



Industrial and Commercial Vibrators

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UL Standard for Safety for Industrial and Commercial Vibrators, UL 2788

First Edition, Dated June 6, 2014

Summary of Topics

This is the First Edition of ANSI/UL 2788.

The new requirements are substantially in accordance with Proposal(s) on this subject dated February 21, 2014.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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JUNE 6, 2014

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ANSI/UL 2788-2014

UL 2788

Standard for Industrial and Commercial Vibrators

First Edition

June 6, 2014

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 2788 as an American National Standard (ANSI) occurred on June 4, 2014. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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 <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover industrial and commercial vibrators designed and intended to facilitate the flow and settling of granular materials and slurries.

1.2 These products are intended to be mounted to bins, chutes, hoppers, tables, forms, and/or vehicle beds or containers.

1.3 The products covered by these requirements are electrically operated, AC and/or DC and are rated 1,000 volts single or three-phase or less.

1.4 These requirements do not cover products intended for use with flammable or combustible liquids.

1.5 These requirements do not cover products intended for use in hazardous locations as defined in the *National Electrical Code*®, NFPA 70.

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1.6 If the risk of fire does not exist at a vibrator, part, or circuit, then the requirements of this Standard intended to address the risk of fire shall not apply to that vibrator, part, or circuit.

1.7 If the risk of electric shock does not exist at a vibrator, part, or circuit, then the requirements of this Standard intended to address the risk of electric shock shall not apply to that vibrator, part, or circuit.

1.8 The requirements of this Standard intended to address the risk of fire do not apply to a product provided with a metal enclosure in which there are no openings in the enclosure through which molten metal, burning insulation, flaming particles, or other ignited material could fall onto flammable material, or through which a flame could be projected.

1.9 The products covered by these requirements have not been evaluated for the sound pressure levels produced during operation.

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 requirement that:

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

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

3 Units of Measurement

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

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 purposes of this Standard, the following definitions apply.

5.2 CORD CONNECTED VIBRATOR – A vibrator that is intended to be connected to a source of supply in the field by means of a flexible cord and an attachment plug that are both provided with the motor.

5.3 ENCLOSURE – That portion of a unit that:

- a) Reduces the accessibility of a part that involves a risk of fire, electric shock, or injury to persons; or
- b) Reduces the risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

5.4 DIRECTLY ACCESSIBLE VIBRATOR – A vibrator that can be physically contacted without opening or removing any part, or is located so that it is accessible to contact.

5.5 FACTORY INSTALLATION – The act of wiring and mounting a vibrator in a manufacturing environment under controlled conditions by trained personnel.

5.6 FIELD INSTALLATION – The act of wiring and mounting a vibrator outside of a manufacturing environment where the installation is subject to the requirements of the National Electrical Code®, NFPA 70.

5.7 FIELD TERMINAL COMPARTMENT – Where the outgoing power is connected to the vibrator at the field installation site and the connection is a wire-to-terminal connection.

5.8 FIELD WIRING COMPARTMENT – Where the outgoing power is connected to the vibrator at the field installation site and the connection is a wire-to-wire connection.

5.9 FIXED EQUIPMENT – Equipment that is intended to be permanently connected electrically to the wiring system.

5.10 GROUND – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

5.11 GROUNDING CONDUCTOR – An equipment or circuit conductor that is intentionally connected between that electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

5.12 INDIRECTLY ACCESSIBLE VIBRATOR – A vibrator that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without the aid of a tool, or is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

5.13 INTERMITTENT DUTY VIBRATOR – A vibrator that is intended to operate for no longer than a specified time period or for a specified duty-cycle.

5.14 PERMANENTLY CONNECTED – Connected to branch circuit wiring by a means other than a flexible cord and attachment plug, such as by using conduit.

5.15 PERMANENTLY INSTALLED – Secured to a mounting surface by a means that requires the use of a tool for removal.

5.16 PORTABLE – A product that is easily carried or conveyed by hand, and is provided with a power-supply cord for connection to the supply circuit.

5.17 PROTECTIVE IMPEDANCE – An impedance connected between live parts and accessible metal parts, and of such a value that the current is limited to a safe value.

5.18 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist at any part if:

a) The potential between the part and earth ground or any other simultaneously accessible part is more than 42.4 V peak for alternating current potentials or 60 volts for direct current potentials; and

b) The continuous current flow through a 1500-ohm resistor connected across the potential exceeds 0.5 mA.

5.19 RISK OF FIRE – A risk of fire is considered to exist if the open-circuit voltage between any two points is equal to or greater than 2500 volts peak, or if power of more than 15 watts can be delivered into an external resistor connected between the two points.

5.20 SIMULTANEOUSLY ACCESSIBLE – Parts are considered to be simultaneously accessible when they are no further than 2 m (6.6 feet) apart.

5.21 SHEET METAL SCREW – A screw with a thread pitch that exceeds the thickness of the sheet metal and is designed to engage an unextruded, unthreaded hole in the metal.

5.22 SMALL PARTS – Materials that do not exceed 2 cm³ (0.12 in³) in volume and 3 cm (1.18 in) in maximum dimension, and are located such that they cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

5.23 STATIONARY – Equipment that is intended to be fastened in place or located in a dedicated space, and is provided with a power-supply cord for connection to the supply circuit.

CONSTRUCTION

6 Vibrators Provided With Controls

6.1 When a vibrator is provided with an electronic control or where an electronic control provides required protection, the control shall comply with the Standard for Industrial Control Equipment, UL 508, or the Standard for Power Conversion Equipment, UL 508C.

7 Motor Protection

7.1 Motor over-temperature protection shall be provided for the motor of a vibrator by one of the following:

- a) Compliance with the requirements contained in the Standard for Impedance Protected Motors, UL 1004-2;
- b) Compliance with the requirements contained in the Standard for Thermally Protected Motors, UL 1004-3;
- c) Compliance with the requirements contained in the Standard for Electronically Protected Motors, UL 1004-7; or
- d) A separate device responsive to motor current and rated and set to trip at not more than the percentage of the motor nameplate full-load current rating specified in Table 7.1. If the percentage protection specified in Column A of Table 7.1 does not correspond to the percentage value of an overload relay of a standard size, the device of the next higher size may be used. However, the overload device of the next higher size shall protect against currents exceeding the percentage values specified in Column B of Table 7.1.

Exception: A vibrator that is intended to be permanently connected or permanently installed and is marked in accordance with 34.7, is not required to comply with this requirement.

Table 7.1
Protective device activation level

Motor	Maximum percent of full-load current rating protection	
	A	B
Motor with marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 40°C (72°F)	125	140
Any other motor	115	130

8 Mechanical Assembly

8.1 A vibrator shall be assembled so that it is not adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise designed to prevent loosening.

8.2 Uninsulated live parts shall be secured to the base or mounting surface so that they are prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable value.

8.3 Friction between surfaces is not acceptable as the sole means to prevent shifting or turning of a live part; but a properly applied lock washer is acceptable for this purpose.

8.4 A switch, a motor-attachment plug, an attachment-plug receptacle or similar component shall be mounted securely and shall be prevented from turning. See 8.5.

Exception: A switch need not be prevented from turning if all of the following conditions are met:

- a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch.*
- b) Means for mounting the switch makes it unlikely that operation of the switch will loosen it.*
- c) Spacings are not reduced below the minimum acceptable values if the switch rotates, and leads or connections are not stressed.*
- d) Operation of the switch is by mechanical means rather than by direct contact by persons.*

8.5 A properly applied lock washer is acceptable as a means to prevent a small stem-mounted switch or other device having a single-hole mounting means from turning.

9 Frame and Enclosure

9.1 General

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

9.1.2 Among the factors taken into consideration when the acceptability of an enclosure is being judged are its:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Combustibility;
- e) Resistance to corrosion;
- f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use; and
- g) Resistance to ignition from electrical sources.

9.1.3 For a nonmetallic enclosure, 9.1.2 (a) – (g) shall be evaluated with respect to thermal aging. See 9.4 for polymeric enclosures and enclosure parts.

9.1.4 Acceptability of the size, number, and location of openings in an enclosure of a vibrator shall consider the following factors:

- a) Environment;
- b) Degree of exposure;
- c) Protection against unintentional contact with moving parts;
- d) Protection against unintentional contact with live parts, including film-coated wire; and
- e) Prevention of expulsion of molten metal, burning insulation, flaming particles and the like onto combustible materials, if applicable.

9.2 Cast metal enclosures

9.2.1 The thickness of cast metal for an enclosure shall be as specified in Table 9.1.

Exception: Cast metal of a lesser thickness is not prohibited when upon investigation (consideration being given to the shape, size, and function of the enclosure) it is found to be mechanically equivalent for the intended use.

Table 9.1
Thickness of cast-metal enclosures

Location or dimension of area	Minimum thickness, mm (inch)	
	Die-cast metal	Cast metal of other than the die-cast type
Area of 154.8 cm ² (24 square inches) or less and having no dimension greater than 152 mm (6 inches)	1.6 ^a (1/16)	3.2 (1/8)
Area greater than 154.8 cm ² (24 square inches) or having any dimension greater than 152 mm (6 inches)	2.4 (3/32)	3.2 (1/8)
At a threaded conduit hole	6.4 (1/4)	6.4 (1/4)
At an unthreaded conduit hole	3.2 (1/8)	3.2 (1/8)
^a The area limitation for metal 1.6 mm (1/16 inch) thick is obtained by the provision of reinforcing ribs subdividing a larger area.		

9.3 Sheet metal enclosures

9.3.1 Sheet metal enclosures shall comply with 9.3.2 or the requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

9.3.2 The thickness of a sheet-metal enclosure shall not be less than that specified in Tables 9.2 and 9.3. Uncoated steel shall not be less than 0.81 mm (0.032 inch) thick, zinc-coated steel shall not be less than 0.86 mm (0.034 inch) thick, and nonferrous metal shall not be less than 1.14 mm (0.045 inch) thick for surfaces of an enclosure at which a wiring system is to be connected.

Exception: The thickness of a sheet metal enclosure may be less than specified in Tables 9.2 and 9.3 when investigated and determined to be mechanically equivalent.

9.3.3 With reference to Tables 9.2 and 9.3, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has the same outside dimensions as the enclosure surface and that has the torsional rigidity to resist the bending moments that are applied via the enclosure surface. An example of a construction that has equivalent reinforcement is one that produces a structure that is as rigid as one built with a frame of angles or channels.

9.3.4 With reference to 9.3.3 and Tables 9.2 and 9.3, a construction does not have a supporting frame when it is:

- a) A single sheet with single formed flanges – formed edges;
- b) A single sheet that is corrugated or ribbed;
- c) An enclosure formed or fabricated from sheet metal; or
- d) An enclosure surface loosely attached to a frame – for example, by spring clips.

Table 9.2
Thickness of carbon steel or stainless steel enclosures

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, mm (inch)	
Maximum width ^b mm (inches)	Maximum length ^c mm (inches)	Maximum width ^b mm (inches)	Maximum length ^c mm (inches)	Uncoated	Metal Coated
102 (4)	Not limited	159 (6-1/4)	Not limited	0.51 ^d (0.020)	0.58 ^d (0.023)
121 (4-3/4)	146 (5-3/4)	171 (6-3/4)	210 (8-1/4)		
152 (6)	Not limited	241 (9-1/2)	Not limited	0.66 ^d (0.026)	0.74 (0.029)
178 (7)	222 (8-3/4)	254 (10)	318 (12-1/2)		
203 (8)	Not limited	305 (12)	Not limited	0.81 (0.032)	0.86 (0.034)
229 (9)	292 (11-1/2)	330 (13)	406 (16)		
318 (12-1/2)	Not limited	495 (19-1/2)	Not limited	1.07 (0.042)	1.14 (0.045)
356 (14)	457 (18)	533 (21)	635 (25)		
457 (18)	Not limited	686 (27)	Not limited	1.35 (0.053)	1.42 (0.056)
508 (20)	635 (25)	737 (29)	914 (36)		
559 (22)	Not limited	838 (33)	Not limited	1.52 (0.060)	1.60 (0.063)
635 (25)	787 (31)	889 (35)	1092 (43)		
635 (25)	Not limited	991 (39)	Not limited	1.70 (0.067)	1.78 (0.070)
737 (29)	914 (36)	1041 (41)	1295 (51)		
838 (33)	Not limited	1295 (51)	Not limited	2.03 (0.080)	2.13 (0.084)
1034 (38)	1194 (47)	1372 (54)	1676 (66)		
1067 (42)	Not limited	1626 (64)	Not limited	2.36 (0.093)	2.46 (0.097)
1194 (47)	1499 (59)	1727 (68)	2134 (84)		
1321 (52)	Not limited	2032 (80)	Not limited	2.74 (0.108)	2.82 (0.111)
1524 (60)	1880 (74)	2134 (84)	2616 (103)		
1600 (63)	Not limited	2464 (97)	Not limited	3.12 (0.123)	3.20 (0.126)
1854 (73)	2286 (90)	2616 (103)	3226 (127)		

NOTE – This table is based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

^a See 9.3.3 and 9.3.4.

^b The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and being made of a single sheet.

^c "Not limited" applies only where the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

^d Sheet steel for an enclosure intended for outdoor use shall not be less than 0.86 mm (0.034 inch) thick when metal coated and not less than 0.81 mm (0.032 inch) thick when uncoated.

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Table 9.3
Thickness of aluminum, copper, or brass enclosures

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness	
Maximum width ^b mm (inches)	Maximum length ^c mm (inches)	Maximum width ^b mm (inches)	Maximum length ^c mm (inches)		
76 (3)	Not limited	178 (7)	Not limited	0.58 ^d	(0.023)
89 (3-1/2)	102 (4)	216 (8-1/2)	241 (9-1/2)		
102 (4)	Not limited	254 (10)	Not limited	0.74	(0.029)
127 (5)	152 (6)	267 (10-1/2)	343 (13-1/2)		
152 (6)	Not limited	356 (14)	Not limited	0.91	(0.036)
165 (6-1/2)	203 (8)	381 (15)	457 (18)		
203 (8)	Not limited	483 (19)	Not limited	1.14	(0.045)
241 (9-1/2)	292 (11-1/2)	533 (21)	635 (25)		
305 (12)	Not limited	711 (28)	Not limited	1.47	(0.058)
356 (14)	406 (16)	762 (30)	940 (37)		
457 (18)	Not limited	1067 (42)	Not limited	1.91	(0.075)
508 (20)	634 (25)	1143 (45)	1397 (55)		
634 (25)	Not limited	1524 (60)	Not limited	2.41	(0.095)
737 (29)	914 (36)	1626 (64)	1981 (78)		
940 (37)	Not limited	2210 (87)	Not limited	3.10	(0.122)
1067 (42)	1346 (53)	2362 (93)	2896 (114)		
1321 (52)	Not limited	3124 (123)	Not limited	3.89	(0.153)
1524 (60)	1880 (188)	3302 (130)	4064 (160)		

NOTE – This table is based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

^a See 9.3.3 and 9.3.4.

^b The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and being made of a single sheet.

^c "Not limited" applies only when the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

^d Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall not be less than 0.74 mm (0.029 inch) thick.

9.4 Polymeric enclosures

9.4.1 A polymeric enclosure or a polymeric part of an enclosure shall comply with the applicable requirements specified in the Standard for Polymeric Materials - Use in Electrical Equipment Evaluations, UL 746C, and with the additional requirements specified in this Standard. See Table 9.4 for an overview of the evaluation.

Exception: Thermoset materials used in a vibrator employing a Class A motor are not required to comply with the mold stress relief test.

9.4.2 Polymeric enclosures intended for field installation shall not deform under conditions of normal use. See Section 27, Mechanical Tests.

Exception: A polymeric plug or other enclosure part less than 645 mm² (1 inch²) made of a material classified in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and assembled to a sheet-metal or aluminum frame to form a part of an enclosure is able to be used when the material is rated minimum V-2 or VTM-2, or rated HB and complying with the 12 mm or 3/4-inch Flame Tests as specified in UL 746C.

Table 9.4
Tests required on polymeric enclosures

Type of equipment	Vibrator enclosure for factory installation	Vibrator enclosure for field installation	Reference in UL 746C
Portable	Flame: HB	Flame: V-0, -1, -2; VTM-0, -1, -2 5000 volt dielectric Impact Severe conditioning Mold stress Volume resistivity	(Section 10) (Section 22) (Section 28) (Section 29) (Section 14)
Stationary or fixed	Flame: HB	Flame: 5VA, 5VB 5000 volt dielectric Impact Crush Severe conditioning Mold stress Conduit connections (Standard for Industrial Control Equipment, UL 508) Volume resistivity UV exposure Water exposure	(Section 10) (Section 22) (Section 21) (Section 28) (Section 29) (Section 14) (Section 25) (Section 26)
References in parentheses, unless otherwise noted, are to the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. In addition, the material shall have the following HAI (Section 11) performance levels.			
Flame rating	HAI performance level		
HB	1		
V-2, VTM-2	2		
V-1, VTM-1	2		
V-0, VTM-0	3		
5VA, 5VB	3		

10 Grounding

10.1 Vibrators exhibiting the following characteristics shall have provision for grounding:

- a) A vibrator for use in damp or wet locations;
- b) A vibrator intended to be field installed and used on a circuit operating at more than 150 volts to ground – see 10.2; or

Exception: A vibrator may be provided with a double insulation system that complies with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, in place of a provision for grounding.

10.2 With reference to 10.1(b), when the vibrator is marked to indicate that it is to be connected to a circuit operating at 150 volts or less to ground, it is not required to comply with this Section.

10.3 A vibrator marked as being provided with double insulation shall not be provided with a means for grounding.

10.4 If a grounding means is provided, whether required or not, it shall comply with this Section.

10.5 All exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any user servicing operation and likely to become energized shall be reliably connected to the means for grounding.

10.6 A grounding terminal or lead shall be provided for a vibrator intended to be permanently connected.

10.7 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 output conductors.

Exception: Interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken are acceptable.

10.8 A terminal solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size necessary for the application. A connection device that depends on solder alone shall not be provided for connecting the equipment-grounding conductor.

10.9 A wire-binding screw or pressure wire connector intended for the connection of an equipment-grounding conductor shall be located so that it is not removed during normal servicing of the vibrator.

11 Grounding Identification

11.1 The surface of the insulation of a grounding conductor of a flexible cord shall be green with or without one or more yellow stripes.

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

11.3 A terminal connector intended for connection of an equipment-grounding conductor shall be plainly identified by:

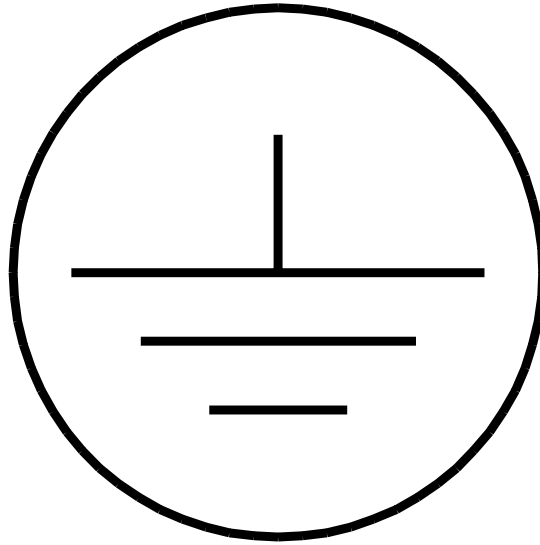
- a) Use of a wire binding screw with a green-colored head that is hexagonal, slotted, cross-slotted, or both;
- b) Use of a threaded stud with a green colored hexagonal nut;
- c) Use of a green colored pressure terminal connector;
- d) Being marked "G", "GR", "GND", "Ground", "Grounding", or the like;
- e) A marking on a wiring diagram provided on the product; or
- f) The grounding symbol illustrated in Figure 11.1, on or adjacent to the terminal, or on a wiring diagram provided on the product.

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Figure 11.1
Grounding symbol



IEC417, Symbol 5019

11.4 The wire-binding screw or pressure wire connector shall be located so that it is not removed during normal servicing of the vibrator.

12 Ventilation Openings

12.1 General

12.1.1 Ventilation openings for vibrators intended for field installation shall comply with the requirements in Section 12, Ventilation Openings.

12.1.2 A ventilation opening in the top of a Type 1 enclosure shall be covered by a hood or protective shield spaced above the opening when there are energized components below the opening.

12.1.3 Any ventilating opening in a Type 1, 2, or 3R enclosure (enclosure types per the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50) shall comply with Section 13, Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts.

12.1.4 The area of an opening covered by a louver, a perforated or an expanded-metal mesh panel that is thinner than the enclosure shall not exceed 1290 cm² (200 square inches).

12.1.5 The diameter of the wires of a screen shall be at least 1.3 mm (0.05 inch) if the screen openings are 323 mm² (0.5 square inch) or less in area, and shall be at least 2.1 mm (0.08 inch) for larger screen openings.

12.1.6 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall be at least 1.1 mm (0.04 inch) thick uncoated steel for mesh openings or perforations 323 mm² (0.5 square inch) or less in area. For larger openings, at least 2 mm (0.08 inch) thick uncoated steel shall be used.

Exception: In a small device where the indentation of a guard or enclosure does not adversely affect the performance or reduce the spacings below the minimum value specified in Section 18, Spacings, expanded-metal mesh of uncoated steel not less than 0.51 mm (0.02 inch) thick may be employed when:

- a) The exposed mesh on any one side or surface of the device so protected has an area not more than 464 cm² (72 square inches) and has no dimension greater than 304.8 mm (12 inches); or*
- b) The width of the opening so protected is not greater than 88.9 mm (3.50 inches).*

12.2 Barriers used with ventilation openings

12.2.1 A barrier interposed between ventilation openings and live parts to prevent the emission of flames or molten metal from an enclosure shall comply with 12.2.

12.2.2 The barrier shall be of such dimensions and so located that any straight line drawn from any arcing part past the edge of the barrier intersects a point in the ventilating opening plane that is at least 6.4 mm (1/4 inch) outside of the edge of the ventilation opening. See Figure 12.1.