



UL 1436

STANDARD FOR SAFETY

Outlet Circuit Testers and Similar Indicating Devices

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UL Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices, UL 1436

Sixth Edition, Dated September 6, 2016

Summary of Topics

The sixth edition of UL 1436, Outlet Circuit Testers and Similar Indicating Devices, has been issued and includes the following revisions:

- ***New and revised requirements to address Absence of Voltage Tester (AVT).***

The new/revised requirements are substantially in accordance with Proposal(s) on this subject dated July 15, 2016.

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INTRODUCTION

1 Scope

1.1 These requirements apply to outlet circuit testers, including screwdriver and pen-style voltage presence indicators, for use on 15-, 20-, and 30-A, 3-wire, 125-, 250-, 277-, 480-, or 600-V receptacles, ground-fault circuit-interrupter testers and arc-fault circuit-interrupter indicators for use on 15- and 20-A, 3-wire, 125-V receptacles, and similar indicating devices that are:

- a) Intended to be connected to the receptacle for a period of time only as long as is necessary to note the indicated pattern of lights or other similar indicating means; and
- b) Not intended to be a comprehensive instrument or to determine the quality of the grounding circuit.

1.2 These requirements also apply to retention testers and other indicating devices with a retention testing capability (hereafter referred to as retention testers) that are intended to indicate the force exerted on the blade or blades of the tester by the contacts of a receptacle.

1.3 These requirements also apply to permanently-mounted Absence of Voltage Testers (AVT) that are intended to confirm the de-energization of normally energized equipment.

1.4 Testers and indicating devices that additionally measure actual electrical phenomena including specific voltage, current, resistance, or similar values shall additionally comply with the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1.

1.5 These requirements do not cover products that are only intended to measure electrical phenomena. Such products shall instead comply with the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1.

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. See Appendix A for a list of standards covering components generally used in the products covered by this Standard.

2.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

2.4 Specific components are recognized as being 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 for which they have been recognized.

3 Units of Measurement

3.1 When a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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 ABSENCE OF VOLTAGE TESTER (AVT) – A permanently-mounted test device that is used to verify that a circuit is de-energized prior to opening an electrical enclosure that contains energized electrical conductors and circuit parts. An AVT is provided with a test circuit with active indications to verify the absence of phase-to-phase voltage and phase-to-ground voltage. AVTs are provided with a test circuit and visual indicators to confirm that the tester is functioning properly before and after the process of determining that voltage is absence.

5.3 ARC-FAULT CIRCUIT-INTERRUPTER (AFCI) INDICATOR – A device with no receptacle outlet that, when plugged into a receptacle and activated, produces arcing current pulses representative of arc-fault current between the ungrounded and grounded conductors, and then indicates by a pattern of lights, or other similar means, whether an AFCI connected to the branch circuit is functioning. An AFCI tester may also include the provisions of an Outlet Circuit Tester, see 5.5, a Ground-Fault Circuit-Interrupter Tester, see 5.4, or both.

5.4 GROUND-FAULT CIRCUIT-INTERRUPTER (GFCI) TESTER – A device with no receptacle outlet that, when plugged into a receptacle and activated, circulates current through the ungrounded circuit conductor, and the grounding conductor and then indicates by a pattern of lights, or other similar means, whether a GFCI connected to the branch circuit is functioning. A GFCI tester may also include the provisions of an Outlet Circuit Tester. See 5.5.

5.5 OUTLET CIRCUIT TESTER – A device with no receptacle outlets that, when inserted into a receptacle, indicates by a pattern of lights, or other similar means, the presence, or absence, of specific elementary wiring conditions. An outlet circuit tester may also incorporate the provisions of a retention tester.

5.6 RETENTION TESTER – A hand held device with no receptacle outlet which, when removed from a receptacle, indicates the force of retention exerted on the line blades and grounding pin of an attachment plug by the contacts of a receptacle. The means to measure the retention may be mechanical, electronic, or both.

5.7 VOLTAGE PRESENCE INDICATOR – Screwdriver and pen style hand-held devices intended for temporary insertion into receptacles to provide an indication that the outlet is current carrying.

CONSTRUCTION

6 General

6.1 An indicating device shall employ materials throughout that are acceptable for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 The dimensions, materials and configurations of blades shall comply with the requirements for attachment plugs in the Standard for Attachment Plugs and Receptacles, UL 498.

Exception: The line blade or blades, and grounding pin of a retention tester shall instead comply with the requirements for Retention Testers, Section 11.

7 Enclosure

7.1 All electrical parts of an indicating device shall be provided with an enclosure.

Exception: Blades for connection to the circuit to be tested need not comply.

7.2 The enclosure of an indicating device shall be strong and rigid so as to resist the abuses likely to be encountered during use. The mechanical strength inherent in the indicating device shall preclude total or partial collapse with attendant reduction of spacings, loosening or displacement of parts, and other conditions that alone or in combination increase the risk of electric shock, fire, or personal injury.

7.3 Among the factors taken into consideration in evaluating an enclosure are:

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

7.4 The enclosure of an indicating device shall be formed of a material having a minimum flammability classification of HB as specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

7.5 An enclosure shall have no openings through which a 3/32 in (2.4 mm) diameter rod can be inserted.

7.6 A polymeric part of the AVT to be installed through an opening in an enclosure shall be made of a material rated in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and shall comply with the following:

a) A polymeric part closing an opening in the enclosure having an area of not more than 1.2 in² (775 mm²) shall be:

- 1) A pilot light lens classed 5VA, 5VB, V-0, V-1, V-2, or HB;
- 2) Rated V-0, V-1, or V-2; or
- 3) Rated HB and comply with the flammability test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) A polymeric part closing an opening in an enclosure having an area of more than 1.2 in² (775 mm²) and having no dimension greater than 12 in (304.8 mm), shall be rated V-0, V-1, V-2, or HB, and shall comply with the flammability and impact test requirements in UL 746C.

Exception: The polymeric part is not required to be subjected to the flammability test when it encloses only parts that do not pose a risk of fire, and is protected from exposure to fire by an internal metal barrier or polymeric barrier that complies with the flammability test. A printed wiring board rated V-0 may serve as a polymeric barrier when the assembly complies with the flammability test. A risk of fire is considered to exist within a circuit unless that circuit is a secondary circuit supplied by a Class 2, limited power source or complies with the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1, Limited-energy circuit requirements.

c) A polymeric part closing an opening in an enclosure having any dimension greater than 12 in (304.8 mm), shall comply with the flammability and impact requirements in (b) above and also comply with requirements for the crush resistance test in UL 746C.

8 Current-Carrying Parts

8.1 Ferrous metal, plain or plated, shall not be used for parts, including battery terminals, that are depended upon to carry current.

Exception: Stainless steel employed for a current-carrying part not subject to arcing meets the intent of the requirement.

8.2 A steel that is corrosion-resistant (stainless) or a steel that is protected against corrosion by cadmium plating, zinc plating, or an equivalent protective coating may be used for wire-binding nuts and screws if these parts are not depended upon to carry current.

8.3 A current-carrying part shall be prevented from turning relative to the surface on which it is mounted by positive means if such turning would adversely affect the performance of the device. Parts within screwdriver voltage presence indicators shall not turn or be adversely affected when the screwdriver is subjected to the Torque Test, Section 22.

8.4 Uninsulated current-carrying parts shall be secured in place so that a reduction in the spacings below those required in Spacings, Section 9 is not likely. All current-carrying parts of a voltage presence indicator shall be mechanically secured, soldered, or both.

9 Spacings

9.1 There shall be a spacing through air or over surface of not less than 3/64 in (1.2 mm) for devices rated 250 V or less and not less than 1/8 in (3.2 mm) for devices rated greater than 250 V:

- a) Between uninsulated current-carrying parts of opposite polarity and between uninsulated current-carrying parts and dead metal parts that are likely to be grounded or exposed to contact by persons when the device is used in the intended manner; and
- b) Between grounded and grounding parts.

Exception: AVTs shall comply with the creepage, clearance and through insulation requirements in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 and the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits, UL 61010-2-030. All mains connect circuits shall meet basic insulation requirements for opposite polarity circuits.

9.2 In measuring a spacing, an isolated dead metal part interposed between current-carrying parts of opposite polarity or between a current-carrying part and a grounded or exposed dead metal part is considered to reduce the spacing by the amount equal to the dimension of the isolated dead metal part.

9.3 For screwdriver and pen style voltage presence indicators, a suitable barrier or insulating material shall be placed around a resistor or the resistor body, to ensure minimum spacings and separation of circuits of the resistor leads.

Exception: Resistor or resistor leads that are secured by space limitations, enclosure projections, mechanical means, or mounted on a printed wiring board, need not comply with this requirement.

10 GFCI Testers and AFCI Indicators

10.1 A normally open momentary contact switch shall be provided on a GFCI tester. The test button on the switch shall be provided with a barrier to guard against unintentional activation. The test button on the switch of a GFCI tester that employs a power-supply cord shall not be required to have a barrier to guard against unintentional activation.

10.2 A normally open contact switch shall be provided on an AFCI indicator. The test button on the switch shall not be required to have a barrier to guard against unintentional activation.

10.3 When an automatic timing circuit is provided in the GFCI tester, the timing circuit shall function to open the circuit in no less than six nor more than 7.2 s after the test button is activated. See 23.3.

10.4 A GFCI tester and an AFCI indicator shall be provided with an audible or visible indicator which shall be present until the GFCI or AFCI trips.

11 Retention Testers

11.1 The line blade or blades of a retention testing device shall have a width of 0.240 – 0.260 in (6.10 – 6.60 mm) and a thickness of 0.055 – 0.058 in (1.40 – 1.47 mm). There shall not be any holes or detents along the length of the blades beyond 0.250 in (6.35 mm) from the point where the blades enter the body of the tester.

11.2 A retention testing device shall include a means to test the retention force of the grounding contact of a receptacle. The grounding pin of the tester need not be located on the same plane as the line blade or blades. The grounding pin shall have a diameter of 0.184 – 0.190 in (4.67 – 4.82 mm) and a rounded tip with a radius of 1/8 in (3.2 mm).

11.3 A retention tester need not be provided with two line blades.

11.4 A retention tester that incorporates more than a single line blade on the same face of the device shall comply with all of the following:

- a) The tester shall indicate the test results of each receptacle contact independently in one single motion (insertion into and removal from a receptacle);
- b) The tester shall have plug blades for testing one or more of the following configurations: 2 pole, 3 wire, 15 A 125 V; 2 pole, 3 wire, 20 A 125 V; 2 pole, 3 wire, 15 A 250 V; or 2 pole, 3 wire, 20 A 250 V as described in the Standard for Wiring Devices – Dimensional Specifications, NEMA WD 6; and
- c) The test results shall not be displayed or otherwise indicated as an average value.

11.5 Each line blade and grounding pin of a retention tester shall be provided with a dedicated means, such as a hole, notch, or the equivalent, intended for the sole purpose of periodically attaching the calibration tool referred to in 11.10. The attachment means shall be located within 0.250 in (6.35 mm) from the point where the blades enter the body of the tester.

11.6 The line blade or blades and grounding pin of a retention tester shall be sufficiently hard to guard against the effects of wear. If a material other than steel is used it shall be hardened by electroplating, anodizing, diffusion, or any other process suitable for the application. The hardness coating shall have a nominal thickness of 0.0025 in (0.064 mm) on each side of the blade and on the surface of the grounding pin and shall have a minimum Rockwell C Scale Hardness of 28 or the equivalent.

11.7 A retention tester shall indicate the force exerted on the test blade by the contacts of a receptacle or otherwise indicate whether the contacts under test have the minimum acceptable retention force of 6.25 ozf (1.74 N).

11.8 If a tester is provided with a scale, the scale shall be calibrated, provide a calibrated readout with a minimum of 0.5 ozf (0.14 N) graduations, have a maximum limit of 32 ozf (8.9 N), and be optically sharp with such resolution that the force of retention will be able to be distinguished within 0.5 ozf (0.14 N). The 6.25 ozf (1.74 N) minimum retention value scale reading shall contrast with the other scale readings.

11.9 A retention tester shall display the value of the measured retention force of a receptacle until manually reset or zeroed and shall be marked to instruct the user to reset the tester after each receptacle contact evaluation. See 36.12.

11.10 A retention tester shall be provided with a calibration tool intended solely to accommodate periodic verification of force values indicated on the scale. The calibration tool shall displace each line blade and grounding pin, individually, by an amount which correlates to a known force of retention as specified by the manufacturer.

11.11 The calibration tool mentioned in 11.10 shall be fabricated from impact-resistant material. Acceptability of the tool shall be determined by the Calibration Tool Drop Test, Section 32.

11.12 If line blades and grounding pins are provided on more than one plane of a device they shall be electrically isolated from one another.

12 Absence of Voltage Tester (AVT)

12.1 General

12.1.1 In addition to the requirements in 12.1 – 12.5, an AVT shall comply with the construction requirements in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 and the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits, UL 61010-2-030.

12.1.2 An AVT shall be provided with a means for the user to initiate the test for the absence of voltage.

12.1.3 An AVT shall provide the user with a visual indicator to confirm the absence of voltage after the absence of voltage test has been performed. The visual indicator shall be green and no other indicators for the AVT shall use the color green.

12.1.4 The AVT shall incorporate a supervisory test circuit to verify that the tester is functioning properly. The supervisory test circuit shall incorporate a secondary power source, such as a battery, and shall not exceed the limit values for accessible parts as defined in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1. Test circuits that incorporate electrical, electronic, or programmable electronic technology and software, shall be subject to the requirements in 12.2 and shall have no critical internal failure that would affect the performance requirements in 12.1.5 – 12.1.9.

12.1.5 The AVT shall incorporate a supervisory test circuit to verify that the tester is functioning properly before and after the AVT performs voltage measurements. The test circuit shall not exceed the limit values for accessible parts as defined in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1.

12.1.6 The visual indicator shall only illuminate green when all phase-to-phase and phase-to-ground voltages are < 3.0 Vac rms or < 3.0 Vdc.

12.1.7 When the phase and ground leads are installed in accordance with the manufacturer's instructions, the visual indicator shall not illuminate green unless the phase and ground leads are in direct contact with the circuit conductors being tested.

12.1.8 When a phase lead is connected to ground or the ground lead is connected to a phase conductor the visual indicator shall not illuminate green.

12.1.9 The visual indicator shall not illuminate green unless the secondary power source is operational.

12.2 Functional safety

12.2.1 The safety functions of an AVT, in accordance with 12.1.5 – 12.1.9, if implemented in electrical, electronic, or programmable electronic technology and software, shall comply with the Standard for Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Part 1: General Requirements, IEC 61508-1 (and all parts), SIL 3. Critical internal failure is defined as any electrical and/or electronic and/or programmable electronic technology where failure would affect the performance requirements in 12.1.5 – 12.1.9.

12.3 Field wiring

12.3.1 Field wiring connections to the circuit being monitored shall be provided with wiring leads (pigtail leads) that are intended to be spliced in the field to a circuit conductor or with factory-installed wiring terminals.

12.3.2 Field wiring leads and electrical sleeving shall be rated for the maximum voltage rating of the AVT. All conductor insulation and conductor sleeving shall be rated minimum 105°C (221°F).

12.3.3 Each field-wiring lead shall be copper, minimum 14 AWG (2.1 mm²), and not be less than 12 in (304.8 mm) or more than 10-ft (3-m) long.

12.3.4 Field wiring leads shall consist of Class 1 wiring or appliance wiring material with insulation at least 0.75 mm (30 mils) "Minimum Average" thickness with at least 0.68 mm (27 mils) thickness "Minimum-At-Any-Point."

12.3.5 Field wiring leads shall comply with the Strain Relief Test in Section 34.

12.4 Branch circuit protection

12.4.1 Overcurrent protection in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1, does not need to be specified.

12.5 Establishing a short circuit current rating

12.5.1 There shall be no component in the primary circuit where a component failure would expose the AVT to available short circuit currents provided on the main supply.

12.5.2 The monitoring circuit shall be provided with one of the following isolated circuits:

- a) Components in limited voltage/current secondary circuits as defined in Appendix B; or
- b) Components in limiting impedance circuits as defined in Appendix B.

12.5.3 Based on the results of the Appendix B testing, a Short Circuit Current rating shall be specified on the product in accordance with 36.16.

PERFORMANCE

13 General

13.1 The performance of an indicating device shall be investigated by subjecting the specified number of indicating devices to the tests shown in Table 13.1. The sequence shall be as shown even though some of the test sections in Table 13.1 may not be numbered consecutively.

Table 13.1
Test program for indicating devices

Outlet circuit testers and/or GFCI testers		
Set 1 ^a	Set 2 ^a	Set 3 ^{a,b}
Proper Operations ^c Security of Blades, Section 16 Crushing Test, Section 17 Drop Test, Section 19 Proper Operations ^c Temperature Test, Section 20	Insulation Resistance Test, Section 15 Input Test, Section 18	Accelerated Aging Test, Section 14 Security of Blades, Section 16
^a Each set shall consist of 3 representative samples of the outlet circuit tester or the GFCI tester. Each sample of the set is to be tested separately. ^b For devices with bodies of molded-rubber, polyvinyl chloride, or copolymer. ^c For an outlet circuit tester, the proper operations test shall be the circuit condition indication test in Circuit Condition Indication, Section 21. For a GFCI tester, the proper operations test shall be the ground fault circuit interrupter condition test in GFCI Condition – Ground Current Measurement, Section 23. Devices that perform more than one function shall be tested under all proper indication tests that apply.		

14 Accelerated Aging Test

14.1 Rubber compounds

14.1.1 A molded rubber body shall show no apparent deterioration and shall show no greater change in hardness than ten numbers after being tested as described in 14.1.2 and 14.1.3.

14.1.2 If possible, the molded rubber device is to be used complete. The hardness of the rubber is to be determined as the average of five readings with an appropriate gauge such as the Rex Hardness Gauge or the Shore Durometer. The device is then to be placed for 70 h in a full-draft circulating-air oven at a temperature of $100 \pm 2^{\circ}\text{C}$ ($212 \pm 3.6^{\circ}\text{F}$). The device is to be at room temperature for four or more hours after removal from the oven. The hardness is to be determined again as the average of five readings. The difference between the average original hardness reading and the average reading taken after oven aging is the change in hardness.

14.1.3 The accelerated aging test mentioned in 14.1.1 and 14.1.2 is to be made on samples of each color of rubber and on samples of each basic rubber compound employed for the device.

14.2 PVC compounds

14.2.1 A device having a body of molded polyvinyl chloride or a copolymer thereof shall show no cracks, discoloration, or other signs of deterioration as the result of exposure for 96 h in a full-draft circulating-air oven at a temperature of $100.0 \pm 1.0^{\circ}\text{C}$ ($212.0 \pm 1.8^{\circ}\text{F}$).

15 Insulation Resistance Test

15.1 When determined as described in 15.3 – 15.6, the insulation resistance shall not be lower than 100 M Ω between:

- a) Current-carrying parts and any surface of insulating material that is exposed to contact by persons or that may be in contact with the ground in service;
- b) Current-carrying parts and dead metal parts that are exposed to contact by persons or that may be grounded in service; and
- c) Current-carrying parts of opposite polarity with the indicator circuit disconnected.

15.2 This test is to be made on rubber and similar materials of any color. Other materials are to be tested if they contain sufficient free carbon to color the material grey or black.

15.3 In determining compliance with the requirements in 15.1, the insulation resistance is to be measured by a magnetomegometer with an open-circuit output of 500 V or by equivalent equipment.

15.4 In measuring insulation resistance to the surface of an insulating material, it is necessary to apply an electrode to insulating material as described in 15.5.

15.5 A quantity of No. 7 lead drop shot (approximate diameter 0.10 in or 2.5 mm) is to be placed in a container that is open at the top. After other openings through which the shot could enter have been plugged carefully with a high resistance insulating material, the device is to be immersed so that the shot serves as an electrode and contacts the surface to which the test is to be applied.

15.6 All rubber parts are to be kept for at least 48 h at room temperature before being subjected to the test mentioned in 15.3 – 15.5.

16 Security of Blades

16.1 The blades and grounding pin of a plug-in indicating device shall be capable of withstanding a direct pull of 20 lbf (89 N) for 2 min without loosening or, if a soft (resilient) molded material is involved, without permanent displacement of 3/32 in (2.4 mm) or more.

16.2 The device is to be supported on a horizontal steel plate with the blades, pins, or both projecting downward through a single hole sufficiently large just to enable the blades, pins, or both to pass through it. A 20 lb (9.1 kg) weight is to be supported by each blade or pin in succession. The measurement of any blade displacement is to be done 2 min after the removal of the weight.

17 Crushing Test

17.1 An indicating device shall be capable of withstanding for 1 min a crushing force of 75 lbf (334 N) applied to any surface at right angles to its major axis without cracking, breaking, or permanent deformation that could

- a) Expose current-carrying parts to unintentional contact; or
- b) Render the device incapable of performing its intended function.

17.2 Any testing equipment that can apply a steady force of 75 lbf (334 N) to the device may be employed. The device is to be placed between two 1/2 in (12.7 mm) or thicker parallel flat maple blocks. The force is to be applied gradually and held at 75 lbf (334 N) for a period of 1 min.

18 Input Test

18.1 A device that introduces a current into the grounding conductor of a permanently installed wiring system shall be so constructed that the current introduced shall not exceed 2 mA.

Exception: A device intended to check the operation of a permanently installed ground fault circuit interrupter shall introduce not less than 6 mA or not more than 9 mA into the grounding conductor of a permanently installed wiring system. The introduction of this test current shall be initiated by activating the test button of the GFCI tester. Three devices shall be subjected to the Ground Current Measurement Test indicated in 23.1.

18.2 To determine compliance with 18.1, the device shall be tested at 120 V, and at the voltage within the range of 102 – 132 V that will introduce the greatest current into the grounding path.

19 Drop Test

19.1 After being subjected to the drop-impact described in 19.2 and 19.3, the enclosure of a device shall not develop any cracks or openings that would expose electrical parts.

19.2 Each of 3 devices shall be dropped 3 times from a height of 5 ft (1.52 m) to strike a hardwood surface.

19.3 The hardwood surface mentioned in 19.2 is to consist of a layer of nominal 1-in (25-mm) tongue-and-groove oak flooring mounted on two layers of 3/4-in (19-mm) thick plywood. The surface is to be a square, nominally 4 ft (1.2 m) on a side. The assembly is to rest on a concrete floor or the equivalent during the test.

20 Temperature Test

20.1 The operating temperature at any point shall not exceed the temperature limits shown in Table 20.1.

Table 20.1
Maximum temperature^a

Materials and component parts	°C	(°F)
1. Fuses	90	(194)
2. Fiber used as electrical insulation	90	(194)
3. Wood or other combustible material	90	(194)
4. Phenolic composition used as electrical insulation or where malfunction would result in a risk of fire or electric shock ^b	150	(302)
5. Copper conductors (bare or insulated) without a nickel coating or other acceptable protection	150	(302)
6. Termination of copper conductor and pressure terminal connector without being nickel-coated or otherwise acceptably protected	150	(302)
7. Points likely to be contacted by hand or fingers while supporting a device ^{c,d,e}		
a. Metal surface	55	(131)
b. Surface of porcelain or vitreous material	65	(149)
c. Surface of molded material, rubber, or wood	75	(167)
8. Sealing compound	40°C (72°F) less than its melting point	

^a Based on an assumed ambient temperature of 25°C (77°F). The test may be conducted at an ambient temperature of 10 – 40°C if the following formula is satisfied:

$$T_1 + (K - T_A) \leq T_L$$

In which:

T_1 is the measured temperature of the material or component,

T_A is the ambient room temperature,

T_L is the temperature limit, and

K is 25 when temperatures are measured in °C and 77 when measured in °F.

^b The limitation on phenolic composition does not apply to a compound which has been investigated and found to have special heat-resistant properties.

Table 20.1 Continued on Next Page

Table 20.1 Continued

Materials and component parts	°C	(°F)
^c Points likely to be contacted by a hand or fingers include those points on the gripping surface and adjacent surfaces close enough to be touched while supporting the device in the intended manner. [The usual length of a gripping surface is considered to be up to 4 in (102 mm). Points on a surface are not to be considered likely to be contacted if protected by a barrier not less than 5/8-in (15.9-mm) wide on which the temperature rise does not exceed the value indicated in (7) or if a through-air spacing of not less than 1-1/2 in (38 mm) at the index finger, tapering to 1-1/4 in (32 mm) at the other end of the hand is provided from the gripping surface to the hot part.] ^d If the temperature on a rivet or screw in a barrier or handle that would be touched in gripping or lifting the device exceeds the value given in (7), it is to be recessed at least half the diameter of the hole and the hole is to be not larger than 3/8 in (9.5 mm) in diameter. ^e Coatings or alternative materials are to be considered on an individual basis.		

20.2 Each indicating device shall be connected to a supply circuit appropriate to its rating until operating temperatures stabilize, but in no case for less than 4 h. When the device has more than one setting, it shall be set in the condition likely to produce the highest operating temperatures.

OUTLET CIRCUIT TESTERS

21 Circuit Condition Indication

21.1 An outlet circuit tester shall indicate each of the following conditions:

- a) Open in grounding conductor;
- b) Reversed polarity of line conductors;
- c) Open neutral (grounded conductor);
- d) Reversal of ungrounded and grounding conductors; and
- e) The absence of conditions (a) – (d).

21.2 To determine compliance with the requirements of 21.1, an outlet circuit tester is to be inserted into a receptacle that is connected to a circuit or circuits arranged to produce the conditions specified in 21.1. The circuit tester shall indicate and identify each of the fault conditions as well as the absence of them.

21.3 An outlet circuit tester that is marked to show that it can indicate conditions in addition to those specified in 21.1 shall be tested to determine that all marked functions can be performed.

22 Torque Test

22.1 After being tested as described in this Section, a voltage presence indicator shall be capable of performing its intended function.

22.2 Pen style voltage presence indicators having a flat tip are to be subjected to a torque as specified in Table 22.1 applied to the tip for a period of 5 s.

Table 22.1
Torque test values

Diameter of tip		Torque	
in	(mm)	lbf•in	(N•m)
0.138	(3.5)	12	(1.4)
0.165	(4.2)	16	(1.8)
0.191	(4.8)	20	(2.3)

22.3 Screwdriver type voltage presence indicators are to be subjected to twice the torque values specified in Table 22.1. The torque is to be applied to the tip four times in opposite directions for 5 s each.

GFCI AND AFCI TESTERS

23 GFCI Condition – Ground Current Measurement

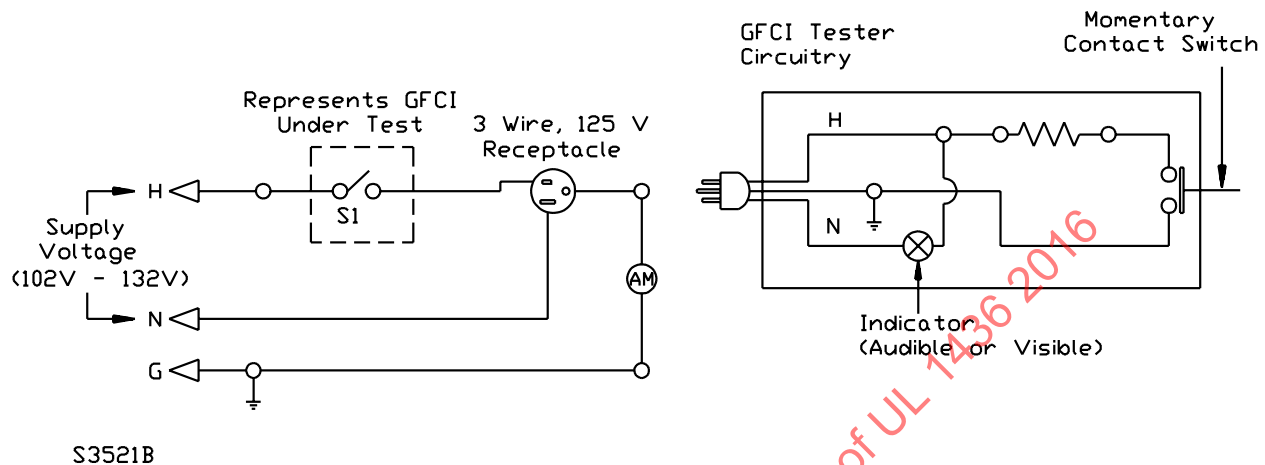
23.1 A ground-fault circuit-interrupter tester shall, when in its operational mode, introduce no less than 6 mA nor more than 9 mA current into the grounding conductor, and provide an audible or visible indication when tested as indicated in 23.2. See 18.1. The grounding conductor current shall be derived from a linear load such that the wave shape of the steady-state current follows the wave shape of the applied source voltage.

23.2 The test sequence, with reference to the measuring circuit in Figure 23.1, is to be as follows:

- Adjust the supply voltage to 120 V; insert the GFCI tester into the 3-wire, 125 V rated receptacle.
- With S1 closed, activate the test button located on the GFCI tester. With current flowing, the audible or visible indicator shall be activated.
- The test current measured shall not be less than 6 mA, or more than 9 mA, and the current shall remain until the test button is released, or the automatic timer circuit, if provided with the tester, opens the circuit after a minimum of 6 s. Release the test button.
- Leaving S1 closed, reactivate the test button and immediately open S1 to simulate a GFCI under test tripping. The GFCI tester shall provide an audible or visible indication that the GFCI is under test until S1 is opened, at which time the indication shall cease.
- Repeat steps (a) – (d) with the supply voltage set at 132 V. Results shall be the same as those obtained in steps (b), (c) and (d).

- f) Repeat steps (a) – (d) with the supply voltage set at 102 V. Results shall be the same as those obtained in steps (b), (c) and (d).

Figure 23.1
Ground current measurement circuit



23.3 A GFCI tester employing a timing circuit is to be inserted into the 3-wire, 125 V rated receptacle. S1 is to be closed, and the test button is to be activated and immediately released. A current of 6 – 9 mA shall be indicated in the ammeter for no less than 6 s nor more than 7.2 s.

24 AFCI Test Conditions

24.1 An arc-fault circuit-interrupter (AFCI) indicator shall, when in its operational mode, introduce not less than 8 nor more than 12 current pulses representative of arc-fault current between the ungrounded and grounded conductors of the circuit under test, and provide an audible or visible indication when tested as indicated in 24.2. Each arc-fault current pulse shall not be longer than 8.3 ms in duration and all 8 – 12 pulses shall occur in 0.5 s or less. The peak current of the arc-fault current pulses shall not be less than 106 A nor more than 141 A, and shall have sufficient waveform characteristics to trip an AFCI that complies with the requirements in the Standard for Arc-Fault Circuit-Interrupters, UL 1699. All current values shall be essentially sinusoidal rms currents, unless stated otherwise.

24.2 The available short-circuit current of the supply for the tests described below is to be 500 Arms $\pm 10\%$. The test sequence is to be as follows:

- With a supply voltage of 120 V, insert the AFCI indicator into a 125-V rated receptacle.
- With the circuit energized, activate the test button located on the AFCI indicator and record the characteristics of the current pulses.

- c) The test current measured between the ungrounded and grounded conductors shall contain no less than 8 nor more than 12 current pulses, with each pulse no longer than 8.3 ms in duration, and all 8 – 12 pulses shall occur in 0.5 s or less. The peak current of each pulse shall be no less than 106 A nor more than 141 A.
- d) Repeat steps (a) – (c) with the polarity of the supply voltage reversed.
- e) With a supply voltage of 120 V, insert the AFCI indicator into a 125-V rated receptacle protected by an AFCI that complies with the requirements in the Standard for Arc-Fault Circuit-Interrupters, UL 1699. One hundred feet of 14 AWG NM-B cable is to be installed between the AFCI and the receptacle. Several different types of AFCIs are to be tested to verify that the AFCI indicator produces sufficient waveform characteristics to trip all AFCIs.
- f) With the circuit energized, activate the test button located on the AFCI indicator. The AFCI indicator shall provide an audible or visible indication that the AFCI under test is opened.
- g) Repeat steps (e) – (f) with the supply voltage polarity reversed.

RETENTION TESTERS

25 General

25.1 In addition to the requirements in Sections 26 – 31, a retention tester shall comply with the requirements in Accelerated Aging Test, Section 14, Insulation Resistance Test, Section 15, Input Test, Section 18, and Temperature Test, Section 20.

Exception: A retention tester that is not electrically operated need not be subjected to the Input and Temperature Tests.

26 Calibration and Accuracy

26.1 A retention tester shall be calibrated and accurate as determined by 26.2 – 26.3.

26.2 Each line blade and grounding pin of 5 representative retention testers in the as-received condition is to be placed under a mechanically applied axial load of a magnitude within the range of the device under test. At least five consecutive retention tester readings per blade or pin under test, three of which are to lie within the 4 to 10 oz range, are to be recorded and compared against a value obtained from calibrated laboratory instrumentation, equipment or both.

26.3 No observation from any representative retention tester shall deviate from an ideal calibration curve (1:1 ratio) more than $\pm 2\frac{1}{2}\%$ of full scale.

27 Mechanism Endurance Test

27.1 After being subjected to 100,000 cycles of endurance in accordance with 27.2, a retention tester shall demonstrate performance as intended and shall be within the specified limits of accuracy as determined by 26.3.

27.2 Each line blade or blades and grounding pin of three representative retention testers that have successfully completed the calibration and accuracy test in Calibration and Accuracy, Section 26, is to be subjected to 100,000 cycles of endurance at a rate of not more than 12 cycles per minute. Another rate may be specified if agreeable to all concerned. Each retention tester is to be fixed in position while a linkage displaces each blade or pin 25% of the overall blade extension.

28 Security of Blades

28.1 Each retention tester that has successfully completed the Mechanism Endurance Test, Section 27, shall also comply with the Security of Blades Test, Section 16. The 20 lb (9.1 kg) weight is to be applied gradually until each blade or pin under test is fully extended. In determining compliance with the 3/32 in (2.4 mm) total displacement requirement, any displacement that is part of the proper operation of the device is to be disregarded.

29 Crush Test

29.1 A retention tester that has successfully completed the test in Calibration and Accuracy, Section 26, is to be subjected to the Crushing Test, Section 17. After completion of the test, the tester shall demonstrate performance as intended and shall be within the specified limits of accuracy as determined by 26.3.

30 Drop Test

30.1 A retention tester that has successfully completed the test in Calibration and Accuracy, Section 26, is to be subjected to the Drop Test, Section 19. After being tested in accordance with that section, the tester shall demonstrate performance as intended and shall be within the specified limits of accuracy as determined by 26.3.

31 Blade Wear Test

31.1 After being subject to 100,000 cycles of insertion into and removal from a receptacle, a blade or grounding pin shall not exhibit more than 0.001 in (0.025 mm) of wear within the "wiped" area of the blade.

Exception: Solid steel line blades and grounding pins need not be subjected to wear conditioning.

31.2 Each of 3 line blades and grounding pins is to be subjected to 100,000 cycles of insertion into and removal from a receptacle. For testing purposes, receptacles of the configurations that comply with the Standard for Attachment Plugs and Receptacles, UL 498, mentioned in 11.4(b) may be used to expose blades to wear conditioning. Each receptacle contact is to exert a minimum force of 8 ozf (2.22 N) onto each blade or pin under test and is to be checked at least twice a day to determine that at least the minimum force is maintained throughout the test. If the force is determined to be less than 8 oz, the receptacle is to be replaced.

32 Calibration Tool Drop Test

32.1 A calibration tool required to be provided with a retention tester:

- a) Shall withstand the drop test in 32.2 – 32.3 without any visual signs of permanent deformation such as cracks, scratches, bends, or other similar disfiguring details that would affect the accuracy of a field check on the calibration of a retention tester; and
- b) Shall not exhibit any change in accuracy.

32.2 Each of 3 representative calibration tools is to be used as intended to record one force reading on an as-received representative retention tester and on a retention tester that has successfully completed the Mechanism Endurance Test, Section 27. Each calibration tool then is to be dropped vertically 3 times from a height of 5 ft (1.52 m) onto a concrete floor.

32.3 Each calibration tool then is to be used on each of the retention testers indicated in 32.2. On the basis of comparison, there shall not be any difference in the readings observed both prior to and following the drop test on the calibration tool.

33 Absence of Voltage Test

33.1 In addition to the requirements in Sections 33 and 34, an AVT shall comply with the testing requirement in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 and the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits, UL 61010-2-030.

33.2 The AVT shall be connected in accordance with the installation instructions. The supply voltage shall be 110% of the maximum rated voltage or, if the equipment is rated for greater fluctuation, the maximum voltage fluctuation. The unit shall be tested at rated frequency. For a unit marked with a dual frequency rating or frequency range testing is conducted at both the high and low of the frequency range. Each of the following conditions shall be confirmed:

- a) When the supply voltage is applied and with any combination of phase-to-ground connection reversed, the visual indicator shall not illuminate green before or after the absence of voltage test is initiated. After the test, the visual indicator shall not illuminate green before or after the absence of voltage test is initiated and the conditions in 33.3 shall be repeated to determine if any damage to the unit affects the performance functions in accordance with 12.1.5 – 12.1.9. The pass criterion for each test is either correct undisturbed operation, or the AVT has no critical internal failure as described in 12.1.5 – 12.1.9.
- b) When the supply voltage is applied and with any individual phase or ground conductor disconnected the unit visual indicator shall not illuminate green when the absence of voltage test is initiated.
- c) The following test is to confirm that a false reading will not occur when the secondary power is absent, such as a battery failure or power source failure. When the supply voltage is on or off and when secondary power is not present, the unit visual indicator shall not illuminate green when the absence of voltage test is initiated.

33.3 The AVT shall be connected in accordance with the installation instructions. Each combination of the phase-to-phase or phase-to-ground voltage is to be connected to a supply voltage set at 3.0 (–0.0, +0.2) Vac rms. The unit visual indicator shall not illuminate green when the absence of voltage test is initiated. The test shall be repeated with a supply voltage set at 3.0 (–0.0, +0.2) Vdc and the unit visual indicator shall not illuminate Green when the absence of voltage test is initiated.

33.4 The test is repeated with the supply voltage de-energized and the unit visual indicator shall illuminate green after the absence of voltage test has been initiated and completed.

33.5 The Transient Overvoltage test described in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 shall be conducted. The impulse value used for the test shall be based on the input rating in Table 33.1. After the test, the conditions in 33.2 – 33.3 shall be repeated to determine if any damage to the unit affects the performance functions in 12.1.5 – 12.1.9. The pass criterion for each test is either correct undisturbed operation, or the AVT has no critical internal failure as described in 12.1.5 – 12.1.9.

Table 33.1
Impulse withstand voltages for overvoltage category

Line-to-neutral mains voltage	Impulse withstand voltage		
Vrms or Vdc	CAT II	CAT III	CAT IV
≤ 50	500	800	1,500
> 50 ≤ 100	800	1,500	2,500
> 100 ≤ 150	1,500	2,500	4,000
> 150 ≤ 300	2,500	4,000	6,000
> 300 ≤ 600	4,000	6,000	8,000
> 600 ≤ 1,000	6,000	8,000	12,000

33.6 The Static Test and Impact Test in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1, shall be conducted. After the test, the conditions in 33.2 – 33.3 shall be repeated to determine if any damage to the unit affects the performance functions in 12.1.5 – 12.1.9. The acceptance criterion for each test is either correct undisturbed operation, or the AVT has no critical internal failure as described in 12.1.5 – 12.1.9.

34 Strain Relief Test

34.1 A pigtail lead intended for field-wiring connection shall withstand without damage or displacement a direct pull of 10 lbf (44.5 N) for 1 min.

RATINGS

35 General

35.1 An indicating device shall be rated in watts (or milliamperes), and volts.

Exception: This requirement does not apply to retention tester that is not electrically operated.

35.2 A retention tester shall have its capacity and graduations rated in ounces. See also 36.1(c).

MARKINGS

36 General

36.1 An indicating device shall have a permanent, legible marking on the device that includes the:

- a) Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified;
- b) Catalog number or the equivalent;
- c) Electrical rating, and, in the case of a retention tester, its rating in ounces; and
- d) Date of manufacture which may be in an established or otherwise acceptable code that will enable the device to be identified as being manufactured within a specific 3-month period. The repetition time cycle of a date code shall not be less than 20 years. The date code shall not require reference to the manufacturer's records to determine the manufacturing date.

Exception: A retention tester that is not electrically operated is not required to be marked with an electrical rating.

36.2 A permanent marking shall be molded, die-stamped, paint stenciled, or printed on an adhesive-backed label or by other means considered equivalent. An adhesive-backed label shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969, for indoor-use labels.

36.3 An indicating device shall be marked to briefly show all possible indications and each probable corresponding circuit condition.

Exception: For AVTs, see 36.14.

36.4 An indicating device shall be marked with the following, or the equivalent: "Read instructions before using."

36.5 The information required by 36.6 – 36.8 shall be on the device or in the form of instructions provided with the device.

36.6 When applicable, an indicating device's marking or instructions shall include the following or equivalent:

- a) "All appliances or equipment on the circuit being tested should be unplugged to help avoid erroneous readings."
- b) "Not a comprehensive diagnostic instrument but a simple instrument to detect nearly all probable common improper wiring conditions."
- c) "Refer all indicated problems to a qualified electrician."
- d) "Will not indicate quality of ground."
- e) "Will not detect 2 hot wires in circuit."
- f) "Will not detect a combination of defects."
- g) "Will not indicate reversal of grounded and grounding conductors."

36.7 The device marking or instructions shall explain the circuit conditions it will indicate. This information shall expand on the marking required by 36.3.

36.8 A GFCI tester marking or instructions shall include the following statements or the equivalent:

- a) "Consult the GFCI manufacturer's installation instructions to determine that the GFCI is installed in accordance with the manufacturer's specifications."
- b) "Check for correct wiring of receptacle and all remotely connected receptacles on the branch circuit."
- c) "Operate the test button on the GFCI installed in the circuit. The GFCI must trip. If it does not – do not use the circuit – consult an electrician. If the GFCI does trip, reset the GFCI. Then, insert the GFCI tester into the receptacle to be tested."
- d) "Activate the test button on the GFCI tester for a minimum of 6 s when testing the GFCI condition. An audible or visible indication on the GFCI tester must cease when tripped."

Exception: The phrase "For a minimum of 6 seconds" need not be included when a GFCI tester incorporates a built-in automatic timing circuit that times out in six seconds.

e) "If the tester fails to trip the GFCI, it suggests:

- 1) A wiring problem with a totally operable GFCI; or
- 2) Proper wiring with a faulty GFCI.

Consult with an electrician to check the condition of the wiring and GFCI."

f) "CAUTION: When testing GFCIs installed in 2-wire systems (no ground wire available), the tester may give a false indication that the GFCI is not functioning properly. If this occurs, recheck the operation of the GFCI using the test and reset buttons. The GFCI button test function will demonstrate proper operation."

36.9 An AFCI indicator marking or instructions shall include the following statements or the equivalent:

- a) "Consult the AFCI manufacturer's installation instructions to determine that the AFCI is installed in accordance with the manufacturer's specifications."
- b) "Check for correct wiring of receptacle and all remotely connected receptacles on the branch circuit."
- c) "Operate the test button on the AFCI installed in the circuit. The AFCI must trip. If it does not – do not use the circuit – consult an electrician. If the AFCI does trip, reset the AFCI. Then, insert the AFCI indicator into the receptacle to be tested."
- d) "Activate the test button on the AFCI indicator when testing the AFCI condition. An audible or visible indication on the AFCI indicator must cease when tripped."
- e) "If the indicator fails to trip the AFCI, it suggests:
 - 1) A wiring problem with a totally operable AFCI, or
 - 2) Proper wiring with a faulty AFCI.

Consult with an electrician to check the condition of the wiring and AFCI."

f) "CAUTION: AFCIs recognize characteristics unique to arcing, and AFCI indicators produce characteristics that mimic some forms of arcing. Because of this the indicator may give a false indication that the AFCI is not functioning properly. If this occurs, recheck the operation of the AFCI using the test and reset buttons. The AFCI button test function will demonstrate proper operation."

36.10 If the retention force is numerically indicated through the use of a scale or other means, the numbers shall be a minimum of 5/64-in (2.0-mm) high.

36.11 A retention tester shall be permanently marked near the resetting means with the following or equivalent wording: "Reset after each test."

36.12 The calibration tool mentioned in 11.10 shall be permanently marked to designate the testing device with which it is intended to be used. Each retention tester shall be permanently marked to indicate the tool to be used when conducting periodic calibrations along with the recommended intervals at which checks should be conducted.

36.13 A voltage presence indicator shall be permanently marked with the following or equivalent wording: "Verify proper operation on a known source before use or taking action as a result of the indications of the device or, a positive means (visual or audible) to indicate the unit is operating properly must be provided. This indication or operation shall be easily distinguishable from other operating modes. In addition, the accompanying documentation must state that the operator needs to verify proper operation before use or taking action as a result of the indications of the device."

36.14 An AVT shall be marked in accordance with the requirements in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 and the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits, UL 61010-2-030. Additionally the following markings shall appear on the product or on a marking label located next to the indicators:

a) An AVT shall be marked to clearly indicate that only when the Green indicator is illuminated is the circuit considered to be de-energized. The following marking shall be used for the Green indication "Equipment De-energized" or "De-energized".

b) Any indicators that show other possible circuit conditions shall be clearly described.

36.15 An AVT shall be marked with the functional safety rating, "SIL 3".

36.16 An AVT shall be marked "Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum." The maximum rms Symmetrical Amperes is not to exceed 300,000 rms Symmetrical Amperes. The maximum voltage specified is based on the value used to determine compliance with the requirements in Appendix B.

INSTRUCTIONS

37 General

37.1 A retention tester shall be provided with instructions indicating the proper technique for removal of the tester from the outlet under test, the proper use of the calibration tool, and the action to be taken if the calibration tool indicates that the tester is no longer calibrated.

37.2 In addition to the requirements in the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1 and the Standard for Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits, UL 61010-2-030 an AVT shall be provided with explanation of all possible indications and each corresponding circuit condition.

37.3 The AVT documentation shall include the short circuit current rating "Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum."

37.4 ATV documentation shall include the minimum and maximum wire gauge size intended for field wiring terminals and an internal wiring diagram showing connection and routing. The instructions shall state: "The conductors used to connect the ATV to the line or bus and to ground shall not be any longer than necessary and shall be routed to avoid sharp edges, pinch points or mechanical damage" or similar wording.