UL 1053

STANDARD FOR SAFETY

Ground-Fault Sensing and Relaying Equipment

UL Standard for Safety for Ground-Fault Sensing and Relaying Equipment, UL 1053

Seventh Edition, Dated August 5, 2015

Summary of Topics:

This revision of ANSI/UL 1053 dated September 15, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated July 10, 2020.

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UL 1053

Standard for Ground-Fault Sensing and Relaying Equipment

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This ANSI/UL Standard for Safety consists of the Seventh Edition including revisions through September 15, 2020.

The most recent designation of ANSI/UL 1053 as a Reaffirmed American National Standard (ANS) occurred on September 3, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 1053 on May 27, 1988. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to 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 ground-fault current sensing devices, relaying equipment, or combinations of ground-fault current sensing devices and relaying equipment or equivalent protection equipment for use in ordinary locations that will operate to cause a disconnecting device to open all ungrounded conductors at predetermined values of ground-fault current, in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 These requirements cover equipment intended for use in circuits that are solidly grounded.

1.3 These requirements do not cover equipment intended to be powered from single-phase circuits operating at more than 600 volts or three-phase circuits operating at more than 600 volts phase-to-phase.

1.4 These requirements do not cover ground-fault circuit-interrupters.

1.5 These devices are intended to operate with shunt-trip circuit breakers, electrically tripped bolted pressure contact switches and the like that constitute the disconnecting means.

1.6 A Class I ground-fault protection device is one that does not incorporate means to prevent opening of the disconnecting means at high levels of fault current and is intended for use with the following:

a) Circuit breakers,

b) Fused circuit breakers,

c) Fused switches having an interrupting rating not less than 12 times their ampere rating, or

d) Fused switches having integral means to prevent disconnecting at levels of fault current exceeding the contact interrupting rating of the switch.

1.7 A Class II ground-fault protection device is one that incorporates means to prevent initiation of opening of the disconnecting device if the fault current exceeds the contact interrupting capability of the disconnecting device with which it is intended to be used.

1.8 These requirements cover enclosed-type devices and also cover open-type devices that are intended for use in other equipment, such as panelboards, switchboards, and the like.

2 Glossary

2.1 GROUND-FAULT RELAYING EQUIPMENT – That element of ground-fault current sensing and relaying equipment that responds to a specified signal from a ground-fault sensor. The power to operate the relaying equipment may be derived from the ground fault, from a separate source, or both. The output of such relaying equipment may:

a) Include a switching device,

b) Transmit a trip energy signal, or

c) Be any combination of a) and b) that is directly or indirectly capable of causing a disconnecting device to operate.

2.2 GROUND-FAULT SENSOR – That element of ground-fault current sensing and relaying equipment that detects ground fault current and transmits a resulting signal to ground fault-relaying equipment.

2.3 OPERATING TIME – The time elapsed between pick-up and operation (tripping or generation of output signal) of ground-fault current sensing and relaying equipment.

2.4 PICK-UP CURRENT – A nominal value that is related to the lowest value of current (pick-up) that will cause ground-fault relaying equipment to ultimately operate under specified conditions, at its setting, if provided, or rating.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this Standard.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

3.4 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.

4 Units of Measurement

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

5 References

5.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

6 Enclosure

6.1 General

6.1.1 An enclosure of ground-fault sensing and relaying equipment shall be so constructed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in an increased risk of fire due to reduction of spacings, loosening or displacement of parts, or other serious defects.

6.1.2 The enclosure referred to in 6.1.1 is the ultimate enclosure and does not include protective covers, dust covers, shields, and the like that are part of open type devices intended to be installed in other equipment that provides the ultimate enclosure.

6.1.3 Among the factors taken into consideration when an enclosure is being judged for acceptability are its physical strength, resistance to impact, moisture-absorptive properties, combustibility, resistance to corrosion, and resistance to distortion at temperatures to which the enclosure may be subject under conditions of normal or abnormal use. For a nonmetallic enclosure or part of an enclosure, all these factors are considered with respect to thermal aging.

6.1.4 There shall be no ventilating openings in the enclosure of ground-fault sensing and relaying equipment unless the conditions of use of such equipment necessitates ventilation and it can be shown by test that electrical disturbances within the enclosure will be contained. In no case shall there be such openings in an enclosure or a compartment of an enclosure containing a fuse or any portion of a circuit breaker other than the operating handle.

6.1.5 A ventilating opening in an enclosure, including a perforated hole, a louver, or an opening protected by means of wire screening, expanded metal, or a perforated cover, shall be of such size or shape that no opening will permit passage of a rod having a diameter greater than 1/2 inch (12.7 mm).

Exception: If the distance between an uninsulated live part and the opening is greater than 4 inches (102 mm), the opening may be larger than that previously mentioned, provided no opening will permit passage of a rod having a diameter greater than 3/4 inch (19.1 mm).

6.1.6 The diameter of the wires of a screen shall not be less than 0.051 inch (1.30 mm) if the screen openings are 1/2 square inch (323 mm^2) or less in area, and shall not be less than 0.081 inch (2.06 mm) for larger screen openings.

6.1.7 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall not be less than 0.042 inch (1.07 mm) thick if uncoated and not less than 0.045 (1.14 mm) if galvanized for mesh openings or perforations 1/2 square inch (323 mm^2) or less in area, and shall not be less than 0.080 inch (2.03 mm) thick if uncoated and not less than 0.084 inch (2.13 mm) if galvanized for larger openings.

6.1.8 No covering is required across the top of the surrounding enclosure of a floor-mounted unit if the enclosure is 6 feet (1.83 m) or more in height and if exposed live parts within the device are not less than 6 inches (152 mm) below the upper edge of the enclosure.

6.1.9 A part of the enclosure such as a door, cover, or the like shall be provided with a means, such as latches, locks, interlocks, or screws for firmly securing it in place.

6.2 Cast metal

6.2.1 A cast-metal enclosure shall:

a) Be at least 1/8 inch (3.2 mm) thick at every point;

Exception: Malleable iron and die-cast or permanent mold cast aluminum, brass, or bronze metal may not be less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension greater than 6 inches (152 mm), and may not be less than 1/16 inch (1.6 mm) thick for any area of 24 square inches or less and having no dimension greater than 6 inches. The area limitation for metal 1/16 inch thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

b) Be more than 1/8 inch thick at reinforcing ribs and door edges; and

c) Comply with Table 6.1 in the area:

1) Where tapped holes are provided for the connection of conduit or

2) Intended to be tapped in the field as noted in 32.8.

Exception: The maximum thickness specified in Table 6.1 may be exceeded if holes for smaller size conduit are counterbored and tapped if the tapped portion complies with the table for the conduit size involved.

Table 6.1
Cast-metal box thickness at tapped holes for conduit

Trade size of conduit, inches	Thickness of metal, inch (mm)			
	Minimum		Maximum	
1/2 – 3/4	7/32	(5.6)	1/2	(12.7)
1 – 2	17/64	(6.8)	45/64	(17.9)
2-1/2 – 6	3/8	(9.5)	1-1/8	(28.6)

6.2.2 Zinc-base die-cast metal shall not be used for an enclosure.

6.2.3 If threads for the connection of conduit are tapped all the way through a hole in an enclosure, or if an equivalent construction is employed, there shall not be less than three threads in the metal, and the construction of the device shall be such that a conduit bushing can be properly attached.

6.2.4 If the threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall or the like, there shall not be less than five full threads in the metal and there shall be a smooth well-rounded inlet hole for the conductors.

6.2.5 The inlet hole shall:

a) Afford protection to the conductors equivalent to that provided by a standard conduit bushing and

b) Have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

6.3 Sheet metal

6.3.1 A knockout in a sheet-metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

6.3.2 A knockout shall be provided with a flat surrounding surface adequate for proper seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than the minimum requirements in Table 14.1 .

6.3.3 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum required in Table 14.1 shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a full-scale drawing furnished with the device may be used to limit such a location.

6.3.4 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in 6.3.1 and 6.3.2, it is to be assumed that a bushing having the dimensions indicated in Table 6.2 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

Table 6.2
Bushings

Trade size of conduit in inches	Overall diameter in		Height in	
	Inches	(mm)	Inches	(mm)
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)
4	4-31/32	(126.6)	1	(25.4)
4-1/2	5-35/64	(140.9)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

6.3.5 The thickness of a sheet-metal enclosure shall not be less than that indicated in Table 6.3 or Table 6.4 as appropriate.

Exception: Uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, galvanized steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick at points at which conduit or armored cable is to be connected.

6.3.6 The reinforcement provided under the requirements in Table 6.3 and Table 6.4 need not consist of a complete frame for all edges but should employ a sufficient number of reinforcing members to provide additional support for all surfaces.

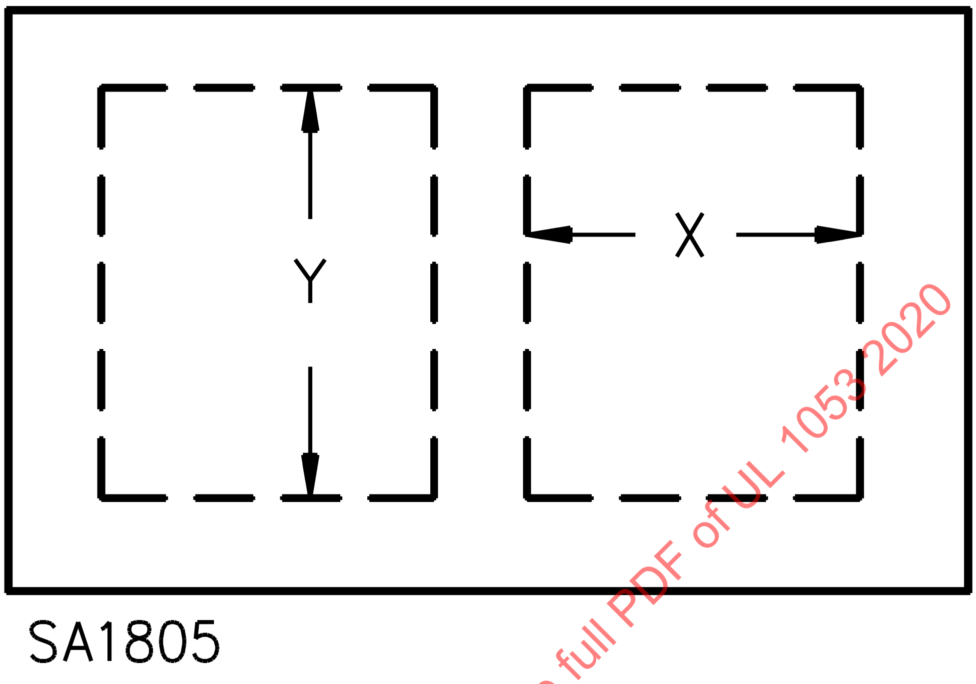
6.4 Nonmetallic

6.4.1 A nonmetallic enclosure or enclosure part shall have mechanical strength and durability and be so formed that operating parts will be protected against damage, and shall resist the abuses likely to be encountered during installation and intended use and service, but in any case, the mechanical strength shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 6.3. The enclosure or enclosure part shall protect persons from electric shock, and the material shall not create or contribute to a risk of fire. The material used for a nonmetallic enclosure shall be evaluated using the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.4.2 The continuity of the grounding system shall not rely on the dimensional integrity of the nonmetallic material.

Figure 6.1

Length between support frames



X, Y – Length between supporting frames, see note (c) to Table 6.3 and Table 6.4.

Table 6.3
Minimum thickness of sheet metal for enclosures carbon steel or stainless steel

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness in inches (mm)			
Maximum width[a]		Maximum length[b]		Maximum width[a,c]		Maximum length[b,c]		Uncoated		Zinc coated	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)				
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)				

Table 6.3 Continued on Next Page

Table 6.3 Continued

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness in inches (mm)			
Maximum width[a]		Maximum length[b]		Maximum width[a,c]		Maximum length[b,c]		Uncoated		Zinc coated	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
35.0	(88.9)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)				
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

[a] The smaller dimension of a rectangular sheet-metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[b] "Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not usually removed in use.

[c] Length of side to be measured between supporting frames as shown in Figure 6.1.

Table 6.4
Minimum thickness of sheet metal for enclosures aluminum, copper, or brass

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness,
Maximum width[a]		Maximum length[b]		Maximum width[a,c]		Maximum length[b,c]		inches
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)

Table 6.4 Continued on Next Page

Table 6.4 Continued

Without supporting frame				With supporting frame or equivalent reinforcing				Minimum thickness, inches (mm)
Maximum width[a]		Maximum length[b]		Maximum width[a,c]		Maximum length[b,c]		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	

[a] The smaller dimension of a rectangular sheet–metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[b] "Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not usually removed in use.

[c] Length of sides to be measured between supporting frames as shown in Figure 6.1.

6.4.3 A part such as a dial or nameplate that serves as a necessary part of the enclosure shall comply with the requirements applicable to enclosures.

6.4.4 A nonmetallic part such as a reset knob, lever, or button protruding through a hole in the enclosure no larger than the area of a 7/8 inch (22.2 mm) diameter circle shall be made of a material classified as V-0, V-1, or V-2. Nonmetallic parts protruding through a hole larger than the area or a 7/8 inch (22.2 mm) diameter circle shall be made of materials that comply with the requirements in 6.4.1 and 6.4.3.

6.4.5 Glass covering an observation opening and forming a part of the enclosure shall be secured in such a manner that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 0.055 inch (1.40 mm) thick. Glass for an opening having no dimension greater than 12 inches (305 mm) shall not be less than 0.115 inch (2.92 mm) thick. Glass used to cover a still larger opening shall have mechanical strength and shall otherwise be acceptable for the purpose.

6.4.6 A transparent material other than glass employed as a covering over an opening in an enclosure shall be investigated to determine if it has mechanical strength and is otherwise acceptable for the purpose.

7 Mounting

7.1 Provision shall be made for securely mounting ground-fault current sensing and relaying equipment to a supporting surface. A bolt, screw, or other part used to mount a component of the equipment shall not be used for securing the complete device to the supporting surface.

7.2 A live screw head or nut on the underside of an insulating base shall be prevented from loosening and shall be insulated or spaced from the mounting surface. This may be accomplished by:

a) Countersinking such parts not less than 1/8 inch (3.2 mm) in the clear and then covering them with a waterproof, insulating sealing compound that does not melt at a temperature 15°C (27°F) higher than its normal operating temperature in the device, and not less than 65°C (149°F) in any case, or

b) Securing such parts and insulating them from the mounting surface by means of a barrier or the equivalent, or by means of through-air or over-surface spacings as required elsewhere in this standard.

8 Insulating Material

8.1 Material for the support of uninsulated live parts shall be porcelain, phenolic or cold-molded composition, or other material acceptable for the support of such parts, and shall be capable of withstanding the most severe conditions likely to be met in service.

8.2 Insulating material, including barriers between parts of opposite polarity and material that may be subject to the influence of an arc, such as that formed by the opening of a switch, shall be acceptable for the particular application.

9 Current-Carrying Parts

9.1 A current-carrying part shall have mechanical strength and current-carrying capacity for the service, and shall be of metal or other material that is acceptable for the particular application.

9.2 An uninsulated live part, including a terminal, shall be so secured to its supporting surface by a method other than friction between surfaces that it will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required in Table 14.1 . The security of a contact assembly shall provide the continued alignment of contacts.

10 Internal Wiring

10.1 The internal wiring of ground-fault protection equipment shall consist of standard building wire, fixture or appliance-wiring material acceptable for the purpose, when considered with respect to the temperature, voltage, and conditions of service to which the wiring is likely to be subjected within the equipment.

10.2 The internal wiring and connections between parts of a ground-fault protection system shall be protected or enclosed.

10.3 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts and so forth, that may cause abrasion of the insulation on conductors.

10.4 A hole in a sheet-metal wall through which insulated wires pass and on the edges of which they may bear shall be provided with a smooth, well-rounded bushing or shall have a smooth, well-rounded surface upon which the wires may bear, to prevent abrasion of the insulation.

10.5 A bare conductor, including pigtails and coil leads, shall be so supported that the spacings required elsewhere in this standard will be maintained unless covered by insulating sleeving or tubing.

10.6 All joints and connections shall be mechanically secure and shall provide adequate and reliable electrical contact without strain on connections and terminals.

10.7 A splice shall be provided with insulation equivalent to that required for the wires involved.

11 Supply Connections

11.1 General

11.1.1 In 11.1.2 – 11.2.8, and particularly where the wiring terminals of stationary equipment are mentioned, supply connections are considered to be those that are made in the field when a device is installed.

11.1.2 Ground-fault sensing and relaying equipment shall be provided with wiring terminals or leads for the connection of conductors.

11.1.3 A lead that is intended to be spliced in the field to a circuit conductor in accordance with the National Electrical Code, ANSI/NFPA 70, shall not be smaller in size than 18 AWG (0.82 mm^2) and the insulation shall not be less than 1/32 inch (0.8 mm) in thickness.

11.1.4 The minimum free length of a lead for field connection shall be 6 inches (152 mm).

11.1.5 The insulation on a lead intended for connection of a grounded conductor shall be substantially white or gray in color and shall be readily distinguishable from other leads. No other lead shall be so identified.

11.2 Terminals

11.2.1 Terminals provided for field connection shall be capable of accommodating 12 AWG (3.3 mm^2) aluminum and 14 – 18 AWG (2.1 – 0.82 mm^2) copper conductors. Solder lugs shall not be used.

Exception: A terminal marked for copper wire only, need only be capable of accommodating 14 – 18 AWG conductors.

11.2.2 Wire connectors shall comply with the requirements in the Standard for Wire Connectors, UL 486A-486B or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

11.2.3 A wire accommodation means consisting of a stud or wire-binding screw that threads into a plate shall have upturned lugs, a cupped washer, or the equivalent to hole the wire in position. The upturned lugs, cupped washer, or equivalent shall be capable of retaining 12 – 18 AWG (3.3 – 0.82 mm^2) solid conductors [14 – 18 AWG (2.1 – 0.82 mm^2) if marked for copper wire only] even with the screw or nut slightly loose.

11.2.4 A wire-binding screw to which field-wiring connections are made shall not be smaller than No. 8 (4.2 mm diameter) with not more than 32 threads per inch (per 25.4 mm).

Exception: A No. 6 (3.5 mm diameter) screw may be used for a terminal to which 14 AWG (2.1 mm^2) or smaller wire would usually be connected.

11.2.5 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm^2) wire, and not less than 0.050 inch (1.27 mm) thick for a 12 AWG (3.3 mm^2) wire. There shall be two or more full threads in metal.

Exception: A terminal plate formed from stock having the minimum required thickness, may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Two full threads are not required if a smaller number of threads results in a connection in which the threads will not strip upon application of a 20-pound inch (2.3 N·m) tightening torque.

11.2.6 A wire-binding screw shall thread into metal.

11.2.7 A terminal plate and wire-binding screw shall be of nonferrous metal.

Exception: A wire-binding screw may be of plated iron or steel. Copper and brass are not acceptable for plating of a steel wire-binding screw, but a plating of cadmium is acceptable. A plating of zinc is acceptable only when the wire binding screw terminal is intended to accommodate copper wire only.

11.2.8 A terminal intended for the connection of a grounded conductor shall be identified as such, for example on an attached wiring diagram.

12 Functions

12.1 A Class **II** ground-fault current sensing or relaying device shall not initiate opening of the disconnecting device if the fault current is as described in 22.8.

12.2 A Class **I** ground-fault current sensing or relaying device need not comply with the requirements of 12.1.

12.3 Ground-fault current sensing and relaying equipment may include provisions for field adjustment of pick-up current and operating time. See Calibration Test, Section 22.

13 Test Circuits

13.1 Ground-fault current sensing and relaying devices may have provisions for testing the operation of the complete system and may also have provisions to indicate normal or abnormal operating conditions and tripping due to fault currents. See Component Failure Test, Section 28.

13.2 The indicating means referred to in 13.1 may be integral with or remote from the ground-fault current sensing and relaying equipment.

14 Spacings

14.1 The spacings in ground-fault sensing and relaying equipment shall not be less than those indicated in Table 14.1 .

Exception No. 1: These spacing requirements do not apply to the inherent spacings of a component, such as spacings being determined on the basis of the requirements for the component in question.

Exception No. 2: The spacing requirements of 14.1 do not apply when the alternative spacings of Section 15 are met.

Table 14.1
Minimum spacings in inches (mm)

Potential involved in volts	(RMS or dc[a])	51 – 150	151 – 300	301 – 600
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure or exposed metal part	Through air or oil	1/8[b,c] (3.2)	1/4[c] (6.4)	3/8 (9.5)
	Over surface	1/4[c] (6.4)	3/8[c] (9.5)	1/2 (12.7)
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable[d]	Shortest distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)

[a] For self–powered devices, the nominal voltage for purposes of determining spacings is to be the voltage developed within the circuit for any setting of the relay, or any fault–current simulation of the relay, up to its rating.

[b] The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded dead metal part is to be not less than 1/4 inch (6.4 mm) if short–circuiting or grounding of such terminals may result from projecting strands of wire.

Table 14.1 Continued on Next Page

Table 14.1 Continued

Potential involved in volts	(RMS or dc[a])	51 – 150	151 – 300	301 – 600
[c] At fixed parts of rigidly clamped special assemblies of live parts and insulating separators, such as contact springs on relays or cam switches, and on printed–wiring boards that are wired at the factory, the spacings may be less than those indicated, but not less than 1/16 inch (1.6 mm) for 0 – 150 V, and not less than 3/32 inch (2.4 mm) for 151– 300 V, through air and over surface.				
[d] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal pieces and uninsulated live parts.				

14.2 The spacings at a field-wiring terminal are to be measured with wire of the appropriate size, for the rating, connected to the terminal as in actual service. The connected wire, if the terminal will accommodate it properly or the device is not marked to restrict its use, is to be the next larger size than would usually be required.

14.3 In open-type ground-fault current sensing or relaying equipment or both, (one not provided with an enclosure), the spacings between live parts and metal parts that may be grounded, such as the heads of mounting screws that pass through an insulating panel, are determined as if they were grounded parts within an enclosure. The spacing between uninsulated live parts and the surface on which the device may be mounted is to be determined as if the mounting surface were part of an enclosure.

14.4 In a circuit involving no potential of more than 50 rms or d-c V, spacings at field-wiring terminals may be 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface, and spacings elsewhere may be 1/16 inch (1.6 mm) through air or over surface; provided that the insulation and clearances between the low-potential circuit and any high-potential circuit are in accordance with the requirements that are applicable to the high-potential circuit. Spacings are not specified for a circuit involving a potential of not more than 42.4 V peak, and supplied by a primary battery or by a standard Class 2 transformer or by an acceptable combination of transformer and fixed impedance having output characteristics in compliance with those required for a Class 2 transformer.

Exception No. 1: In a series circuit the spacings between resistor terminals, transformer taps, and the like are to be based on the normal operating voltage existing between such parts.

Exception No. 2: On a printed-wiring board, the spacings between parts of a 50 V (rms or d-c) or less potential may be less than 1/16 inch (1.6 mm) but shall not be less than 1/32 inch (0.8 mm).

Exception No. 3: On a printed-wiring board, the spacings between parts of 20 V (rms or d-c) or less potential may be less than 1/16 inch (1.6 mm) but shall not be less than 0.015 inch (0.38 mm).

14.5 Where required in place of spacings between a magnet-coil winding and other uninsulated live parts or grounded dead metal parts, the type of insulation may differ from that required in 14.9 and 14.10. The type and thickness of crossover lead insulation and insulation under coil terminals secured to the coil winding may be less than that specified in 14.9 and 14.10, provided that for thicknesses less than 0.013 inch (0.33 mm), the coil is capable of withstanding a dielectric voltage-withstand test between coil-end leads after breaking the inner coil lead where it enters the layer, or an equivalent opposite-polarity test. The application of the test potential is to be in accordance with the Dielectric Voltage-Withstand Test, Section 27.

14.6 A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be uniform, reliable, and otherwise acceptable for the purpose.

14.7 Enamel-insulated and similar film-insulated wire is considered to be the same as an uninsulated live part in determining compliance of a device with the spacing requirements in this standard.

14.8 An insulating barrier or liner used as the sole separation between uninsulated live parts and grounded dead metal parts – including the enclosure – or between uninsulated live parts of opposite polarity, shall be of material of a type that is acceptable for the mounting of uninsulated live parts and is not less than 0.028 inch (0.71 mm) thick.

Exception: Fiber not less than 0.028 inch (0.71 mm) thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.

14.9 An insulating barrier or liner that is used in addition to an air space in place of the required spacing through air shall not be less than 0.028 inch (0.71 mm) thick. If the barrier or liner is of fiber, the air space shall not be less than 1/32 inch (0.8 mm), and if the barrier or liner is of other material of a type that is not acceptable for the support of uninsulated live parts, the air space provided shall be such that, upon investigation, it is found to be acceptable for the particular application.

14.10 A barrier or liner that is used in addition to not less than one half the required spacing through air may be less than 0.028 inch (0.71 mm) but shall not be less than 0.013 inch (0.33 mm) thick provided that the barrier or liner is of material of a type that is acceptable for the mounting of uninsulated live parts, of adequate mechanical strength if exposed or otherwise likely to be subjected to mechanical injury, reliably held in place, and so located that it will not be affected adversely by operation of the equipment in service.

14.11 Insulating material having a thickness less than that indicated in 14.8 – 14.10 may be used if, upon investigation, it is found to be acceptable for the particular application.

14.12 Surfaces separated by a gap of 0.013 inch (0.33 mm) or less are considered to be in contact with each other for the purpose of determining over surface spacings.

15 Alternative Spacings

15.1 With reference to Exception No. 2 of 14.1, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be used. The spacing requirements of UL 840 shall not be used for field wiring terminals or for spacings to a dead metal enclosure. The characteristics of 15.2 – 15.6 shall be used in applying the requirements of UL 840.

15.2 Unless specified elsewhere in this Standard, equipment shall be evaluated for pollution degree 3.

15.3 The environment for a printed wiring board assembly is considered to be:

a) Pollution degree 2 for:

1) An assembly with a conformal coating complying with the requirements for conformal coatings in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards, UL 746E,

2) An assembly without a conformal coating when the printed wiring board is contained in a sealed housing that complies with the Dust Test, Section 30, or

b) Pollution degree 1 for an assembly complying with the Printed Wiring Board Coating Performance Test in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

15.4 For the purpose of applying this alternative, all printed wiring boards complying with the Standard for Printed Wiring Boards, UL 796, shall be considered as having a minimum comparative tracking index of 100 without further investigation.

15.5 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage protection device or system as an integral part of the equipment.

15.6 Where measurement of clearances and creepage distances is involved to establish the minimum spacings, the methods specified in Measurement of Clearance and Creepage Distances in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, shall be used.

16 Wiring Space

16.1 The space within the enclosure of ground-fault current sensing and relaying equipment shall provide ample room for the distribution of wires and cables required for the proper wiring of the device.

16.2 The wiring space shall be free of sharp edges, burrs, fins, moving parts, or the like that can damage conductor insulation.

17 Reset

17.1 Immediately after operation in response to a ground fault, ground-fault current sensing and relaying equipment shall:

a) Be in full functional status so as to be capable of initiating opening of the disconnect device upon sensing of a ground fault if the disconnect device is reclosed, or

b) Incorporate a reset function as indicated in 17.2.

17.2 If the design of ground-fault current sensing and relaying equipment is such that a reset operation is required to restore the equipment to functional status following operation due to a ground fault or test:

a) The design shall be such as to prevent closing and maintaining contact of the disconnect device to be controlled by the ground-fault current sensing and relaying equipment until the reset operation is performed, or

b) The installation instructions furnished with the ground-fault current sensing and relaying equipment shall clearly indicate that such means shall be incorporated in the disconnect device.

PERFORMANCE

18 General

18.1 Performance of ground-fault current sensing and relaying equipment shall be investigated by subjecting representative devices to the tests described in Sections 19 – 30, except that the same representative device shall be subjected to all of the tests in Calibration Test, Section 22.

19 Control Power Test

19.1 If power is required from the line to operate ground-fault current sensing and relaying equipment, such power consumption shall not exceed by more than 10 percent the rated values, quiescent and operating, while rated voltage is applied. The energy required to effect the operation of the ultimate trip device is not included in such rating.

20 Output Test

20.1 If the output of ground-fault current sensing and relaying equipment is a trip-energy signal, such output, in any present quantity, (that is – charge on a capacitor, voltage, current) shall not be less than 100 percent of the rated value, open circuit, or with a specific load as particularly rated. This determination shall be made with the equipment set at the minimum pick-up setting or rating and while tested at pickup magnitudes of fault currents.

21 Temperature Test

21.1 When tested in accordance with 21.2 – 21.8 the equipment shall not attain a temperature rise higher than shown in Table 21.1 .

Table 21.1
Maximum acceptable temperature rises

Materials and component parts	°C	(°F)
1. Varnished-cloth insulation	60	(108)
2. Fuses	65	(117)
3. Fiber employed as electrical insulation	65	(117)
4. Wood and other combustible materials	65	(117)
5. On external surfaces	65	(117)
6. Class 105 insulation systems on windings of relays, solenoids, and the like		
Thermocouple method	65	(117)
Resistance method	85	(153)
7. Class 130 insulation systems on windings of relays, solenoids, and the like		
Thermocouple method	85	(153)
Resistance method	105	(189)
8. Phenolic composition employed as electrical insulation	110[a]	(198)[a]
9. Rubber- or thermoplastic-insulated wires	35[a]	(63)[a]
10. At any point on a selenium rectifier	50	(90)
11. Body of silicon diodes, SCR's and the like	75	(135)
12. Imbedded resistor	350	(630)
13. Transformer enclosure	65	(117)
14. Sealing compound	40°C (104°F) less than melting point	
15. Capacitors	b	(b)

[a] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to have special heat–resistant properties.

[b] For a capacitor, the maximum allowable temperature rise is not to exceed the marked temperature limit of the capacitor minus an assumed ambient (room) temperature of 25°C (77°F).

21.2 The equipment shall be connected to a rated source of voltage, if intended to be so connected, and with normal load connected to the output, the equipment shall be energized until constant temperatures are attained under the following conditions:

a) The pick-up setting shall be set to maximum current and time, if adjustable.

b) Simulated ground-fault currents shall be applied to the sensor. The value of the applied current shall be equal to 90 percent of the trip-setting employed, provided that the value of applied current need not exceed the pick-up current.

21.3 The load referred to in 21.2 may be omitted if the nature of the circuit is such that no current flows through the load prior to tripping.

21.4 The temperature test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). The ambient temperature may be determined using either thermometers or thermocouples placed in the vicinity of the equipment being tested.

21.5 The acceptability of insulating materials, other than those listed in Table 21.1 , is to be determined with respect to properties such as flammability, arc-resistance, and the like, based on an operating temperature rise plus 40°C (104°F).

21.6 For tests, thermal equilibrium is to be 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 10 minute intervals, indicate no change.

21.7 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2), except that a coil temperature may be determined by the change-of-resistance method. When thermocouples are used in determining temperatures, it is standard practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouple wire is to conform with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

21.8 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material whose temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

22 Calibration Test

22.1 The operating time of a ground-fault current sensing and relaying device shall not exceed the times indicated in Table 22.1 when the ground-fault current is as indicated in 22.2 – 22.8 under each of the following conditions:

a) Immediately following humidity conditioning for 48 hours in 85 ±5 percent relative humidity at 32.0 ±2.0°C (89.6 ±3.6°F).

b) After 4 hours in 40 ±2.0°C (104 ±3.6°F) ambient.

c) After 5 cycles of thermal shock consisting of 4 hours at 40 ±2.0°C (104 ±3.6°F), followed by 4 hours at 0 ±2.0°C (32 ±3.6°F).

d) At 25.0 ±3.0°C (77.0 ±5.4°F).

Table 22.1
Operating time

Ground-fault current – (amperes)	Time (seconds)
85 percent of pickup	Shall not trip
115 percent of pickup	ultimately
150 percent of pickup	2.0
250 percent of pickup	1.0

22.2 A ground-fault current relaying device with an indicated delay in operating time (see 32.4), whether fixed or adjustable, shall, as a part of the test sequence of 22.1, and in each of the conditions, be evaluated for such delay.

22.3 With respect to 22.2, the delay is to be within the tolerance band specified by the manufacturer for the particular setting. If the tolerance band is temperature dependent, the particular band for the temperature involved in the test is to be used. If a range of delay is provided, the determination is to be made at the maximum, middle, and minimum settings of the delay adjustment. A delay expressed in terms of cycles is to be converted to time assuming a 60-Hz frequency.

22.4 In determining the operating time (including delay) under the environmental conditions of 22.1, the test is to be conducted at the end of the specified exposure time while the device is still in the test environment.

22.5 To determine whether ground-fault current sensing and relaying equipment complies with the calibration test requirements, the equipment is to be tested three times under each test condition. The circuit is to be preset to deliver the required ground-fault current and, after the current is applied to the ground-fault sensor, the time required for the relaying equipment to operate is to be observed. If the equipment is intended to be connected to a separate source of control power, the control voltage is to be adjusted to its rated value.

22.6 Any field pickup current adjustment is to be set at its maximum value.

22.7 If power from a control power source is required to operate the device, the test described in 22.1 – 22.3 shall be repeated with the equipment connected to 55 percent of its rated voltage for a-c control power and 80 percent of its rated voltage for d-c control power.

22.8 Class II ground-fault current sensing and relaying devices shall not initiate operation of the disconnect device when fault current in any phase reaches or exceeds 95 percent of the disconnect device interrupting capability and shall not prevent electrical operation of the disconnect device when the fault current in any phase is 75 percent or less of the disconnect device interrupting capability. See 32.7.

23 Backfed Calibration Test

23.1 Ground-fault sensing and relaying equipment that is not a circuit breaker but incorporates an integral switching function with direct "line" and "load" connections, may be marked in accordance with 32.12 if it additionally complies with the Calibration Test, Section 22, with the supply connected to the load side terminals of the device.

23.2 Only the 25.0 ±3.0°C (77.0 ±5.4°F) portion of the Calibration Test in Section 22 shall be conducted.