(84)
0.46	(18)	24.5	(54)	40.8	(90)	57.1	(126)
0.61	(24)	32.6	(72)	54.4	(120)	76.2	(168)
0.76	(30)	40.8	(90)	68.0	(150)	95.2	(210)
0.91	(36)	49.0	(108)	81.6	(180)	114.3	(252)
1.07	(42)	57.2	(126)	95.2	(210)	133.4	(294)
1.22	(48)	65.3	(144)	108.8	(240)	152.4	(336)

[a] For drawer or shelf widths that are in between values in the table, interpolation is allowed.

62.2.4 During the 5 minute loading duration, the shelves and drawers under test shall not break or fall from their original positions. There shall be no damage to mounting means that would increase the risk of injury to the user.

62.3 Section loading test

62.3.1 This test is performed on cabinets provided with sections that are connected together.

62.3.2 The sections are to be connected together as intended. If the cabinet is provided with electrical connections, these connections may be omitted for this test.

62.3.3 All sections of the cabinet are to be loaded, one at a time if more than one section is provided, to the loads specified below. The loads are to be gradually increased from zero to the specified values and maintained for 5 minutes.

a) For a section that contains shelves or drawers, the shelves or drawers are to be loaded in accordance with 62.2.3, except the drawers are to be closed for this test.

b) For a section that contains hooks, pegboard, or some other device to hang items, the manufacturer shall specify a maximum load and four times this specified load shall be applied.

c) For sections that consist of one structure, such as overhead bins, the section shall be loaded as a shelf in accordance with 62.2.3.

d) When the maximum load for a section is specified in the manufacturer's installation instructions, the load used for the test is to be four times the specified weight.

Exception: Sections of a cabinet that are supported by the floor and are only physically connected together for aesthetics or stability support, need not comply with this test.

62.3.4 This test may be combined and performed at the same time as the Shelf and drawer loading test, 62.2, if acceptable to all those involved.

62.3.5 During the 5 minute loading duration, the sections under test shall not break or fall from their original position. There shall be no damage to mounting means that would increase the risk of injury to the user.

63 Mounting Tests

63.1 The mounting means of equipment intended for wall or ceiling mounting shall withstand a force of four times the weight of the equipment, but not less than 4.5 kg (10 lbs), without malfunction of or damage to the mounting bracket, its securing means, or that portion of the equipment to which it is attached. When tested as described, the equipment and mounting systems shall remain in place with no evidence of damage to the mounting system.

63.2 To determine if the equipment complies with 63.1, the equipment is to be mounted in accordance with the manufacturer's installation instructions, using the hardware and construction as prescribed by the manufacturer. If the details of wall construction are not specified, 10 mm metric size (3/8 inch trade size) thick plasterboard (gypsum wallboard or drywall) on nominal 38 by 89 mm (1-1/2 by 3-1/2 inch, 2 by 4 inch trade size) wood studs spaced on approximately 406 mm (16 inch) centers is to be used as the support surface. The hardware is to be applied as specified in the instructions, and if not otherwise indicated, the securing screws are to be positioned between the studs and secured into the plasterboard. Adjustable equipment is to be adjusted to the position that will give the maximum projection from the wall. The force is to be applied through a 76 mm (3 inch) wide strap at the dimensional center of the equipment and is to be increased over a 5 to 10 second interval, until a load equal to the weight of the equipment plus a force of three times the weight of the equipment, but not less than 4.5 kg (10 lbs), is applied to the mounting system. The load is to be maintained for one minute.

64 Handle Strength Test

64.1 A handle intended for lifting and carrying equipment shall withstand a force equal to four times the weight of the equipment when tested in accordance with 64.2.

64.2 The force is to be applied with the handle in the intended carrying position, over a 76 mm (3 inch) length at the center of the handle. The force is to be applied gradually such that the required value is attained in 5 to 10 seconds and then maintained for 1 minute. If more than one handle is provided, the force is to be determined by the percentage of the equipment weight sustained by each handle with the equipment in the intended carrying position. If equipment weighing less than 25 kg (55 lbs) is provided with more than one handle, but can be carried using only one handle, each handle is to be capable of withstanding a force based on the total weight of the equipment.

65 Strain Relief Test

65.1 General

65.1.1 All cords that are permanently connected and may result in a risk of fire or electric shock if internal connections are damaged shall be subjected to the tests outlined in 65.2 and 65.3.

65.2 Pull force relief test

65.2.1 The cord is subjected to a steady pull of the value shown in Table 65.1, applied in the most unfavorable direction. The test is conducted 25 times, each time for a duration of 1 second.

Table 65.1
Force values for strain relief tests on power cords

Mass (M) of the equipment kg	Pull N
M ≤ 1	30
1 < M ≤ 4	60
M > 4	100

65.2.2 During the tests, the cord shall not be damaged. This is checked by visual inspection, and by an electric strength test between the cord conductors and accessible conductive parts, in accordance with Dielectric Voltage Withstand Test, Section 54.

65.2.3 After the test, the power supply cord shall not have been longitudinally displaced by more than 2 mm (2/25 inch) nor shall there be appreciable strain at the connections, and spacings shall not be reduced, as described in Spacings, Section 33.

65.3 Push-back relief test

65.3.1 To determine compliance with 12.2.3, a product shall be tested in accordance with 62.2 without occurrence of any of the conditions specified in 12.2.3 (a) – (c).

65.3.2 The cord or lead is to be held 25.4 mm (1 inch) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 25.4 mm is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 25.4 mm increments until the cord buckles or the force to push the cord into the product exceeds 26.7 N (6 lbf). The supply cord or lead within the product is to be manipulated to determine compliance with 13.2.3 (a) – (c).

66 Tests for Switches, Controls, Interlocks, and Overload Protective Devices

66.1 Controls for solenoids, relay coils, and the like

66.1.1 To determine if a switch or other control device complies with 24.3.1, the device is to be subjected to the overvoltage test described in 66.1.2. There shall not be any electrical or mechanical failure of the device or undue burning or pitting of the contacts as a result of the test. The fuse in the grounding connection shall not rupture during the test.

66.1.2 The device is to be connected to a supply circuit of rated frequency and 110 percent of maximum rated voltage. The load on the device being tested is to be the same as that which it is intended to control during normal operation. During the test, exposed dead metal parts of the equipment are to be connected to ground through a 3 ampere plug fuse. The device is to be operated for 50 cycles, at a rate of not more than 10 cycles per minute.

Exception: The device may be operated at a faster rate if agreeable to all concerned.

66.2 Controls for motors

66.2.1 To determine if a switch or other control device complies with 24.4.1 the device is to be subjected to the test described in 66.2.2. There shall not be any electrical or mechanical failure of the device or undue pitting or burning of the contacts. The fuse in the grounding connection shall not rupture during the test.