UL 1963

STANDARD FOR SAFETY

Refrigerant Recovery/Recycling Equipment

UL Standard for Safety for Refrigerant Recovery/Recycling Equipment, UL 1963

Fourth Edition, Dated June 1, 2011

Summary of Topics

This revision to ANSI/UL 1963 dated March 25, 2021 includes the following:

- ***Clarifications and addition of alternate method for evaluating protective electronic circuits and controls using requirements based on UL 60335-1; 3.12.1, 3.13, 3.14, 3.16.1, 3.16.2, 3.26.1, 3.28.1, 3.28.2, 3.28.4, 9.2.1, 17.14 – 17.18.8, 17.19.1, Table 19.2, 25.1.2.2, 27.1 – 27.6, 42.3, 42.4, 45.3, 48.1, 48.2, Section 69A, Section 74, Section 85A, Section 90A, Appendix B***

- ***Addition of requirements for remotely operated refrigerant recovery/recycling equipment; 3.18.0, 10.4.7, 14.16, Section 17A, 94.13***

- ***Update of motor-protection requirements; 19.2.1, 19.2.1.1, 19.2.3, 19.2.4***

- ***Clarify requirements for large nonmetallic exterior surface materials; Table 52.1***

- ***Alternate compliance option for EMI filters; 33.1***

- ***Alternate power supplies; 3.28.3, 3.30, 25.3.1, 25.3.3, 25.3.3.1, 25.3.4, 25.3.6, 25.4 (title), 25.4.1, 25.4.1.1, 25.4.2, 25.4.5, 25.4.7 – 25.4.9, 36.1.1, 36.2, Section 36A, Section 69B, 91.27***

- ***Addition of new capacitor standard requirements; 3.5.1, 24.1 – 24.3, 24.5 – 24.7***

- ***Gasket requirements; 9.3.8, 83.1, 83.3 – 83.4.2, 83.5, 83.6***

- ***Wiring subjected to movement; 12.1.10, Section 82A***

- ***Clarification to marking requirements; 91.1.1***

- ***Maximum operating current and maximum rated current requirements; 3.2.1, 3.2.2, 3.19.1, 3.19.2, 11.11, 12.1.2, 17.1 – 17.3, 17.11, 17.11.1, 17.13, 19.3.1, 19.3.2, 19.3.2.1, 56.3, 66.3, 66.4, 73.1.4 – 73.1.4.2, 92.2, 92.5, 92.6.1, 92.12***

- ***Refrigerant requirement revisions; 44.1 – 44.4, Section 86A, Section 90B, SB1.2***

- ***Clarifications to barrier requirements; 3.3, 3.4, 5.2.1, 7.1 – 7.2.1, 7.4, 12.1.21, 12.1.26, 12.1.27, 12.1.29, 13.1, 13.3 – 13.6, 14.2, 14.2.1, 16.2, 18.3, 18.4, 20.1, 20.1.1, 41.9, Table 52.1, Table 57.1, A7.2***

- ***Miscellaneous clarifications; 10.1.1, 5.3.1, 5.3.1.1, Table 52.1, 52.3.1, 52.3.2, 73.1.6, 76.8, 76.8.1, A52.3.1***

- ***Revisions for hose assembly requirements for flammability for class 2 and class 3 refrigerants; SB4.1 (title), SB4.1.1, SB4.2.1***

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated May 17, 2013.

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UL 1963

Standard for Refrigerant Recovery/Recycling Equipment

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This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through March 25, 2021.

The most recent designation of ANSI/UL 1963 as an American National Standard (ANSI) occurred on March 17, 2021. 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 UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover refrigerant recovery and recycling equipment to be employed in accordance with the National Electrical Code, NFPA 70 and include battery operated equipment.

1.2 These requirements apply to equipment intended for indoor or outdoor use or both.

1.3 These requirements do not cover equipment rated more than 600 volts or employing a universal motor rated more than 250 volts or intended for installation and use in a hazardous (classified) location.

1.3.1 These requirements cover recovery/recycling equipment intended for use with a flammable refrigerant when investigated to the requirements in Supplement SB.

1.4 Refrigerant recovery/recycling equipment intended for use with commercial refrigerant systems, other than automotive, is judged on the basis of compliance with the requirements in this standard, insofar as they are applicable, and further examination and test to determine whether the equipment is acceptable for the purpose.

2 General

2.1 Units of measurements

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

2.1.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are rms.

2.2 References

2.2.1 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.

2.3 Terminology

2.3.1 The term “equipment” as used in these requirements refers to all refrigerant recovery/recycling and recovery (extraction) equipment or any part thereof covered by these requirements unless specifically noted otherwise.

3 Glossary

3.1 For the purpose of these requirements, the following definitions apply.

3.2 ACCESSORY – An optional electrical device or other component intended for installation in or connection to the equipment for the purpose of modifying or supplementing its functions. The accessory may be factory installed or intended for installation by the user or service personnel.

3.2.1 ADJUSTABLE SPEED DRIVE – A combination of power converter, inverter, motor, and motor-mounted auxiliary devices such as encoders, tachometers, thermal switches and detectors, air blowers, heaters, and vibration sensors.

3.2.2 ADJUSTABLE SPEED DRIVE SYSTEM – An interconnected combination of equipment that provides a means of adjusting the speed of a mechanical load coupled to a motor. A drive system typically consists of an adjustable speed drive and auxiliary electrical apparatus.

3.3 BARRIER, INSULATING – A partition for the isolation of high-voltage electrical components or circuits.

3.4 BARRIER, MECHANICAL – A rigid partition for the isolation of ignition sources, moving parts or protection of wiring.

3.5 CABINET – The part of the product that provides physical protection to insulated wiring, enclosures, moving parts, motors, enclosed electrical parts, refrigeration tubing or other parts that may cause a risk of injury to persons.

3.5.1 CAPACITOR, CLASS Y – Capacitor or resistor-capacitor unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock. (Examples would include capacitors connected across the primary and secondary circuits where electrical isolation is required to prevent an electric shock or between hazardous live parts and accessible parts.)

3.6 CAPILLARY TUBE – Device made of tubing with an outer diameter of less than 3/16 in. (4.7 mm) and used to reduce the pressure of the refrigerant between the condenser and evaporator. It also regulates the refrigerant flow.

3.7 CIRCUITS, ELECTRICAL –

a) Extra-Low-Voltage – A circuit supplied by:

1) An AC potential of not more than 42.2 volts peak (30 V rms) and power of 100 VA or less; or

2) A DC potential of 30 V supplied by a primary battery; or

3) A Class 2 transformer, as defined by the National Electrical Code, NFPA 70; or

4) A combination of an isolating transformer and fixed impedance which as a unit complies with all performance requirements for a Class 2 transformer.

b) High-Voltage – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of an extra low-voltage circuit.

3.8 COMPONENT – A device or fabricated part of the recovery/recycling equipment covered by the scope of a safety standard dedicated to that purpose. If incorporated in recovery/recycling equipment, a product that is otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as aluminum or copper, are not considered components. Generally, components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under specific, limited conditions, such as certain temperatures not exceeding specified limits.

3.9 COMPRESSOR – A refrigerant motor-compressor with the suction side (low side) intended to be connected to a system from which the refrigerant is being removed. The discharge side is connected to the refrigerant recovery tank.

3.10 CONTROL CIRCUIT – A circuit that carries electric signals directing the performance of a controller that in turn, governs power delivered to a motor or other load in the equipment. A control circuit does not carry main power current.

3.11 CONTROL CIRCUIT, DIRECT-CONNECTED HIGH-VOLTAGE – A circuit that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the equipment. It is not tapped from the load side of the overcurrent device(s) of the controlled circuit(s) within the equipment.

3.12 CONTROL CIRCUIT, TAPPED HIGH-VOLTAGE – A circuit that is tapped within the equipment from the load side of the overcurrent device for the controlled load.

3.12.1 CONTROL FUNCTION (CLASS A, B or C) – Actuation of an electrical or electronic device (or devices) that are part of the refrigerant recovery/recycling equipment. Software may be used in the actuation of the device(s). Class A is not intended to be relied upon to reduce the risk of electric shock, fire or injury to persons. Class B is intended to reduce the risk of electric shock, fire or injury to persons. Class C is intended to further reduce the risks involving special hazards, such as explosion. A device with Class A actuation is considered to be an operating control, whereas a device with Class B or Class C actuation is considered to be a protective control.

3.13 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a thermal cutout/limiter or another layer of protection would mitigate the potential hazard, is considered an operating control. Operating controls are also referred to as “regulating controls”. Operating controls can also include other controlling devices such as switches, contactors, relays and similar devices. Appendix B specifies control functions that are not considered to result in a risk of fire, electric shock or injury to persons.

3.14 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the product. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as “limiting controls” or “safety controls” and are investigated under normal and single-fault conditions. Appendix B specifies control functions that are considered to result in a risk of fire, electric shock or injury to persons. Such functions may also be known as “safety critical”.

3.15 CONTROL, TEMPERATURE-LIMITING – A control that serves to prevent excessive temperature.

3.16 DESIGN PRESSURE – The maximum acceptable working pressure for which the equipment or a specific part is designed.

3.16.1 ELECTRONIC COMPONENT – A part in which electrical conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor. A Metal Oxide Varistor (MOV) is considered to be an electronic component, but neon indicators are not.

3.16.2 ELECTRONIC DISCONNECTION – The de-energizing of a load within a product by an electronic device of a circuit. No electro-mechanical component having an air gap, such as a switch, contactor or relay is used to de-energize the load.

3.17 ENCLOSURE – The part of the product that does one or more of the following:

a) Isolates ignition sources;

b) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock; or

c) Retards propagation of flame initiated by electrical disturbances within.

3.18 FUNCTIONAL PART – A part of the product, other than an enclosure or cabinet, used to maintain the intended relative physical position of fixed or moving parts, or maintain the integrity of the structure.

3.18.0 GROUNDING, FUNCTIONAL – Grounding of a point in a product which is necessary for a purpose other than safety.

3.18.1 HOSE ASSEMBLY – A segment of flexible, usually nonmetallic, tubing and having a threaded fitting at each end for the purpose of connecting two components of a refrigeration system.

3.19 IGNITION SOURCE – Any high-voltage electrical component not located within an enclosure.

3.19.1 MAXIMUM OPERATING CURRENT (MOC) – The current resulting when an electric motor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor/adjustable speed drive or drive system is at a maximum.

3.19.2 MAXIMUM RATED CURRENT (MRC) – The current resulting when a hermetic refrigerant motor-compressor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor-compressor/adjustable speed drive or drive system is at a maximum.

3.20 MOTOR CONTROLLER – Any switch or device normally used to start and stop a motor by making and breaking the motor current directly.

3.21 NONFUNCTIONAL PART – A part of the product that does not perform a specific function.

3.22 NONFUNCTIONAL PART, SMALL – A nonfunctional part that does not occupy a volume greater than 0.12 in^3 (2 cm^3), does not have a dimension greater than 1.2 in (3 cm), is located so it cannot propagate flame from one area to another, and does not connect a possible source of ignition to other ignitable parts.

3.23 PIPING – Includes pipe, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components, such as strainers and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

3.24 PRESSURE-LIMITING DEVICE – A pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

3.25 PRESSURE-RELIEF DEVICE – A pressure-actuated valve or rupture member designed to relieve excessive pressure automatically. The device is not temperature-actuated.

3.26 PRESSURE VESSEL – Any refrigerant-containing receptacle of a system other than evaporators [each separate section of which does not exceed 1/2 ft^3 (0.014 m^3) of refrigerant containing volume], evaporator coils, compressors, condenser coils, controls, headers, pumps, piping, filters and strainers.

Exception: A refrigerant-containing receptacle identified as an ASME pressure vessel in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.

3.26.1 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a risk of fire, electric shock or injury to persons under abnormal operating conditions.

3.27 RECOVERY EQUIPMENT – An appliance that transfers refrigerant in any condition from a product to an external container without necessarily testing or processing the refrigerant.

3.28 RECYCLING EQUIPMENT – An appliance that extracts refrigerant from a product and cleans the refrigerant for reuse.

3.28.1 SOFTWARE – Pre-loaded data which creates, affects, and/or modifies the functionality of the equipment except that this does not include any pre-loaded data programmed into an integrated circuit chip that requires physical access and removal of the chip for reprogramming.

3.28.2 SOFTWARE UPDATE – Occurs if a version of data (software) replaces or modifies the previous version of data. This could include replacing or re-installing a version of data with an identical version of data.

3.28.3 SWITCH MODE POWER SUPPLY UNIT – Electronic device incorporating transformer(s) and electronic circuitry(ies), that converts electrical power into single or multiple power outputs by rapidly switching a solid-state device on and off. It may also isolate the input circuit from the output circuit and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including dc output.

3.28.4 THERMISTOR – A thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature characteristic a significant non-linear change in its electrical resistance with a change in temperature. A thermistor may be either of the positive temperature coefficient (PTC) type or of the negative temperature coefficient (NTC) type.

3.29 ULTIMATE STRENGTH – The highest stress level that the refrigerant component or vessel can tolerate without rupture.

3.30 VOLTAGE FOLDBACK – A circuit design feature intended to protect the power supply output transistors. When overcurrent is drawn by the load, the supply reduces the output voltage and current to within the safe power dissipation limit of the output transistors.

CONSTRUCTION

4 General

4.1 Ferrous metal parts used to support or retain electrical components in position shall be protected against corrosion by metallic or nonmetallic coatings, such as plating or painting.

Exception: This requirement does not apply to parts, such as washers, screws, bolts, and similar parts, where corrosion of such unprotected parts would not affect compliance with the requirements of this standard.

4.2 Exposed unimpregnated asbestos material shall not be used. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

4.3 Electrical insulating materials and systems used inside a hermetically sealed motor-compressor enclosure shall be compatible with the refrigerants and oils intended to be used in accordance with the Standard for Safety of Household and Similar Electrical Appliances, Part 1, General Requirements, UL 60335-1, together with the Standard for Household and Similar Electrical Appliances, Part 2: Particular Requirements for Motor-Compressors, UL 60335-2-34. They shall also be compatible with each other and with other materials used within the system.

4.4 Movable equipment employing carrying handles or straps shall be permanently marked according to 91.30.

4.5 All nonmetallic parts, excluding small nonfunctional parts shall comply with 5.1, 5.2, 5.3, and Table 52.1.

4.6 In addition to the requirement in 4.5, nonmetallic materials that serve as electrical insulation or that directly support live parts shall comply with the requirements for electrical insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

4.7 A component shall:

a) Comply with the safety standard covering that component;

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

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

d) Comply with the applicable requirements of this end product standard; and

e) Not contain mercury.

Exception: A component of a product covered by this standard is not required to comply with a specific component requirement that:

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

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

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

4.8 A component that is also required to perform other necessary functions, such as overcurrent protection, ground-fault circuit interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) covering products that provide those functions.

4.9 A component made of drawn or machined brass and containing more than 15 percent zinc shall comply with the 10-Day Moist Ammonia Air Stress Cracking Test as specified in the Standard for Refrigerant-Containing Components and Accessories, Nonelectrical, UL 207.

5 Nonmetallic Material

5.1 Classification

5.1.1 Materials shall be classified with respect to flammability characteristics that are established by the tests specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

5.1.2 Materials shall be assigned flammability ratings based on greatest to least resistance to flame and are identified as: 5VA, 5VB, V-0, V-1, V-2, HF-1, HF-2, HB, and HBF.

5.1.3 In reference to 5.1.2, the assigned flammability rating shall be appropriate for the material-use application in accordance with 5.2 and Table 52.1.

5.2 Ignition sources

5.2.1 Parts formed from nonmetallic materials rated HB or HBF and positioned as shown in Figure 5.1 shall be separated from ignition sources by means of a mechanical barrier, extending at least to the boundary surface of the space if such parts are located:

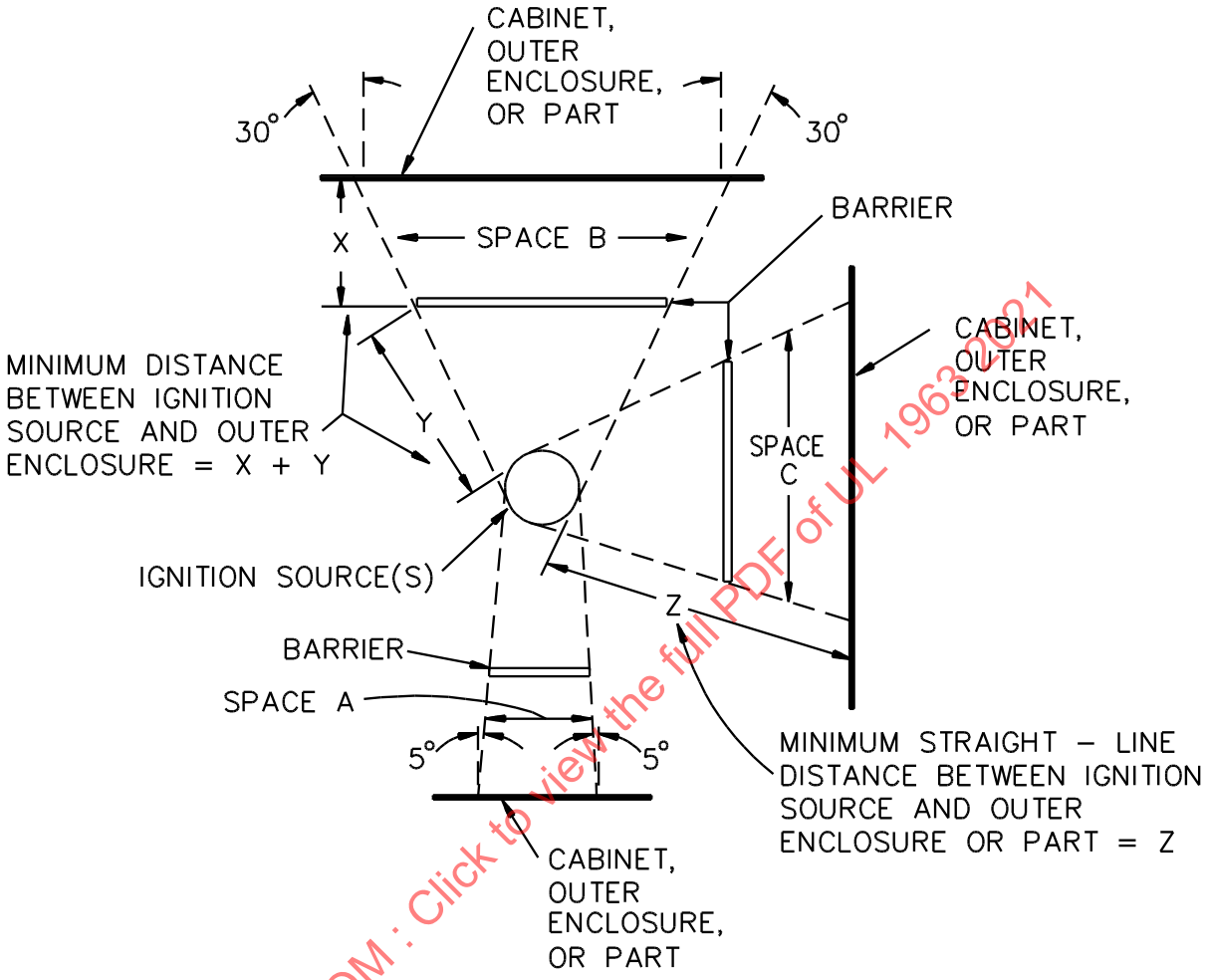
a) Below an ignition source and within Space A; and

b) Above an ignition source and within Space B; and

c) In the vertical plane relative to an ignition source and within Space C.

Figure 5.1

Separation of Ignition Sources from Nonmetallic Materials



Notes:

Space A – Represents the volume below the ignition source determined by a straight line that moves about the ignition source while remaining at the angle of 5 degrees from the vertical and is always so oriented that the volume is maximum.

Space B – Represents the volume above the ignition source determined in the same manner as Space A, except that the angle is 30 degrees from the vertical.

5.2.2 The HB or HBF materials referenced by 5.2.1 shall be located such that the distance between:

a) High-voltage wiring not employing VW-1 and the HB or HBF materials shall be a minimum of 2 in (51 mm), and

b) Any other ignition source and the HB or HBF materials shall be a minimum of 4 in (102 mm).

5.2.3 In reference to 5.2.2 and Figure 5.1, the minimum distance for materials located:

a) Above the ignition source shall be as shown in Distance X + Y; and

b) In the vertical plane relative to the ignition source shall be as shown in straight-line Distance Z.

5.3 Application and location

5.3.1 Nonmetallic fasteners used as a part of the enclosure, cabinet or functional part shall comply with the Fastener Strength Test, 52.3.

5.3.1.1 In reference to 5.3.1, nonmetallic fasteners required to comply with 52.3 shall include:

a) Nonmetallic ultrasonic, solvent or heat welds;

b) Nonmetallic screws and/or nuts; and

c) Nonmetallic parts into which metal or nonmetallic screws will be threaded.

5.3.2 The combined total exposed surface area of all small, nonfunctional parts shall not exceed 144 in^2 (929 cm^2).

5.3.3 When thermal insulation is located between a cabinet and inner liner, the product shall comply with both (a) and (b) or it can comply only with item (c):

a) All holes within the cabinet and inner liner shall be closed;

b) The cabinet surfaces shall be securely fastened such that the maximum spacing between screws, spot welds, or other securement means does not exceed 6 in (152.4 mm);

c) The thermal insulation shall be rated HF-1.

6 Assembly

6.1 General

6.1.1 Refrigerant recovery and/or recycling equipment shall be provided with the necessary hoses for connection in the intended manner to the equipment being serviced. These hoses shall be no longer than 8 ft (2.44 m), shall be provided with shut-off devices within 12 in (0.3 m) of the ends, and shall be constructed in accordance with Section 46.

6.1.2 The shut-off devices mentioned in 6.1.1 shall prevent refrigerant flow when the hose is not connected.

6.1.3 The equipment shall be assembled so that removal and replacement of tanks and containers, and the like, will not result in damage to electrical components and wiring, or to refrigerant-containing components.

6.1.4 Equipment having provision for the storage of refrigerant cylinders or the like shall be provided with means for retaining the cylinders in position.

6.1.5 Electrical components shall be installed on the unit and wired as necessary for intended operation.

6.1.6 Pressure-limiting devices, when required, shall be installed on the assembly and connected to the high side of the system.

6.1.7 Except as specified in 6.1.8, refrigerant-containing parts shall be factory connected with tubing or piping.

6.1.8 In reference to 6.1.7 refrigerant-containing parts not factory connected with tubing or piping shall be:

a) Intended for installation in the field;

b) Intended for connection to the refrigeration system being serviced;

c) Be packaged with the recovery/recycling equipment; and

d) Comply with the requirements in this standard.

6.1.9 In reference to 6.1.7, if flexibility is needed, a hose assembly used within recovery/recycling equipment in place of metal tubing or piping shall comply with 46.2.1. In addition, the hose assembly shall not:

a) Exceed 36 in. (0.91 m) in length; and

b) Be connected to another hose assembly located within the recovery/recycling equipment.

6.2 Mechanical protection

6.2.1 Horizontally-hinged doors that provide access to the storage compartments that may cause injury to persons upon unintentional closing shall be counterweighted, spring loaded, or provided with an automatic latch to retain them in the open position. Action members, such as springs and latches that may cause injury to persons due to pinching or the like, shall be enclosed or guarded.

6.2.2 A slideout component, such as a drawer or shelf, shall be restrained to prevent it from being unintentionally pulled free of its supporting means. Compliance shall be determined in accordance with the Component Restraint Test, Section 82.

6.2.3 With the equipment installed in its intended manner as specified in the Installation and Operating Instructions, Section 94, openings in the equipment shall be constructed or located to reduce the risk of injury to persons due to unintentional contact with:

a) Moving parts, such as fan blades, blower wheels, gears, and belts, and

b) Surfaces that exceed the temperatures permitted by subitems 2 and 3 of item D of Table 57.1.

6.2.3.1 Except as specified in 6.2.3.2, in evaluating openings, parts of the cabinet or enclosure, such as covers, panels, grilles, and guards shall be removed unless tools are required for their removal.

6.2.3.2 If a cover, panel, grille or guard can be removed without the use of a tool to expose a moving part, the moving part shall be made inoperative through the use of an interlocking mechanism complying with 9.2.1.

6.2.3.3 Except as specified in 6.2.3.4, the minor dimension of any opening shall not exceed 3 in (76.2 mm).

6.2.3.4 In reference to 6.2.3.3, equipment having an opening with a minor dimension larger than 3 in (76.2 mm) shall be provided with fixed components located to reduce the likelihood of contact with a moving part. Fixed components could include baffles, refrigerant tubing, and the like.

6.2.4 *Deleted*

6.2.5 Except as specified in 6.2.5.2, a fan blade employing a guard with openings having a minor dimension sized:

a) Less than 1 in (25.4 mm) shall be guarded such that the probe illustrated in Figure 6.1 cannot contact any part of the fan blade.

b) One inch (25.4 mm) or larger shall be guarded such that the distance from the opening to the fan blade complies with Table 6.1.

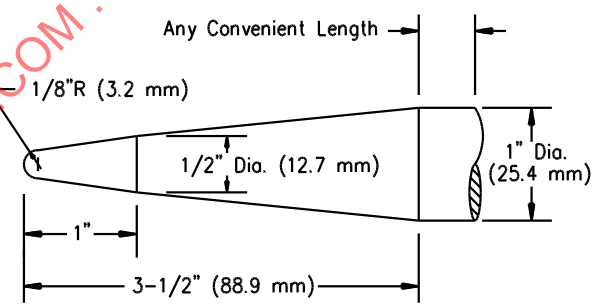
6.2.5.1 In reference to 6.2.5, the probe shall be inserted through openings in the guard with a force of not more than 2.5 lb (11.1 N).

6.2.5.2 In reference to 6.2.5, if the probe illustrated in Figure 6.1 contacts the fan blade, it shall not contact any part other than the trailing edge of the fan blade. Also, the relationship between weight (w) in pounds, radius (r) in inches and speed (n) in revolutions per minute of the fan blade shall be such that k in the following equation is less than 100:

$$k = 6 \times 10^{-7} (wr^2 n^2)$$

Figure 6.1

Probe for fan blades



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6.2.6 Except as specified in 6.2.6.1, a moving part other than a fan blade shall be guarded such that the distance from an opening to the moving part is in accordance with Table 6.1.

Table 6.1
Clearance from openings

Minor dimension of opening[a,d]		Minimum distance from opening to moving part[c]	
in	(mm)	in	(mm)
1/4	(6.4)	3/8	(9.5)
3/8	(9.5)	1-1/4	(31.8)
1/2	(12.7)	2	(50.8)
3/4	(19.1)	3-5/8	(92.1)
1	(25.4)	5-1/4	(133.4)
1-1/2	(38.1)	8-3/8	(212.7)
2	(50.8)	11-5/8	(295.3)
Over 2[b]	(Over 50.8)	30	(762.0)

[a] Openings less than 1/4 in (6.4 mm) are not to be considered.

[b] But not more than 3 in (76.2 mm). See 6.2.3.3.

[c] Also applies to hot parts. See 6.2.3 (b).

[d] For fan blade guards that have openings with minor dimensions less than 1 in (25.4 mm), see 6.2.5 (a).

6.2.6.1 In reference to 6.2.5(b) and 6.2.6, if an opening has a minor dimension intermediate between two of the values shown in Table 6.1, the distance from the opening to the moving part shall not be less than that found by interpolating between the corresponding values in the right column of the table.

6.2.7 The minor dimension of the opening shall be determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of not more than 2.5 lbs (11.1 N).

6.2.8 *Deleted*

6.2.9 *Deleted*

6.3 Electrical protection

6.3.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of unintentional contact with uninsulated live parts. Parts of the enclosure, such as covers, panels, or grilles shall be removed unless:

a) Tools are required for their removal, or

b) An interlock complying with 9.2.1 is provided.

6.3.2 If an opening in the enclosure does not permit the entrance of a 3/4 in (19.1 mm) diameter rod, the probe illustrated in:

a) Figure 6.2 shall not be capable of touching any uninsulated live parts; and

b) Figure 6.3 shall not be capable of touching any film-coated insulated wire.

6.3.2.1 In reference to 6.3.2, the probes shall be inserted through any openings in grilles, screens, louvers, or the like, with a force of not more than 5.0 lbs (22.3 N).

Figure 6.2

Probe

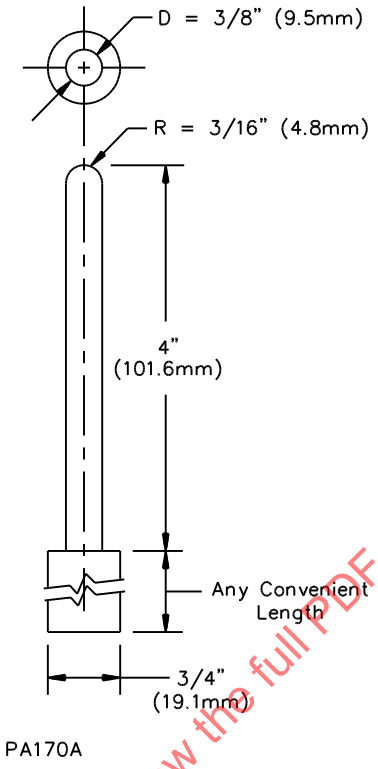
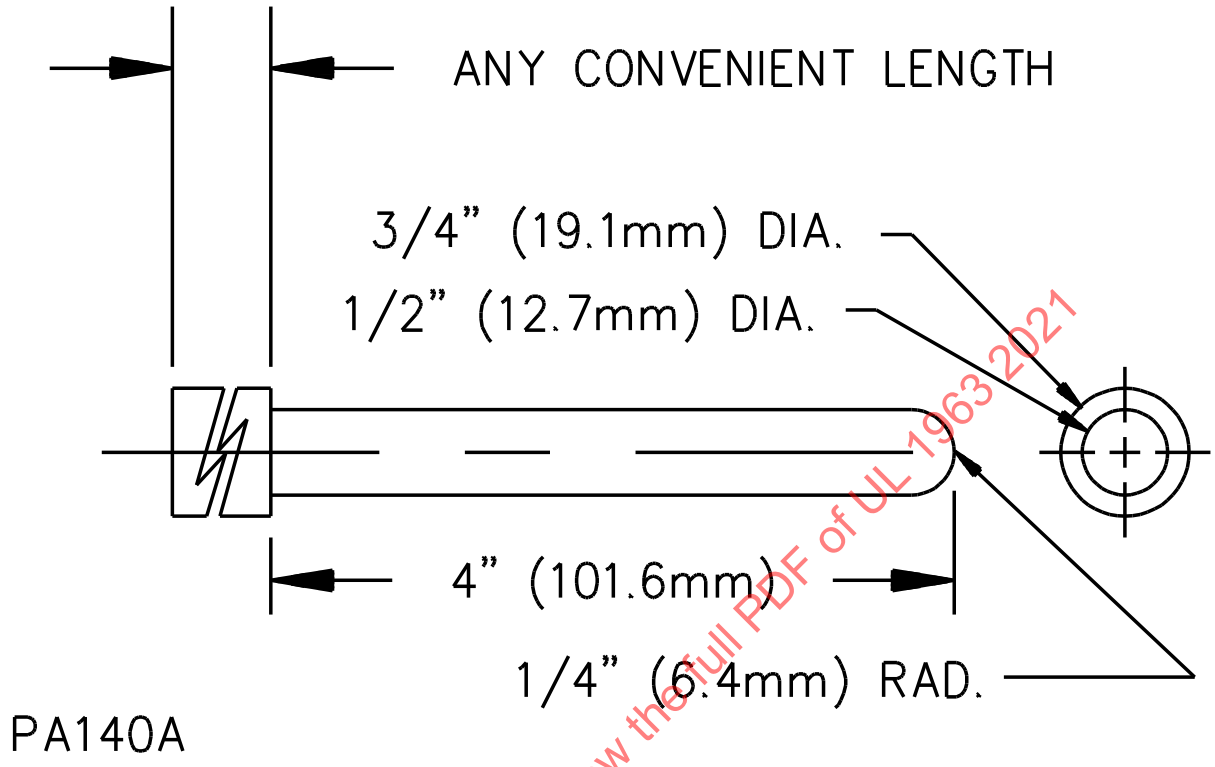


Figure 6.3

Probe

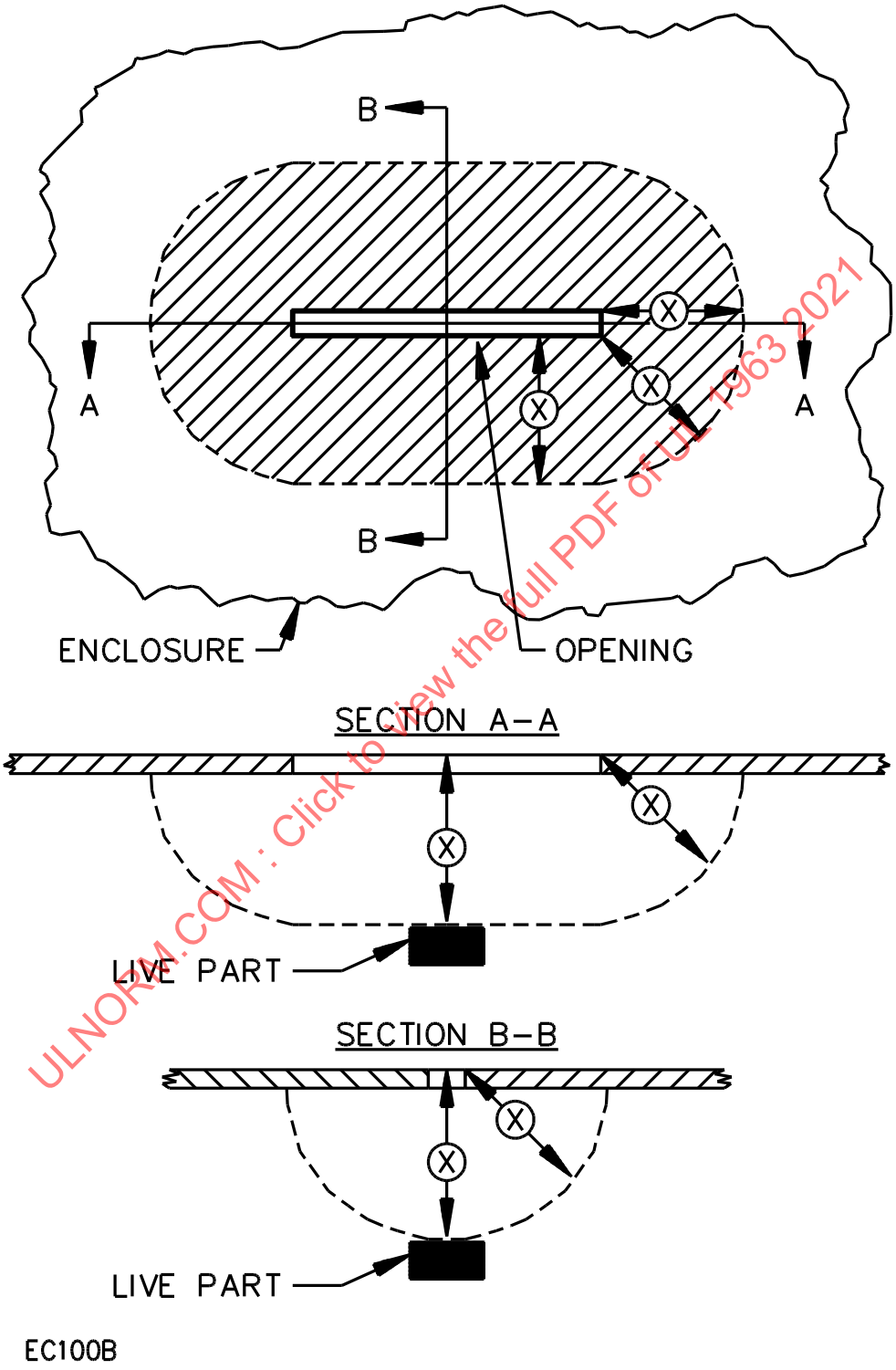


6.3.3 When an opening in the enclosure permits the entrance of a 3/4 in (19.1 mm) diameter rod, the conditions described in Figure 6.4 shall be used to determine compliance with the requirements. The minor dimension of the opening shall not exceed 1 in (25 mm) in any case.

6.3.4 In addition to the requirements of 6.3.2 and 6.3.3, uninsulated live parts located inside the enclosure that are likely to be contacted by persons performing operations, such as replacing fuses, resetting manual-reset devices, oiling motors, or other such service operations shall be located, guarded or enclosed to prevent unintentional contact, unless tools are required to expose the live part.

Figure 6.4

Opening in enclosure



The opening is acceptable when, within the enclosure, there is no uninsulated live part or film-coated insulated wire (1) less than X in (mm) from the perimeter of the opening, as well as (2) within the volume generated by projecting the perimeter X inches normal to the plane. X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 4 in (102 mm).

6.3.5 Except as specified in 6.3.5.2 and 6.3.5.4, a switch, lampholder, an attachment-plug receptacle, or similar component shall be secured in position and shall be prevented from turning. The means for preventing rotation shall consist of more than friction between surfaces.

6.3.5.1 In reference to 6.3.5, a stem-mounted switch or other similar device intended for mounting within a single-hole shall be prevented from rotating by either a:

a) Toothed lock washer; or

b) An interference lock, such as by a notch in the stem of the device.

6.3.5.2 In reference to 6.3.5, a switch that is not prevented from rotating shall:

a) Be operated by mechanical means rather than direct contact by persons;

b) Be of a plunger or other type that does not tend to rotate when operated;

c) Be mounted such that operating the switch is unlikely to loosen it;

d) Not cause electrical spacings to be reduced below the minimum required values specified in Sections 41 – 43 if the switch rotates.

6.3.5.3 In reference to 6.3.5.2 (b), a toggle switch shall not be used since such a switch is subjected to forces that tend to rotate the switch during its operation.

6.3.5.4 In reference to 6.3.5, a lampholder that is not prevented from rotating shall:

a) Be of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel; and

b) Not cause electrical spacings to be reduced below the minimum required values specified in Sections 41 – 43 if the lampholder rotates.

6.3.6 *Deleted*

6.3.7 An uninsulated current-carrying part, or a part that supports a live part, shall not rely solely upon friction between surfaces and shall be positively secured:

a) To the base or mounting surface so that it will be prevented from turning or shifting in position if such motion results in a reduction of electrical spacings below the minimum required values specified in Sections 41 – 43; or

b) By a toothed lock washer or an interference lock as specified in 6.3.5.1.

6.3.8 *Deleted*

7 Barriers

7.1 A mechanical barrier shall be secured to the mounting surface such that tools are required for its removal and shall be formed from one or more of the following:

a) Metal, minimum 0.026 in (0.66 mm) thick,

b) A nonmetallic material which shall be considered a part of the cabinet and which shall comply with the cabinet requirements of Table 52.1,

c) A finned coil in which the coil is located in the:

1) Vertical plane such that a 2 in long by 1/4 in diameter (51 by 6.4 mm) rod cannot contact the part or material being protected from the opposite side of the finned coil; or

2) Horizontal plane if the coil employs flat plate fins with a minimum of 12 fins per inch (12 fins per 25.4 mm) and having at least two rows of tubing in depth.

d) Any other material or construction determined to be equivalent to (a) – (c).

7.1.1 An insulating barrier shall:

a) Be constructed to withstand the most severe condition anticipated in service;

b) Comply with 7.2 and with the requirements for mechanical barriers in 7.1 if exposed or otherwise subjected to mechanical damage; and

c) Be reliably held in place.

7.2 Except as specified in 7.2.1, an insulating barrier shall be formed from one or more of the following:

a) Vulcanized fiber or varnished cloth not less than 0.028 inch (0.71 mm) thick,

b) Fiberglass, minimum 0.5 in (12.7 mm) thick,

c) A nonmetallic that complies with 5.1 – 5.3 and the functional parts requirements of Table 52.1 together with the requirements for electrical insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C,

d) Any other material or construction determined to be equivalent to (a) to (c).

7.2.1 An insulating barrier not complying with 7.2 shall be used only for extra-low-voltage circuits that do not contain a protective control.

7.3 In reference to 7.2, a rigid backing or a mechanical barrier shall be provided behind these materials unless the materials are determined to be suitably rigid.

7.4 *Deleted*

8 Accessories

8.1 Equipment having provisions for the use of electrical accessories to be attached in the field shall be constructed so that the use of these accessories will not introduce a risk of fire, electric shock, or injury to persons. See 91.18 and 91.20.

8.2 The equipment shall comply with all requirements of this standard with or without the accessory installed.

8.3 Installation of accessories by the user shall be restricted to an arrangement that can be accomplished by means of receptacles and plug-in connectors.

8.4 Installation of accessories by service personnel shall be by means of receptacles, plug-in connectors, insulated wire connectors, or by connection to existing wiring terminals.

8.5 Accessories intended for connection to a source of field supply independent of that of the unit shall:

a) Comply with the requirements specified in Section 10 when intended to be a permanently connected accessory.

b) Comply with the requirements specified in Section 11 when intended to be a cord-connected accessory.

In no case shall a permanently connected accessory be used with supply cord connected equipment.

8.6 When an accessory is powered from a source of supply separate from that supplying the unit, disconnection of any one supply shall automatically cause de-energization of all circuits within the unit and accessory.

Exception: Automatic de-energization may be omitted when the unit and accessory are marked in accordance with 91.36.

8.7 Installation of accessories shall not require the cutting of wiring or the soldering of connections by the installer. Installation shall not require cutting, drilling, or welding either in electrical enclosures, or other areas where such operations may result in damage to electrical or refrigeration components and wiring within the enclosure.

8.8 Strain-relief means shall be provided for the wiring in the accessory when there is a possibility of transmitting stress to the terminal connections during installation. See Strain Relief Test, Section 64.

8.9 All terminals and wiring intended to be field connected shall be identified on the:

a) Accessory,

b) Equipment when connections are to be made between the accessory and the equipment, and

c) Wiring diagram(s).

8.10 The mounting location of the accessory shall be indicated on the equipment.

Exception: When the mounting location is fixed due to the function of the accessory and arrangement of the equipment, and instructions are provided covering the installation and location for the accessory, the mounting location of the accessory need not be indicated.

8.11 As part of the investigation, accessories are to be trial-installed to determine that their installation is feasible, the instructions are detailed and correct, and the use of the accessories does not introduce a risk of fire, electric shock, and injury to persons.

9 Enclosures

9.1 General

9.1.1 An enclosure shall be formed and assembled so that it will have the strength and rigidity necessary to resist the conditions of intended use without increasing the risk of fire or injury to persons due to total or partial collapse and the resulting reduction of spacings, loosening or displacement of parts, or other defects. Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with this requirement.

9.1.2 Among the factors that are to be taken into consideration when judging the acceptability of an enclosure are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flame resistance,

e) Resistance to distortion at temperatures to which the material may be subjected under conditions of use, and

f) Resistance to corrosion.

For a nonmetallic enclosure or part of an enclosure, all of these factors, including the effect of exposure to weathering when for outdoor use, are to be considered with respect to aging.

9.1.3 The enclosure of the equipment shall reduce the risk of mechanical damage to wiring, electrical components, and refrigerant tubing.

9.1.4 The enclosure shall reduce the risk of emission of molten metal, burning insulation, flaming particles, or the like, through openings onto flammable material, including the surface over which the equipment is mounted.

9.1.5 Electrical components, such as controls, solenoids, starting relays, and switches, shall be individually enclosed except terminals unless it can be determined that failure of a component will not result in a risk of fire. See Burnout Tests – Electromagnetic Components, Section 65.

9.1.6 Electrical parts, see 9.1.5, within the outer cabinet need not be individually enclosed when the assembly complies with (a) – (c):

a) Their construction and location with respect to openings in the outer cabinet will not result in the emission of flame or molten metal through openings in the cabinet, or it can be shown that failure of the component would not result in a risk of fire,

b) There are no openings in the bottom of the compartment in which the part is located that would permit dropping of molten metal, and the like, on flammable material, and

c) The part is not in proximity to flammable material other than electrical insulation.

9.1.7 A sheet metal enclosure is to be judged for acceptability with respect to its size, shape, metal thickness, and use in a particular application. Sheet steel shall be not less than 0.026 in (0.66 mm) thick when uncoated or 0.029 in (0.74 mm) when galvanized, and nonferrous sheet metal shall be not less than 0.036 in (0.91 mm), except for relatively small areas or for surfaces which are curved or otherwise reinforced.

9.1.8 Sheet metal to which a wiring system is to be connected in the field shall be not less than 0.032 in (0.081 mm) thick when uncoated steel, not less than 0.034 in (0.86 mm) thick when galvanized steel, and not less than 0.045 in (1.14 mm) thick when nonferrous.

9.1.9 When threads for the connection of conduit are tapped through a hole in an enclosure wall, or when an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction shall permit a conduit bushing to be attached. When threads for the connection of conduit are not tapped through a hole in an enclosure wall, conduit hub, or the like, there shall be no less than 3-1/2 threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductor equivalent to that provided by a standard conduit