# UL 943

ISBN 0-7629-1123-9

# Ground-Fault Circuit-Interrupters

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Ground-Fault Circuit-Interrupters, UL 943

Fourth Edition, Dated February 1, 2006

***Summary of Topics***

***This is the harmonized trinational Standard (Fourth Edition) for Ground-Fault Circuit-Interrupters, UL 943, and includes the Addition of Requirements for the GFCI Receptacle End of Life Test, Addition of Requirements for the Reverse Line-Load Miswire Test, and other miscellaneous revisions.***

The new requirements are substantially in accordance with UL's Proposal(s) on this subject dated June 10, 2005.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.



Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

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

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.



This Standard consists of pages dated as shown in the following checklist:

**Association of Standardization and Certification**
**NMX-J-520-ANCE-2006**
**First Edition**

**Canadian Standards Association**
**CSA C22.2 No. 144.1–06**
**First Edition**

**Underwriters Laboratories Inc.**
**UL 943**
**Fourth Edition**

# Ground-Fault Circuit-Interrupters

February 1, 2006

**ANSI/UL 943-2005**

**Commitment for Amendments**

This Standard is issued jointly by the National Association of Standardization and Certification of the Electrical Sector (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the Standard may be submitted to ANCE, CSA, or UL at any time. Revisions to this Standard will be made only after processing according to the standards development procedures of ANCE, CSA, and UL. CSA and UL will issue revisions to this Standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the Standard bearing the same date of issue as the CSA and UL pages.

---



---

**ISBN 1–55397–652–5**


---

**ISBN 0-7629-1123-9**


Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

The most recent designation of ANSI/UL 943 as an American National Standard (ANSI) occurred on November 15, 2005.

This ANSI/UL Standard for Safety, which consists of the Fourth edition is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

The Department of Defense (DoD) has adopted UL 943 on November 30, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

---

## CONTENTS

**SUPPLEMENT SA - OPTIONAL 10 KA SHORT CIRCUIT CURRENT TEST FOR OUTLET-BOX TYPE GROUND-FAULT CIRCUIT-INTERRUPTERS**

**INTRODUCTION**



**PERFORMANCE**



**MARKINGS**



**Annex A (Normative) Reference Standards**



**Annex B (Informative) French Translations and Markings**



**Annex C (Informative) Spanish Translations and Markings**



**Annex D (Informative) Reference Publications**



**Annex E (Normative in Canada and the United States; informative in Mexico) Installation Instructions – Configuration Drawings**

# Preface

This is the harmonized ANCE, CSA, and UL Standard for ground-fault circuit-interrupters. It is the first edition of NMX-J-520-ANCE-2006, the first edition of CSA C22.2 No. 144.1, and the fourth edition of UL 943. This edition of CSA C22.2 No. 144.1 supersedes the requirements for Class "A" Ground-Fault Circuit-Interrupters in the second edition of CSA C22.2 No. 144 published in 1991. This edition of UL 943 supersedes the previous edition published on August 27, 1993, and revised on August 2, 2005.

This harmonized Standard was prepared by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc. (UL). The efforts and support of the CANENA Technical Harmonization Subcommittee 23E, Ground-Fault Circuit-Interrupters, are gratefully acknowledged.

This Standard was reviewed by the CSA Subcommittee on Ground-Fault Circuit-Interrupters, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This Standard was reviewed by UL's Standards Technical Panel (STP) for Ground-Fault Circuit-Interrupters, STP 943.

This Standard will be submitted to the Standards Council of Canada (SCC) for approval as a National Standard of Canada.

This Standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

Where reference is made to a specific number of samples to be tested, the specified number shall be considered a minimum quantity.

**Note:** *Although the intended primary application of this Standard is stated in its scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

### Level of harmonization

This Standard uses the IEC format but is not based on, nor shall it be considered equivalent to, an IEC Standard. This Standard is published as an identical Standard for ANCE, CSA, and UL.

An identical Standard is a Standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

### Reasons for differences from IEC

This Standard provides requirements for ground-fault circuit-interrupters for use in accordance with the electrical installation codes of Canada, Mexico, and the United States. At present there is no IEC Standard for ground-fault circuit-interrupters for use in accordance with these codes. Therefore, this Standard does not employ any IEC Standard for base requirements.

### Interpretations

The interpretation by the standards development organization of an identical or equivalent Standard is based on the literal text to determine compliance with the Standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

### ANCE effective date

The effective date for ANCE will be announced through the Diario Oficial de Ia Federación (Official Gazette) and is indicated on the cover page.

### CSA effective date

The effective date for CSA International will be announced through CSA Informs or a CSA certification notice.

### UL effective date

As of July 28, 2006 all products Listed or Recognized by UL must comply with the requirements in this Standard except for clauses, figures, and tables in the following list, which are effective August 1, 2008.

Clauses 1.5, 5.1.4, 5.4.2, 5.8.1, 5.8.2, 5.10.2, 5.13.3, 6.1.7, 6.3.8, 6.7.2.2(c), 6.14.8, 6.18.1, 6.19.1, 6.22, 7.2.5, 7.2.7, 7.4.6, 7.4.7, Section 6.7.4, and Table 5.12.3.1.

Between July 28, 2006 and August 1, 2008, new product submittals to UL may be evaluated under all requirements in this Standard or, if requested in writing, evaluated under requirements effective July 28, 2006, only, contained in this Standard.

Between February 1, 2006 and July 28, 2006, new product submittals to UL may be evaluated under all requirements in this Standard or, if requested in writing, evaluated under presently effective requirements only. The presently effective requirements are contained in the third edition of UL 943.

A UL effective date is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved Standard.

## 1 Scope

1.1 This Standard applies to Class A, single- and three-phase, ground-fault circuit-interrupters intended for protection of personnel, for use only in grounded neutral systems in accordance with the National Electrical Code (NEC), ANSI/NFPA 70, the Canadian Electrical Code, C22.1 (CEC), and Electrical Installations (Use), NOM-001-SEDE. These devices are intended for use on alternating current (AC) circuits of 120 V, 208Y/120 V, 120/240 V, 127 V, or 220Y/127 V, 60 Hz circuits.

**Note: In Canada, the text "intended for protection of personnel" is excluded.**

1.2 These requirements do not cover ground-fault circuit-interrupters intended for use in circuits served by a transformer having windings wholly insulated from each other.

1.3 This Standard applies to all Class A ground-fault circuit-interrupters. These Class A GFCIs are permitted to be integrated into other devices, in which case, besides complying with this Standard, these devices are to comply with the corresponding applicable Standard for the device in question.

1.4 This Standard includes minimum requirements for the function, construction, performance, and markings of ground-fault circuit-interrupters included in the scope.

1.5 This Standard is intended to cover only Class A GFCI devices.

## 2 Normative References

2.1 Any normative 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. See Annex D.

2.2 When a reference is made to another code or Standard, the product shall comply with the installation code or Standard of the country or countries in which the product is intended to be used.

2.3 For products intended for use in Canada general requirements are given in CSA Standard C22.2 No. 0, *Definitions and General Requirements – Canadian Electrical Code, Part II*.

## 3 Definitions

For the purposes of this Standard, the following definitions apply:

3.1 ACCESSIBLE PART – A part so located that it can be contacted by a person, either directly or by means of a probe or tool.

3.2 AUTOMATIC RECLOSURE – Denotes the act of a ground-fault circuit-interrupter resetting itself after having been tripped.

3.3 CLASS A – Class A, when applied to a ground-fault circuit-interrupter (GFCI), is an interrupter that will interrupt the circuit to the load when the ground-fault current is 6 mA or more but not when the ground-fault current is 4 mA or less.

3.4 CORD-CONNECTED – Denotes connection to a supply circuit by way of a flexible cord terminating in an attachment plug.

3.5 DOUBLE INSULATION – The insulation system resulting from a combination of functional and supplementary insulation.

3.6 ENCLOSURE – A surrounding case constructed to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

3.7 ENERGIZED PART – A part at some potential with respect to another part, or to earth.

3.8 FUNCTIONAL INSULATION – The insulation necessary for the proper functioning of the device, and for basic protection against electrical shock hazard.

3.9 GFCI RECEPTACLE END OF LIFE – When a GFCI receptacle is incapable of passing its internal test function it has reached its end of life.

3.10 GROUND FAULT – Denotes an unintentional electrical path between a part operating normally at some potential to ground, and ground.

3.11 GROUND-FAULT CIRCUIT-INTERRUPTER – In the US and Mexico, a device intended for the protection of personnel that functions to de-energize a circuit or portion of a circuit within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

In Canada, a device whose function is to interrupt, within a predetermined time, the electrical circuit to the load when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

3.12 HOUSING – The integral envelope directly surrounding the circuit components of the ground-fault circuit-interrupter.

3.13 LEAKAGE CURRENT – Denotes all currents including capacitively coupled currents which may be conveyed between energized parts of a circuit and (1) ground or (2) other parts.

3.14 OUTLET-BOX TYPE GROUND-FAULT CIRCUIT INTERRUPTER – A permanently connected ground-fault circuit-interrupter provided with a mounting yoke for mounting in an outlet box; may or may not be provided with receptacle outlets. May be referred to as a receptacle-type GFCI.

3.15 PERMANENTLY CONNECTED – Denotes connection to a supply circuit by way of fixed electrical conductors (see cord-connected).

3.16 PORTABLE GROUND-FAULT CIRCUIT-INTERRUPTER – A plug-in type ground-fault circuit-interrupter provided with male blades for connection to a receptacle, or one that is cord-connected. (See cord-connected).

3.17 RATED CURRENT – The marked value of current.

3.18 RATED VOLTAGE – Voltage assigned by the manufacturer. See Table 7.2.1 for details and marked voltage.

3.19 REINFORCED INSULATION – An insulation providing protection against electrical shock hazard that is equivalent to double insulation.

3.20 ROOM TEMPERATURE – Air at 25.0 ±5.0°C (77.0 ±9.0°F).

3.21 SHOCK HAZARD – A shock hazard is considered to exist at a part of a ground-fault circuit-interrupter if:

a) There would be current of 6 mA or more in a resistance of 500 ohms connected between the part in question and the grounded supply conductor, and

b) The device would not operate to open the circuit to the 500-ohm resistor within the time allowed in 6.7.1.1.

3.22 SUPPLEMENTARY INSULATION – An independent insulation provided in addition to the functional insulation to insure protection against electric shock hazard in the event that functional insulation should fail.

3.23 TRIP – Denotes automatic interruption by the ground-fault circuit-interrupter of the electric circuit to the load.

## 4 General

### 4.1 Components

4.1.1 Except as indicated in 4.1.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components generally used in the products covered by this Standard and applicable Mexican Standards. A component shall comply with the ANCE, CSA, or UL Standards as appropriate for the country where the product is to be used. When a product is intended for use in more than one country, a component shall comply with the appropriate component Standard for the countries in which it is being used.

4.1.2 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.

4.1.3 A component shall be used in accordance with its ratings for the intended conditions of use.

4.1.4 Specific components are accepted as being incomplete in construction features, or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as temperatures not exceeding specified limits, and shall be used only under those specified conditions for which they have been investigated.

### 4.2 Units of measurement

4.2.1 If 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.

## 5 Construction

### 5.1 All types

5.1.1 A ground-fault circuit-interrupter which is intended to be connected to a supply circuit having more than one ungrounded conductor shall be so designed that their intended purpose will not be defeated if any of the ungrounded conductors is not energized in the normal way.

5.1.2 An interrupter having an adjustable circuit component, the setting of which affects the clearing time or the sensitivity, shall be constructed so that:

a) The component is not visible to the user when the interrupter is in normal use or when it is opened for connecting supply circuit and load circuit conductors; and

b) Any cover or other part which obscures the component from view requires a tool for removal and is so secured or sealed that the removal can be readily detected. The application of a sealing material directly to the component is considered to comply with the intent of Item (b) for sealing.

5.1.3 Male and female contact devices such as plugs, connectors, current taps, and receptacles provided with, or as an integral part of, a ground-fault circuit-interrupter shall also comply with the applicable construction and performance requirements in the Standards referenced in Annex A, Ref. No. 1.

5.1.4 In Canada, a portable ground-fault circuit-interrupter:

a) Is required to have a fixed grounding pin,

b) Of the direct plug-in type, other than one designed solely for use in a locking type receptacle, shall not include a mounting tab which is intended to connect with a screw retaining the cover of a duplex receptacle in place, or any other means for securing the interrupter to a receptacle or its cover.

### 5.2 Resistance to corrosion

5.2.1 Parts shall be protected against corrosion if failure of such parts would be likely to result in a hazardous condition, including failure to perform with high-resistance ground faults as provided in these requirements. To verify compliance with 5.2.1, see the Corrosion test, Clause 6.21.

### 5.3 Grounding

5.3.1 All accessible parts of a permanently connected ground-fault circuit-interrupter that are likely to become energized if there should be arc-over, insulation failure, or the like, shall be connected together and to the terminals intended for the equipment grounding conductor (see 5.11.1). The resistance of the circuit is not to exceed 0.1 ohm, and the circuit shall be capable of withstanding continuously a current of 25 A.

5.3.2 In Canada, the grounding and bonding shall comply with the requirements of Annex A, Ref. No. 2, except the screw size shall be permitted to comply with 5.3.3.

5.3.3 For devices rated 15 A or 20 A the minimum screw size is 4.5 mm (No. 8).

5.3.4 In considering the provisions of 5.3.1, a grounded or insulating barrier may be employed to reduce the likelihood that accessible parts will become energized.

5.3.5 If provided, the equipment grounding conductor of a portable or cord-connected ground-fault circuit-interrupter shall be conductively connected to the grounding contacts of the attachment plug and of the receptacles, and shall not be connected to accessible conductive parts.

5.3.6 A ground-fault circuit-interrupter shall operate normally if there is an open circuit in the grounding conductor.

**Note: In Canada, equipment grounding conductors are referred to as bonding conductors.**

### 5.4 Enclosure and housing

5.4.1 A ground-fault circuit-interrupter housing shall be capable of withstanding the abuses to which it might be subjected in normal use without affecting the GFCI to the extent that the GFCI would fail to comply with the requirements of this Standard. A ground-fault circuit-interrupter intended to be incorporated into equipment having an enclosure that is subject to the requirements of the end-product *Standard, shall be permitted to be constructed without enclosures.

*See Annex D for a list of possible end-product Standards.

5.4.2 A device which is capable of being used as a ground-fault circuit interrupter without being installed in an additional enclosure, shall comply with the enclosure requirements as referenced in Annex A, Ref. No. 3, and shall also comply with the applicable enclosure requirements for the intended environment as referenced in Annex A, Ref. No. 4. See 6.3.8.

5.4.3 Doors and covers shall have means for securing them firmly in place. If bare live parts are exposed by the opening of such doors or covers, means requiring the use of a tool to open, or provision for locking, shall be provided to hold them in the closed position.

### 5.5 Provision for connection to permanent wiring systems

5.5.1 There shall be provision at a permanently connected ground-fault circuit-interrupter for attachment of raceway or cable and grounding in accordance with the National Electrical Code (NEC), ANSI/NFPA 70, Canadian Electrical Code (CEC), C22.1 or Electrical Installations (Use), NOM-001-SEIE-1999.

5.5.2 Interrupters shall be so constructed that:

a) The position of the openings for conduit or cable connection is unlikely to cause confusion in connecting field-installed conductors;

b) Field-installed conductors will be separated by barriers from conductors of internal wiring; and from components of interrupters other than wiring terminals; and

c) Circuit components will be protected from damage during field installation. See Enclosure and housing – performance, Clause 6.3.

### 5.6 Insulation

5.6.1 Except as described in 5.6.2 and 5.6.3, a portable ground-fault circuit-interrupter shall have double insulation or reinforced insulation throughout its construction.

5.6.2 Functional insulation alone is acceptable in a portable device where, in the event that the functional insulation should fail, there would be no shock hazard at the ground-fault circuit-interrupter.

5.6.3 In performing the evaluation described in 5.6.2 at a manual switch in the supervisory circuit (described in 5.15.1), the device need not trip if the value of current available in the event that the functional insulation of the switch should fail would not exceed the value of current employed by the supervisory circuit.

5.6.4 Functional insulation shall be interposed between grounding conductors and accessible parts of a cord-connected ground-fault circuit-interrupter. If such insulation is inherent in a receptacle:

a) There shall be instructions visible when the receptacle is being removed for replacement to replace the receptacle with only an identical replacement, and how to obtain the replacement, and

b) It shall not be possible to use a standard grounding-type receptacle as a replacement without first performing a drilling or cutting operation.

5.6.5 Except where specifically acceptable for the purpose, the jacket of the power-supply cord of the ground-fault circuit-interrupter is not considered to provide insulation. See 5.10.5.

### 5.7 Accessibility of energized parts

5.7.1 Parts of a ground-fault circuit-interrupter shall not be accessible when they are energized.

5.7.2 In determining compliance with the provisions of 5.7.1:

a) Except at a contact of an attachment-plug receptacle, a part is considered to be accessible if it can be touched with a 2.4 mm (3/32-inch) diameter rod,

b) A permanently connected device shall be mounted as intended,

c) A door or cover that can be opened or removed without the use of a separate tool is to be open or removed,

d) A door or cover that must be opened or removed in order to use a ground-fault circuit-interrupter shall be opened or removed, and

e) Material that is not acceptable as insulation is considered to be conductive.

5.7.3 Access to the trip mechanism and electronics of a portable ground-fault circuit-interrupter, not intended to be repaired, shall not be attainable with ordinary tools. Access shall be limited by use of tamper-resistant screws, rivets, welding or other equivalent means.

### 5.8 Internal wiring

5.8.1 The gauge and insulation of wires shall withstand the mechanical and electrical stresses of service. Particular consideration should be given to the effect of vibration and user servicing where wire smaller than 0.205 $mm^2$ (24 AWG) is employed. Compliance shall be determined by completion of the impact test and drop test as described in Enclosure and housing – performance, Clause 6.3, and conducting the Visual inspection test, Clause 6.22.

5.8.2 In a portable cord-connected ground-fault circuit-interrupter, at a wire termination or splice there shall be at least one independent means provided which alone could prevent the conductor from becoming free to bridge supplementary or reinforced insulation in the event that the wire should break at the termination or splice. A wire-binding screw or nut shall be suitably prevented from loosening such as with a spring-type lockwasher or equivalent, if such loosening could allow the attached conductor to become free to bridge supplementary or reinforced insulation. Compliance shall be determined by conducting the Visual inspection test, Clause 6.22.

5.8.3 Insulated conductors shall be suitable for the temperature, voltage, and the intended use in accordance with the applicable requirements of relevant component Standards (see also Separation of circuits, subclause 5.12.4).

5.8.4 All joints and connections shall be made mechanically secure and shall provide adequate and reliable contact without strain on connections and terminals. Compliance shall be determined by conducting the Visual inspection test, Clause 6.22.

5.8.5 All joints shall be provided with insulation suitable for the temperature, voltage, and intended use of the conductors themselves, in accordance with applicable requirements of the relevant component Standards listed in Annex A, Ref. No. 5, or shall comply with Spacings, Clause 5.12, or Alternate spacings – clearances and creepage distances, Clause 5.13. Compliance shall be determined by conducting the Visual inspection test, Clause 6.22.

**5.9 Field wiring**

5.9.1 A ground-fault circuit-interrupter intended for permanent connection to the branch circuit shall be provided with means for the connection of wires having an ampacity in accordance with the National Electrical Code ANSI/NFPA 70, and the Canadian Electrical Code, C22.1, and Electrical Installations (Use), NOM-001-SEDE.

5.9.2 In a permanently connected ground-fault circuit-interrupter, either:

a) Acceptable barriers shall be employed to separate load-circuit conductors and terminals from terminals and conductors of any other circuit, or

b) All such parts shall be insulated for the maximum voltage of either circuit.

5.9.3 If a ground-fault circuit-interrupter is provided with leads for connection to the branch circuit, the leads shall not be more than two sizes smaller than the size referred to in 5.9.1 and shall not be smaller than 2.082 $mm^2$ (14 AWG).

5.9.4 A lead-type terminal shall be so constructed as to withstand the stress of normal handling without damage to the ground-fault circuit-interrupter. To determine compliance, each terminal lead shall be subjected to the force described in 6.1.5.

5.9.5 Green coloring with or without one or more yellow stripes and white or gray coloring shall not be used for the covering of a terminal lead unless intended for connection to grounding and grounded conductors respectively. See also 8.2.5.

**In Canada, an equipment grounding conductor is referred to as a bonding conductor and the grounded conductor is referred to as the identified conductor.**

5.9.6 The free length of a terminal lead shall be at least 100 mm (4 inches).

5.9.7 A terminal connector shall be prevented from moving so as to strain factory connections or reduce spacings to unacceptable values. Friction alone is not to be depended upon to prevent such movement.

5.9.8 At a terminal that is not considered to be a pressure terminal connector, it shall not be necessary to assemble or adjust parts other than loosening or tightening a screw, bolt, or nut. In order to determine compliance with the provisions of 5.9.8, a wire-binding screw or nut is to be tested in accordance with 6.1.8.

5.9.9 A terminal connector of the wire-binding type is permitted to terminate conductors no larger than 5.26 $mm^2$ (10 AWG).

## 5.10 Power-supply cord

5.10.1 A cord-connected ground-fault circuit-interrupter shall be provided with an attachment plug for connection to the supply circuit. The rating of the attachment plug is to be equal to the rating of the ground-fault circuit-interrupter.

5.10.2 The flexible cord shall be of a type, which complies with the requirements for:

a) Hard usage or extra-hard usage in accordance with Table 11 of the Canadian Electrical Code, Part I, or

b) Hard service or junior hard service cords in accordance with Flexible Cords and Cables, Table 400-4 of the National Electrical Code, ANSI/NFPA 70, or

c) Extra-hard service or hard service in accordance with Electrical Products, Wire and Cables, Heavy Duty and Extra Heavy Duty Flexible Cords, Up to 600 V, NMX-J-436.

5.10.3 Strain on the power-supply cord that may occur by way of pulling, twisting, or pushing into the ground-fault circuit-interrupter housing shall not be transmitted to cord-conductor terminations.

5.10.4 In order to determine that the strain of pulling on the supply cord will not be transmitted to the cord terminations as provided in 5.10.3, the power supply cord is to be subjected to be the test in 6.1.6.

5.10.5 A clamp or similar device of conductive material applied to the power-supply cord shall have supplementary insulation interposed between the cord and the clamping device or shall not be accessible.

5.10.6 A surface of a ground-fault circuit-interrupter against which a flexible cord is likely to bear shall be smooth and well-rounded.

5.10.7 Unless protection is provided in a ground-fault circuit-interrupter to prevent overloading of the supply-cord conductors, the current rating of the supply cord shall not be less than the current rating of the attachment plug on the supply cord.

5.10.8 The points within the ground-fault circuit-interrupter intended for the termination of power-supply-cord conductors shall be plainly identified as detailed in 7.4.3.

5.10.9 The attachment plug of a ground-fault circuit-interrupter shall be a molded-on type or shall have the cord-conductor terminations sealed, or shall be provided with other means to prevent accidental contact between the grounding conductor and either or both of the power conductors, within the attachment plug.

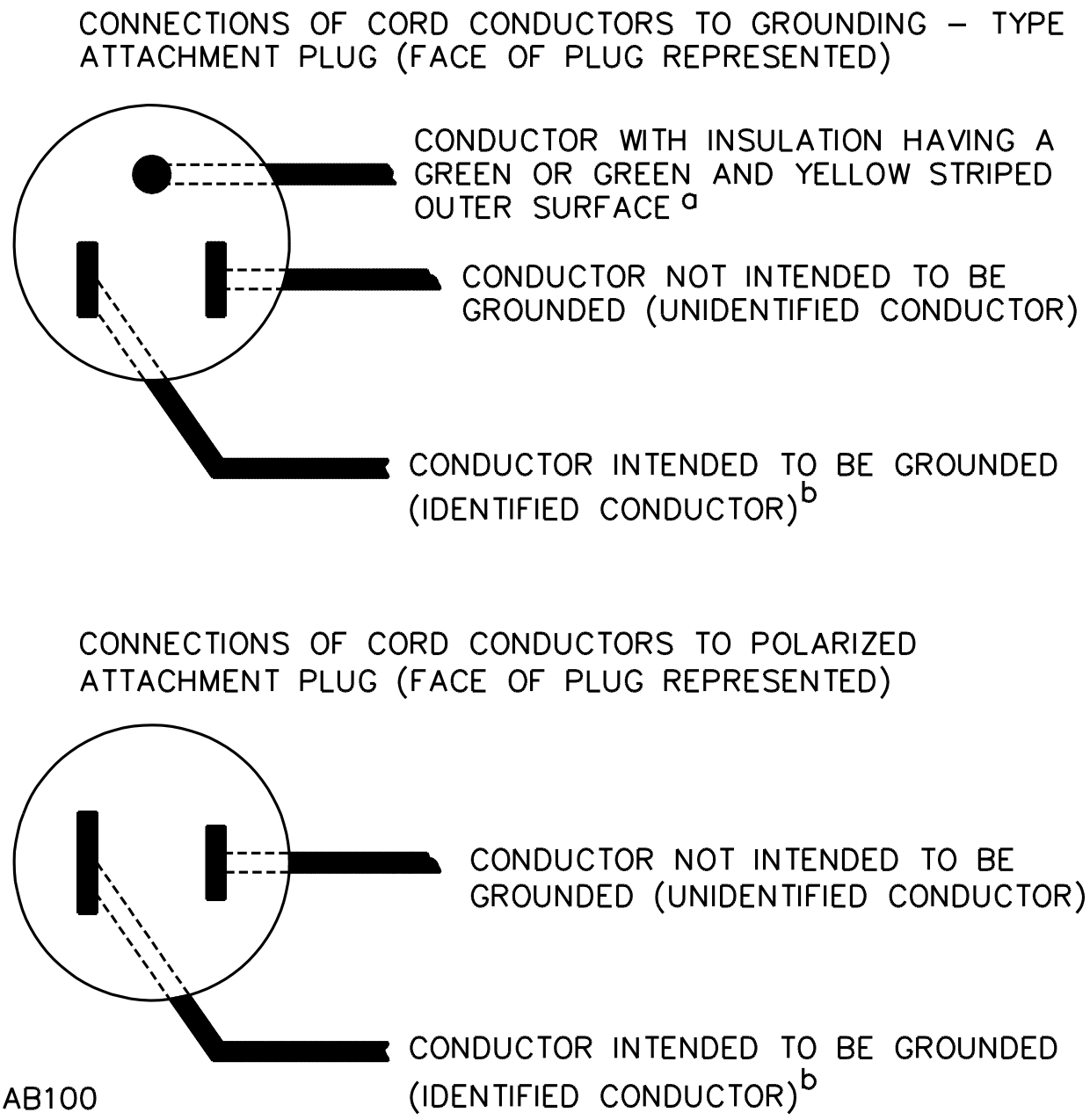
5.10.10 A portable ungrounded ground-fault circuit-interrupter shall be provided with a polarized attachment plug cap.

5.10.11 If a 3-wire grounding-type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connections shall comply with Figure 5.10.1, and the polarity identification of the flexible cord shall comply with Table 5.10.1.

5.10.12 The power supply cord of a portable GFCI having a permanently attached cord shall be subjected to the test in 6.1.7.

5.10.13 The power-supply cord shall be separately insulated from exposed metal parts at the point where it enters the equipment. The jacket on a cord is not considered as supplementary insulation.

**Figure 5.10.1**
**Connection to attachment plug**




[a] In the above illustration, the blade to which the green conductor is connected may have a U-shaped or circular cross section.

[b] Signifies a conductor identified in accordance with Table 5.10.1 as wire intended to be grounded.

**Table 5.10.1**
**Polarity identification of flexible cords**

| Method of Identification | Acceptable combinations | | |
|---|---|---|---|
| | Wire intended to be grounded[b,c] | | All other wires[b] |
| Color of braids on individual conductors | A | Solid white or gray – without tracer | Solid color other than white or gray – without tracer |
| | B | Color other than white or gray, with tracer in braid | Solid color other than white or gray – without tracer |
| Color of insulation[a] on individual conductors | C | Solid white or gray | Solid color other than white, or gray |
| | D | Light blue | Solid color other than light blue, white |
| Note: In Canada, an equipment grounding conductor is referred to as a bonding conductor and the grounded conductor is referred to as the identified conductor. | | | |
| [a] Only for cords having no braid on any individual conductor.<br>[b] Wire finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment-grounding conductor. See Figure 5.10.1.<br>[c] The color blue or use of a tracer braid is not permitted for this use in Canada. | | | |

## 5.11 Receptacles

5.11.1 A receptacle of a ground-fault circuit-interrupter shall be of the grounding type with the grounding terminal conductively connected to the grounding conductor of the power-supply cord, except as noted in 5.11.2.

5.11.2 A portable ground-fault circuit-interrupter that is not provided with an equipment ground shall not be provided with a receptacle or cord connector of the grounding type, but shall be provided with a polarized receptacle or cord connector. See 5.5.

5.11.3 The ampere rating of the receptacle of a ground-fault circuit-interrupter that has only a single receptacle shall be equal to the rating of the attachment plug of the supply cord.

5.11.4 The rating of any receptacle not having individual overcurrent protection, provided on a ground-fault circuit-interrupter having more than one receptacle outlet, shall be one of those shown in Table 5.11.1.

5.11.5 The face of a two-conductor ungrounded receptacle or cord connector shall obstruct the insertion of a 2-pole 3-wire grounding type attachment plug cap.

**Table 5.11.1**
**Receptacle current rating in amperes**

| | | | |
|---|---|---|---|
| Supply – Cord Cap Amperes | 15 | 20 | 30 |
| Receptacle | 15 | 15 or 20 | 30 |

## 5.12 Spacings

5.12.1 General

5.12.1.1 A through-air spacing between bare, current-carrying parts shall be considered to be the shortest distance measured around any insulating barriers between them, except that any joint in a barrier shall be treated as a gap in the barrier, unless the joint has been shown to have an effective dielectric strength equivalent to that of the barrier.

5.12.1.2 An over-surface spacing between bare, current-carrying parts shall be considered to be the shortest distance measured along the surface of the insulating material between them, except that the following distances shall not be included:

a) The length of the contour of a slot or groove where the width of the slot or groove in the surface is less than 0.8 mm (1/32 inch) wide.

b) The distance measured around an insulating barrier which is not integral with its supporting base and not otherwise joined to it so that the dielectric strength of the joint is effectively equivalent to that of the barrier.

5.12.1.3 In determining spacings, film-coated magnet wire is considered to be un-insulated.

5.12.1.4 Parts not locked in position, parts subject to random orientation (such as non-circular heads of screws), and the like are to be moved to the most adverse position for spacing measurement.

5.12.1.5 The spacing at wiring terminals shall be measured with appropriate wires in place and connected to the terminals as in actual service.

5.12.1.6 All bare current-carrying parts connected to different circuits shall be spaced from each other as though they were parts of opposite polarity and spacing requirements shall be judged on the basis of the voltage involved. In the case of isolated circuits, the polarity and spacing between the adjacent bare conductors of the two circuits shall be consistent with the requirements of the highest voltage involved.

5.12.1.7 In determining spacings through openings in a housing of insulated material, tightly drawn metal foil may be used to bridge the opening, but is not to be pressed into the opening.

5.12.2 Requirements – other than field-wiring terminals

5.12.2.1 Through-air and over-surface spacings shall not be less than the values shown in Table 5.12.2.1 and Table 5.12.2.2.

5.12.3 Requirements – field-wiring terminals

5.12.3.1 The spacings between field-wiring terminals not operating at the same potential shall not be less than those shown in Table 5.12.3.1.

5.12.4 Separation of circuits

5.12.4.1 Unless supplied with insulation suitable for the highest voltage, insulated conductors of different circuits (internal wiring) shall be separated by barriers or shall be segregated; and shall be separated or segregated from bare live parts connected to different circuits. Clamping, routing, or equivalent means of permanent separation from insulated or bare live parts of a different circuit may be considered as appropriate segregation of the insulated conductors.

**Table 5.12.2.1**
**Spacing in mm (inches)**

| Parts separated by | Operating potential between parts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 70 V peak or less | | | | 71 – 200 V peak | | | |
| | Though air | | Over surface | | Through air | | Over surface | |
| | Open[a] | Closed-in[b] | Open[a] | Closed-in[b] | Open[a] | Closed-in[b] | Open[a] | Closed-in[b] |
| Functional insulation[c] | 1.6 (1/16[d]) | 1.6 (1/16[d]) | 1.6 (1/16[d]) | 1.6 (1/16[d]) | 3.2 (1/8) | 1.6 (1/16) | 6.4 (1/4) | 1.6 (1/16) |
| Supplementary insulation | 3.2 (1/8) | 1.6 (1/16) | 6.4 (1/4) | 1.6 (1/16) | 3.2 (1/8) | 1.6 (1/16) | 6.4 (1/4) | 3.2 (1/8) |
| Double or Reinforced insulation | 6.4 (1/4) | 3.2 (1/8) | 12.7 (1/2) | 3.2 (1/8) | 6.4 (1/4) | 3.2 (1/8) | 12.7 (1/2) | 6.4 (1/4) |

[a] A space that is not specially protected from deposition of dirt.

[b] A space that is specially protected from deposition of dirt; i.e., a sealed housing that meets the requirements of the dust test outlined in Clause 6.20.

[c] Smaller spacings may be acceptable where they are inherent in a suitable component.

[d] May be less than 1.6 mm (1/16 in), but not less than 0.8 mm (1/32) at a printed wiring board without conformal coating.

[e] For printed wiring boards with suitable conformal coating which has been determined to comply with the requirements in Annex A, Ref. No. 6 spacings may be reduced to 0.8 mm (1/32 in), and may be further reduced if the coating is determined to be suitable and a special dielectric withstand test is performed between the conductors.

**Table 5.12.2.2**
**Spacing in mm (inches)**

| Parts separated by | Operating potential between parts | | | |
|---|---|---|---|---|
| | 201 – 400 V peak | | | |
| | Though air | | Over surface | |
| | Open[a] | Closed-in[b] | Open[a] | Closed-in[b] |
| Functional insulation[c] | 6.4 (1/4) | 3.2 (1/8) | 9.5 (3/8) | 3.2 (1/8) |
| Supplementary insulation | 6.4 (1/4) | 1.6 (1/16) | 9.5 (3/8) | 3.2 (1/8) |
| Double or Reinforced insulation | 12.7 (1/2) | 6.4 (1/4) | 19 (3/4) | 6.4 (1/4) |

[a] A space that is not specially protected from deposition of dirt.

[b] A space that is specially protected from deposition of dirt; i.e., a sealed housing that meets the requirements of the dust test outlined in Clause 6.20.

[c] Smaller spacings may be acceptable where they are inherent in a suitable component.

[d] May be less than 1.6 mm (1/16 in), but not less than 0.8 mm (1/32) at a printed wiring board without conformal coating.

[e] For printed wiring boards with suitable conformal coating which has been determined to comply with the requirements in Annex A, Ref. No. 6 spacings may be reduced to 0.8 mm (1/32 in), and may be further reduced if the coating is determined to be suitable and a special dielectric withstand test is performed between the conductors.

**Table 5.12.3.1**
**Minimum spacing at field wiring terminals**

| Voltage peak | Spacing, mm (inches) | | |
|---|---|---|---|
| | Through air (between opposite polarities) | Over surface in air (between opposite polarities) | Through air or over surface (between live parts to ground) |
| up to 200 | 6.4 (1/4) | 6.4 (1/4) | 6.4 (1/4) |
| 201 – 400 | 9.5 (3/8) | 9.5 (3/8) | 12.7 (1/2) |

## 5.13 Alternative spacings – clearances and creepage distances

5.13.1 As an alternative to the measurement method specified in Spacings, Clause 5.12, for functional insulation, the minimum acceptable clearances (through air spacings) and creepage distances (over surface spacings) for a printed wiring board assembly shall be evaluated as specified in 5.13.2 – 5.13.4 using the applicable requirements in Annex A, Ref. No. 7.

5.13.2 When applying the requirements in Annex A, Ref. No. 7, the environment for a printed wiring board assembly within a ground-fault circuit-interrupter is considered to be:

a) Pollution degree 3 for an assembly without a conformal coating,

b) Pollution degree 2 for

1) an assembly with a conformal coating, or

2) an assembly without a conformal coating when the printed wiring board is contained in a sealed housing that complies with the Dust test, Clause 6.20, or

c) Pollution degree 1 for an assembly with a conformal coating complying with the Printed Wiring Board Coating Performance Test in Annex A, Ref. No. 7.

5.13.3 When applying Clearance B (controlled overvoltage) construction requirements from Annex A, Ref. No. 7, the applicable overvoltage category for line voltage circuits is Category III. Category I is applicable to low voltage circuits if a short circuit between the parts involved results in operation of the controlled equipment which increases the risk of fire, the risk of electric shock, or both. Any overvoltage protection device needed to achieve these categories shall be provided as an integral part of the ground-fault circuit-interrupter.

5.13.4 Where measurement of clearances and creepage distances is involved to establish the minimum spacings, the methods specified for measurement of clearance and creepage distances in Annex A, Ref. No. 7, shall be used.

**5.14 Operating mechanism**

5.14.1 Compliance with the provisions of 6.7.1.1 – 6.7.2.2 shall not be prevented by manipulation or restraint of accessible control levers, knobs, and the like of a ground-fault circuit-interrupter. To verify compliance with 5.14.1, see Operating mechanism test, Clause 6.25.

5.14.2 A ground-fault circuit-interrupter that has tripped in accordance with the provisions of 6.7.1.1 – 6.7.2.2 shall not be capable of automatic reclosure.

5.14.3 If a permanently connected ground-fault circuit-interrupter trips because of a loss of power on the line side, it shall be capable of automatic reclosure when power is restored.

5.14.4 A portable ground-fault circuit-interrupter which trips due to a loss of power on the line side is not prohibited from being provided with the capability of automatic reclosure when power is restored.

5.14.5 A receptacle Type GFCI that contains separate line and load terminals, and that is powered through its load terminals, shall not reset and supply power to its receptacle face or line terminals. See Reverse line-load miswire test, Clause 6.23.

**5.15 Supervisory Circuit**

5.15.1 A ground-fault circuit-interrupter shall be provided with a supervisory circuit that will conveniently allow for periodic, manual testing of the ability of the device to trip by way of a ground fault.

5.15.2 If it is necessary to employ a separate tool in order to operate the supervisory circuit, operation is considered not to be convenient within the intent of these requirements.

5.15.3 The supervisory circuit shall be connected to the grounded supply-circuit conductor and at least one ungrounded load-circuit conductor.

5.15.4 The results of the test shall be made known by means of an audible or visual indication.

5.15.5 When the internal test function is performed, a ground-fault circuit-interrupter receptacle that has reached its end of life shall comply with either (a) or (b):

a) Indicate by visual means, audible means, or both, that the device must be replaced.

b) Rendering itself incapable of delivering power.

5.15.6 The current employed by the supervisory circuit shall be sufficient to cause tripping at 85 percent of rated voltage, provided that at rated voltage the current shall not exceed 9 mA.

## 6 Tests

### 6.1 General

6.1.1 When evaluated in accordance with 6.1.2, a product having integral blades for direct insertion into a receptacle shall comply with the specifications in Table 6.1.1.

6.1.2 The limits specified in Table 6.1.1 shall be determined as follows:

a) For units with an output cord, the cord is to be cut off at the enclosure, or at the strain relief means if the strain relief means is outside the enclosure.

b) For units with integrally mounted accessories or optional components, the values are to be measured with the accessories or components in place.

c) A removable part is to be in place.

d) A mounting tab is not to be included in the measurement of linear dimensions for the purpose of determining moments unless:

1) There is no deformation of the tab and enclosure after being subjected to the impact described in Enclosure and housing – performance, Clause 6.3, and

2) For a polymeric-enclosed product having an integral tab, there is no distortion at temperatures to which the polymeric material may be subjected under conditions of normal and abnormal use as determined by subjecting the product to the applicable mold stress-relief distortion test requirements in Annex A, Ref. No. 8.

6.1.3 When the integral blades are inserted into a parallel-blade duplex receptacle, no part of the product, including a mounting tab, shall interfere with the full insertion of an attachment plug into the adjacent receptacle, except as noted in 6.1.4. See Figure 6.1.2.

6.1.4 A unit that renders the adjacent receptacle completely unusable in any one mounting position is acceptable.

## Table 6.1.1
## Specifications for plug-in GFCIs

| Algebraic Quantity | Maximum acceptable value | |
|---|---|---|
| W | (7.78 N) | 28 ozf |
| WY/Z | (13.34 N) | 48 ozf |
| WY/S | (13.34 N) | 48 ozf |
| WX | (0.56 N·m) | 80 ozf-in. |

In this table the variables are defined as follows:

W is the weight of the product in N (ozf) and is considered to be a force equal to the product mass in kg (oz) as measured on a scale or balance.

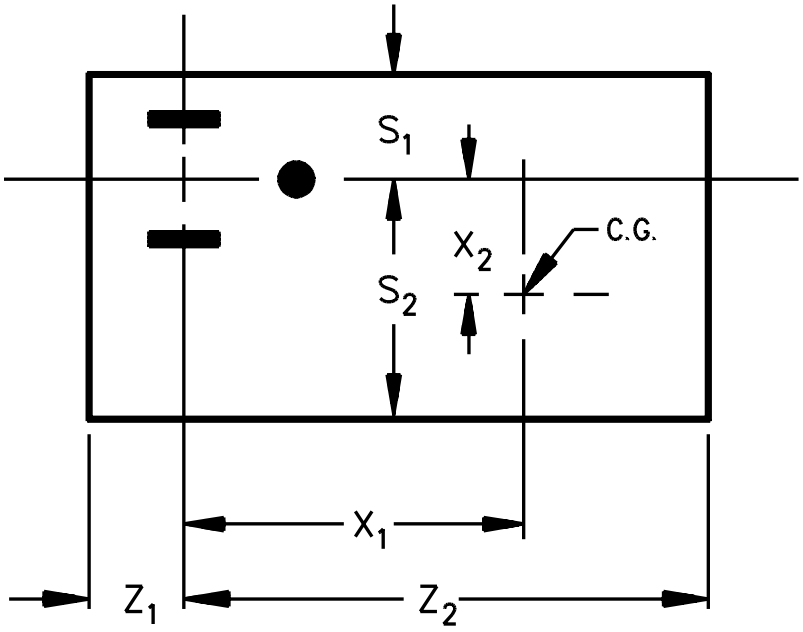
Y is the distance, in mm (inches), illustrated in Figure 6.1.1.

Z is the shorter distance, in mm (inches), of $Z_1$ or $Z_2$ illustrated in Figure 6.1.1.

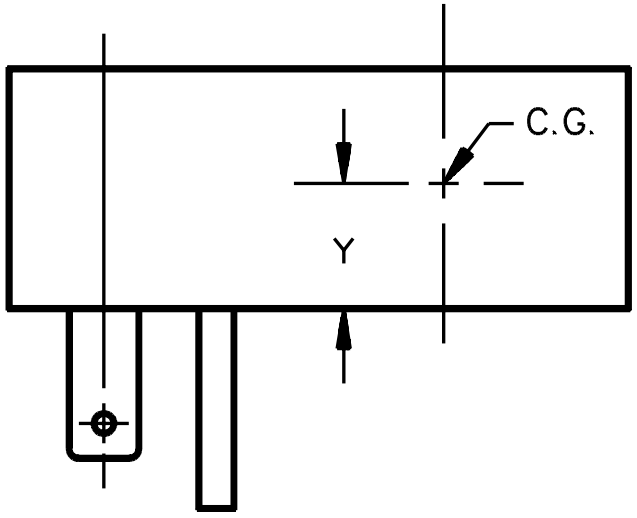
S is the shorter distance, in mm (inches), or $S_1$ or $S_2$ illustrated in Figure 6.1.1.

X is the shorter distance, in mm (inches), of $X_1$ or $X_2$ illustrated in Figure 6.1.1.

**Figure 6.1.1**
**Dimensions of a plug-in product**




FRONT VIEW

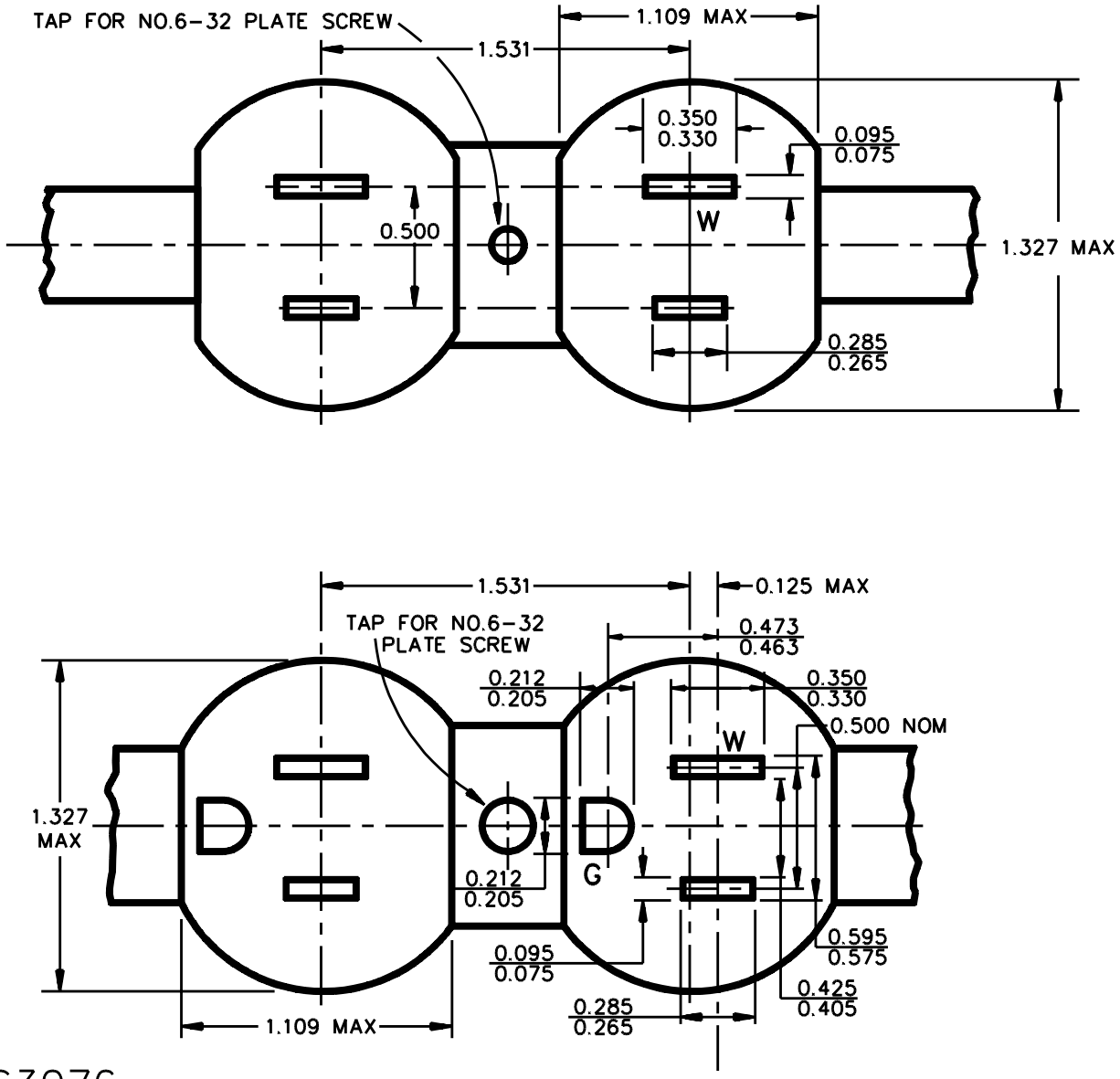



SIDE VIEW

C.G. = Center of Gravity

CP100A

**Figure 6.1.2**
**Parallel duplex receptacle**



6.1.5 Each field wiring terminal lead mentioned in 5.9.4 is to withstand a tensile force increased gradually to 89 N (20 lbf), and maintained at that value for five minutes.

6.1.6 In order to determine that the strain of pulling on the power-supply cord mentioned in 5.10.4 will not be transmitted to the cord terminations, a tensile force is to be applied to the cord and increased gradually to 156N (35lbf). The force is to be maintained at 156 N (35 lbf) for one minute.

6.1.7 The power-supply cord of a portable GFCI having a permanently attached cord mentioned in 5.10.12 shall be subjected to a pull equal to three times the weight of the equipment. The test shall be repeated ten times with the pull being applied each time for 1 s without jerks. The strain relief shall be judged to comply with the Standard if the cord has not been displaced by more than 2.4 mm (0.094 in) and there is no evidence of any strain being imposed on the wiring connections.

6.1.8 In order to determine compliance with the provisions of 5.9.8, a wire-binding screw or nut is to be tightened on a conductor selected in accordance with the provisions of 5.9.1 to a torque of 2.3 N·m (20 lbf-in) without causing displacement of the wire or damage to the terminal assembly or the wire. Except where the configuration of the terminal assembly does not permit it, or markings allow the use of unformed wire, the wire is to be formed into a 3/4 loop that will just be accommodated by the assembly, before tightening.

## 6.2 Polymeric enclosures

6.2.1 General

6.2.1.1 A polymeric enclosure, or a polymeric part of an enclosure of a ground-fault circuit-interrupter shall comply with the Standard for the polymeric enclosure as specified in Annex A, Ref. No. 9, except as noted in 6.2.1.2.

6.2.1.2 For a direct plug-in ground-fault circuit-interrupter, the crushing test shall be conducted in accordance with Annex A, Ref. No. 1.

6.2.1.3 An adhesive used in the assembly of a ground-fault circuit-interrupter shall comply with the applicable requirements for adhesives in accordance with the applicable requirements in Annex A, Ref. No. 10, except as noted in 6.2.1.4.

6.2.1.4 Methods utilizing fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding need not be investigated.

6.2.2 Thermal stability – enclosures made of nonmetallic material

6.2.2.1 Enclosures or parts thereof of nonmetallic material shall comply also with the requirements of the thermal stability test in 6.2.2.2 – 6.2.2.3.

6.2.2.2 A sample of the enclosure shall be subjected to a temperature 10°C higher than that attained by the enclosure under normal operating conditions, but in no case less than 70°C for a period of 7 h.

6.2.2.3 The enclosure shall be judged to comply with the requirements if any distortion of the enclosure neither impairs the operation of the interrupter nor results in failure to comply with requirements for Accessibility of energized parts, Clause 5.7.

**6.3 Enclosure and housing – performance**

6.3.1 Except as specified in 6.3.2, a permanently connected ground-fault circuit-interrupter is to be subjected to an externally applied impact of 6.8 J (5 ft-lbs) applied by way of a solid, smooth, steel sphere 50.8 mm (2 inches) in diameter.

6.3.2 Receptacle-type ground-fault circuit-interrupters are to be subjected to a 0.91-m (3-ft) drop test onto a concrete floor. The method of doing the test shall be in accordance with the provisions of 6.3.5.

6.3.3 The sphere mentioned in 6.3.1 is to be allowed to fall freely from rest through the distance required to cause the specified impact upon the surface under test. For surfaces other than horizontal, the sphere may be suspended by a cord and allowed to fall as a pendulum through the required distance. The ground-fault circuit-interrupter is to be placed against a vertical wall with the surface to be tested in the same vertical plane as the point of support of the pendulum.

6.3.4 The ground-fault circuit-interrupter shall be judged to comply with the requirements if the enclosure still complies with the requirements for Accessibility of live parts, Clause 5.7, there is no damage to prevent the normal use of switches, spacings specified have not been reduced below the minimum specified by Spacings, Clause 5.12, and actuation of the test means or the external application of a fault indicates that the interrupter operates correctly.

6.3.5 A cord-connected or portable device is to be allowed to fall from a height of 0.91 m (3 ft) such that a different part will strike a hardwood surface in each of three drops. Doors or covers are to be moved to any position likely in normal service providing that a captive door or cover is not forced to remain in any position by some means not part of the ground-fault circuit-interrupter.

6.3.6 The hardwood surface mentioned in 6.3.5 is to consist of a layer of nominal 1-inch tongue-and-groove oak flooring mounted on two layers of 19 mm (3/4-inch) plywood. The surface is to be a square 1.2 m (4 ft.) on a side. The assembly is to rest on a concrete floor or the equivalent.

6.3.7 Device compliance shall be verified by the test sequence in Representative devices, Clause 6.4.

6.3.8 A representative device which is capable of being used as a ground-fault circuit-interrupter without being installed in an additional enclosure, shall be tested in accordance with the applicable enclosure requirements in Annex A, Ref. No. 4 and Annex A, Ref. No. 3. See 5.4.2.

## 6.4 Representative devices

6.4.1 A representative ground-fault circuit-interrupter that has been conditioned as described in 6.5.7 and then subjected to the Leakage current test, Clause 6.5, shall at any convenient time and in the following order comply with the requirements for impact as described in 6.3.1 or 6.3.5, Voltage surge, Clause 6.6, High-resistance ground-fault, Clause 6.7, and Dielectric voltage withstand, Clause 6.11.

6.4.2 Separate, unconditioned representative ground-fault circuit-interrupters shall be subjected to each of the tests in Clause 6, except as noted in 6.4.1. For tests and test sequences, see Table 6.4 for typical test program.

**Table 6.4**
**Representative device test program[a]**

| Test | Clause | Representative device number | |
|---|---|---|---|
| | | Portable GFCI | Permanently connected GFCI |
| Humidity | 6.5.7 | 1 | 1 |
| Leakage current | 6.5 | 1 | 1 |
| Ball impact | 6.3.1 | – | 1[d] |
| Drop impact | 6.3.5 | 1 | – |
| Voltage surge | 6.6 | 1 | 1 |
| High resistance ground fault | 6.7 | 1 | 1 |
| Open neutral | 6.7.2.1(c) | 1[b] | – |
| Most adverse | 6.7.3.4 | 1[b] | 1[b] |
| Trip threshold | 6.7 | 1 | 1 |
| Trip times | 6.7 | 1 | 1 |
| Grounded neutral | 6.7.4 | 1 | 1 |
| False tripping | 6.8 | 1[b] | 1[b] |
| Dielectric | 6.11 | 1 | 1 |
| Overload | 6.12 | 2 | 2 |
| Low resistance ground fault | 6.13 | 3 | 3 |
| Endurance | 6.14 | 4 | 4 |
| Dielectric | 6.11 | 4 | 4 |
| Abnormal | 6.15 | c | c |
| Extra low resistance ground fault | 6.18 | 5, 6 | 5, 6 |
| Short circuit | 6.19 | 7 | 7 |
| Dielectric | 6.11 | 5 – 7 | 5 – 7 |
| Normal temperature | 6.10 | 8 | 8 |
| Resistance to environmental noise | 6.9 | 9 | 9 |
| Surge current test | 6.16 | 10 – 12 | 10 – 12 |
| Abnormal overvoltage tests | 6.17 | 13 – 17 | 13 – 17 |
| Corrosion test | 6.21 | 18 | 18 |
| Reverse line-load miswire test | 6.23 | – | 19 |
| Supplemental voltage surge immunity test | 6.24 | 19[b] | 20[b] |
| Operating mechanism test | 6.25 | 20 | 21 |
| GFCI receptacle end of life test | 6.26 | – | 22 |

[a] This table does not include construction requirements or enclosure tests. With the agreement of all concerned, fewer samples may be used, except where tests are required to be performed on a previously untested sample.

[b] Separate representative devices may be used for these tests

[c] As many representative devices as necessary



Table 6.4 Continued on Next Page

**Table 6.4 Continued**

| Test | Clause | Representative device number | |
|---|---|---|---|
| | | Portable GFCI | Permanently connected GFCI |
| [d] Receptacle type ground-fault circuit interrupters are subjected only to the drop impact test per 6.3.2 | | | |

## 6.5 Leakage current test

6.5.1 The leakage current of a ground-fault circuit-interrupter is to be tested in accordance with 6.5.2 – 6.5.7.

a) The leakage current with the test voltage applied between the supply circuit and accessible surfaces shall be no more than 0.5 mA. In the U.S., transient voltage surge suppressor circuits may have higher leakage if they comply with the performance and marking requirements of Annex A, Ref. No. 11.

b) If a portable GFCI has electronic components (e.g. a transient voltage surge suppressor) connected between line and ground, the leakage current shall be measured through these components.

6.5.2 All accessible parts of a ground-fault circuit-interrupter are to be tested for leakage currents. The accessible parts are to be tested individually, collectively, and from one part to another.

6.5.3 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil with an area of 10 cm (3.94 inches) by 20 cm (7.87 inches) in contact with the surface. Where the surface is less than 10 cm (3.94 inches) by 20 cm (7.87 inches), the metal foil is to be the same size as the surface. The metal foil is not to be pressed into openings and is not to remain in place long enough to affect the temperature of the sample.

6.5.4 The measurement circuit for leakage current of a cord-connected device is to be as shown in Figure 6.5.4.1. The measurement instrument is defined in items a – d of this paragraph. The meter that is actually used for a measurement need only indicate the same numerical value for a measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

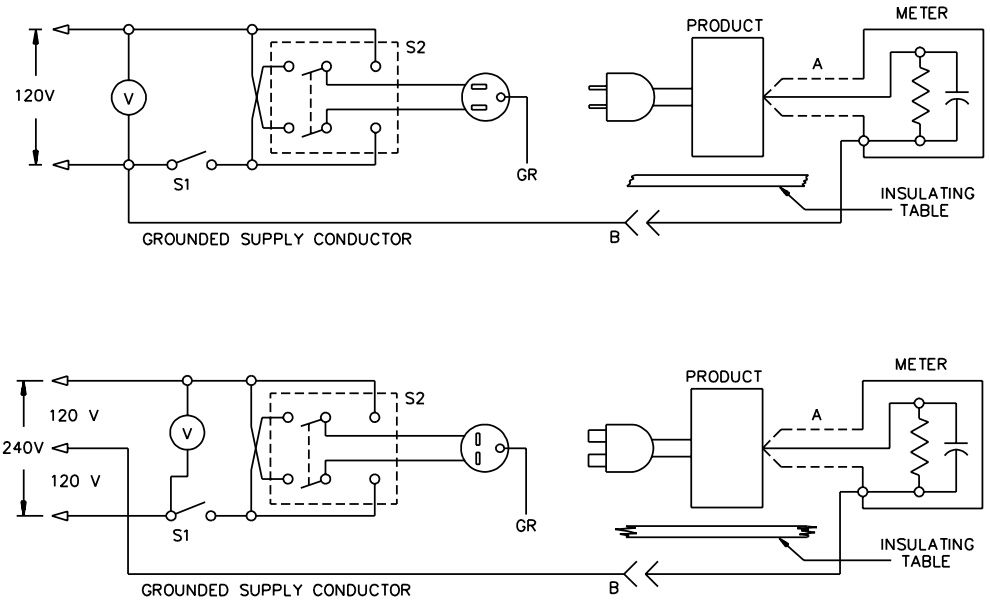
a) The meter is to have an input impedance of 1500 Ohms resistive shunted by a capacitance of 0.15 µF.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistance or current through the resistance.

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is to the ratio of the impedance of a 1500-Ohm resistance, shunted by a 0.15-µF capacitance, to 1500 Ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than five percent at any frequency within the range of 0 – 100 kHz.

d) Unless the meter is being used to measure leakage from one part of the sample to another, the meter is to be connected between the accessible parts and the ground supply conductor.

**Figure 6.5.4.1**
**Leakage-current measurement circuits**




NOTE:
A – Probe with shielded lead.
B – Separated and used as clip when measuring currents from one part of the device to another.

LC201E

6.5.5 A permanently connected ground-fault circuit-interrupter is to be connected to the supply by way of the line terminals of the device, and tested in the same manner as a cord-connected device.

6.5.6 A sample of the ground-fault circuit-interrupter is to be tested for leakage current after the conditioning described in 6.5.7. If removed from the humidity chamber the testing is to start within one minute after its removal. The grounding conductor of a cord-connected unit is to be open at the supply receptacle and the grounding conductor of a permanent connected unit is not to be used. The supply voltage is to be adjusted to 110 percent of the rated voltage. The test sequence, with reference to the measuring circuit in Figure 6.5.4.1, is as follows:

a) With switch S1 open, the sample is to be connected to the measurement circuit. The leakage current is to be measured using both positions of switch S2 and if physically possible with the sample switching devices in all their positions.

b) Switch S1 is then to be closed, energizing the sample, and within a period of five seconds, the leakage current is to be measured using both positions of switch S2 and with the control settings varied throughout the operating range.

c) Leakage current is to be monitored at intervals necessary to determine the maximum leakage current, with additional measurements being taken until such time as thermal equilibrium is attained. Both positions of switch S2 are to be used in determining this measurement.

6.5.7 The conditioning mentioned in 6.5.6 and 6.4.1 is exposure to air at a relative humidity of 93 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). The ground-fault circuit-interrupter is to be exposed to ambient air at a temperature of at least 30°C (86°F) until thermal equilibrium is attained before placed in the test chamber. Devices are kept in the chamber for 168 hours, except as noted in 6.5.8.

6.5.8 Devices restricted for indoor use are kept in the chamber for 48 hours.

## 6.6 Voltage surge test

6.6.1 General

6.6.1.1 The line side terminals of the Line-Neutral and Line-Line terminals that are protected by the representative ground-fault circuit-interrupter shall be subjected to the following surge tests in accordance with the sequence described in Clause 6.4.1: Unwanted tripping test, Clause 6.6.2 and the Surge immunity test, Clause 6.6.3. Previously untested representative ground-fault circuit-interrupters shall be tested as specified in the Surge current test, Clause 6.16, the Abnormal overvoltage test, Clause 6.17, and the Supplemental voltage surge immunity test, Clause 6.24.

6.6.1.2 The ground-fault circuit-interrupter is to be connected to a supply of rated voltage. The grounding lead or terminal of the ground-fault circuit-interrupter (if provided) is to be connected to the supply conductor serving as the neutral. The ground-fault circuit interrupter is to be in the ″on″ condition with no load connected. GFCI's that are intended only for use in enclosures shall be tested in their intended enclosure for the tests referenced in 6.6.1.1. The enclosure shall be representative of the worst case situation for the tests.

6.6.2 Unwanted tripping test (ring wave)

6.6.2.1 One representative ground-fault circuit interrupter shall not trip after being subjected to ten random applications or three controlled applications of a 3 kV surge applied at 60 second intervals. When three controlled applications are employed, one application is to be essentially at zero of the supply voltage wave, one at the positive peak, and one at the negative peak.

6.6.2.2 The surge generator is to have a surge impedance of 50 ohms. When there is no load on the generator, the waveform of the surge is to be essentially as follows:

a) Initial rise time, 0.5 microseconds between 10 percent and 90 percent of peak amplitude,

b) The period of the following oscillatory wave, 10 microseconds, and

c) Each successive peak, 60 percent of the preceding peak.

6.6.2.3 Figures 6.6.1 and 6.6.2 show a typical surge generator and control relay.

6.6.3 Surge immunity test (combination wave)

6.6.3.1 The GFCI subjected to the Unwanted tripping test shall be subjected to the Surge immunity test without demonstrating, either during or after testing:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product,

b) Ignition of the enclosure, or

c) Creation of any opening in the enclosure that results in accessibility of energized parts, when judged in accordance with Accessibility of energized parts, Clause 5.7.

6.6.3.2 The test method is to be conducted in accordance with the testing methods described in IEC 61000-4-5 Electromagnetic Compatibility (EMC) Part 4-5: Testing and Measurements Techniques – Surge Immunity Test.

6.6.3.3 The surges shall be applied at phase angles of 90 and 270 electrical degrees.

6.6.3.4 Only the surge impulse test levels in Table 6.6.3.1 shall be used.

**Table 6.6.3.1**
**Surge impulse test level**

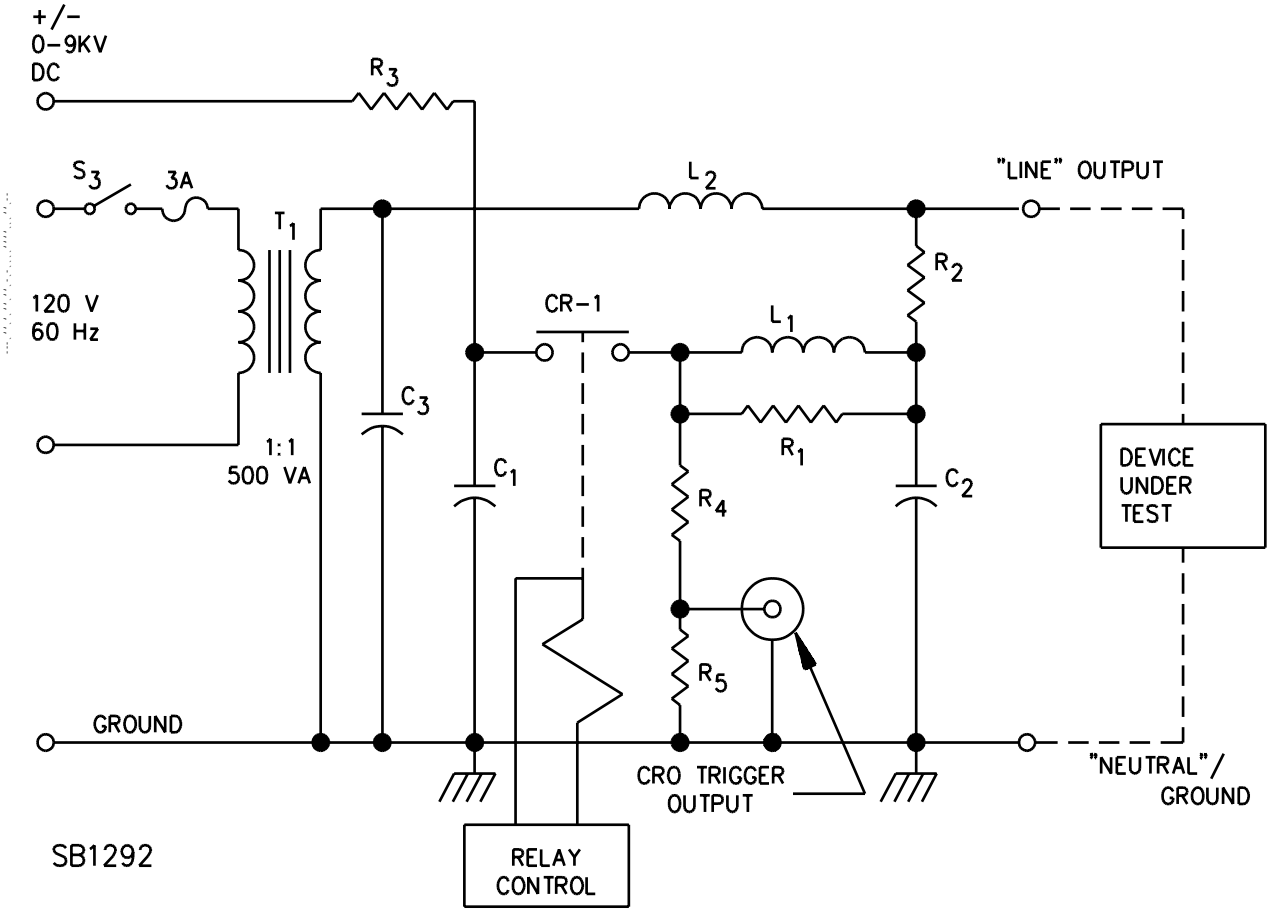
| Impulse[a] | |
|---|---|
| **Peak voltage ($kV_p$)** | **Peak current ($kA_p$)** |
| 4 | 2 |

[a] Combination 1.2/50 µs, 8/20 µs Voltage/Current surge waveform. For specifications and tolerances, refer to IEC 61000-4-5 Electromagnetic Compatibility (EMC) – Part 4-5: Testing and Measurements Techniques – Surge Immunity Test.

6.6.3.5 The GFCI is permitted to trip during surge immunity testing. If the GFCI trips, it is to be reset prior to the next surge application.

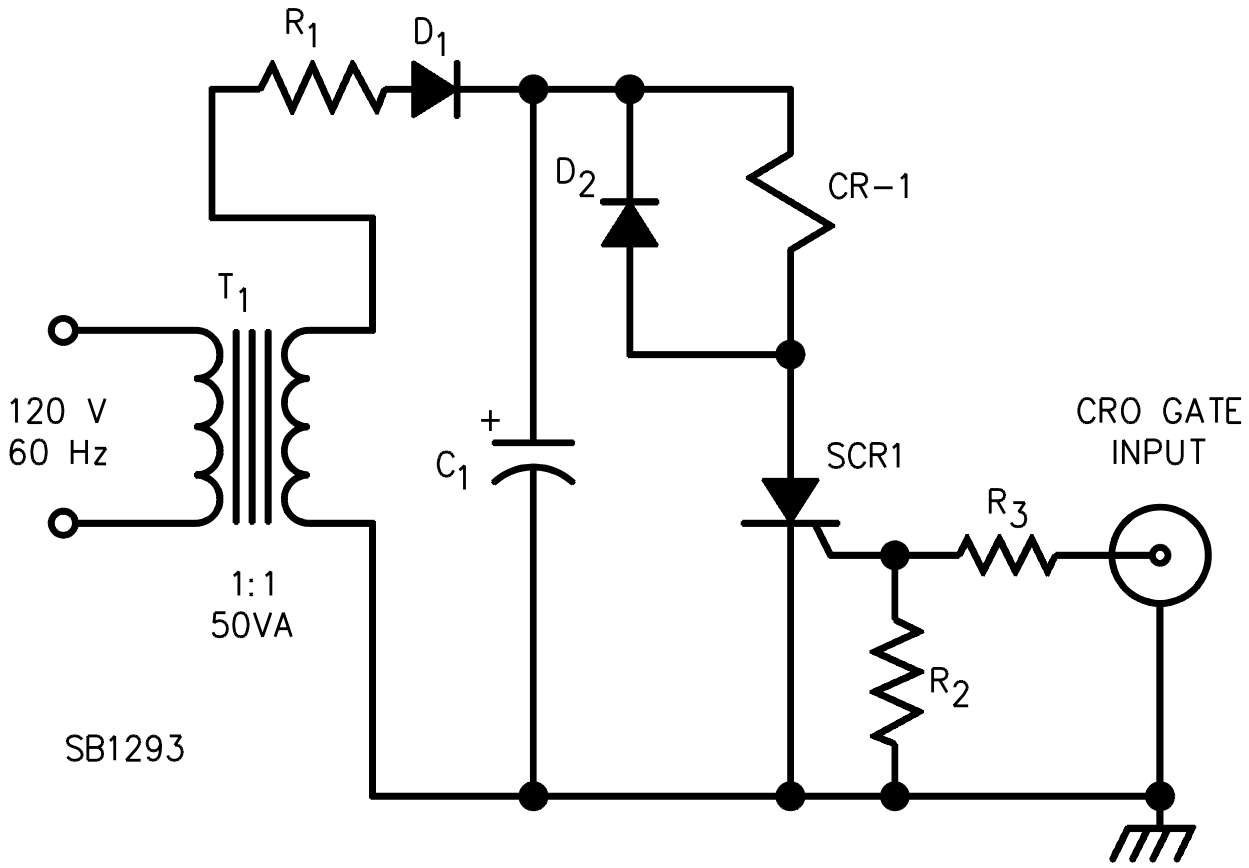
6.6.3.6 After this test the same GFCI shall comply with the High-resistance ground fault and the Dielectric voltage withstand tests.

**Figure 6.6.1**
**Surge generator circuit**




| | | | | | |
|---|---|---|---|---|---|
| C1 | = | 0.025 µf, 10 Kv | R1 | = | 22 Ohmw, 1 W, composition |
| C2 | = | 0.02 µf, 10 Kv | R2 | = | 12 Ohms, 1W, composition |
| C3 | = | 4 µf, 400v | R3 | = | 1.3M Ohms (12 x 110K Ohms, 1/2 W) |
| | | | R4 | = | 47K Ohms (10 x 4.7K Ohms, 1/2 W) |
| L1 | = | 15 µh [23 turns, 0.258 $mm^2$ (23 AWG wire), 18 mm (0.7 inch) diameter air core] | R5 | = | 200 Ohms, 1/2 W |
| L2 | = | 70 µH [28 turns, 0.258 $mm^w$ (23 AWG) wire, 66 MM (2.6 inch) diameter air core] | CR-1 | = | Relay |

**Figure 6.6.2**
**Relay control circuit for surge generator**




| | | |
|---|---|---|
| R1 | = | 10K Ohms, 1 W |
| R2 | = | 1K Ohms, 1/2 W |
| R3 | = | 1K Ohms, 1/2 W |
| C1 | = | 32 µF, 250 V |
| D1 | = | IN5060 or equivalent |
| D2 | = | IN5060 or equivalent |
| SCR1 | = | GE C122B or equivalent |
| CR–1 | = | Relay GE CR 2790 E 100 A2 or equivalent |
| T1 | = | Triad N4S X or equivalent |

## 6.7 High-resistance ground fault

6.7.1 General

6.7.1.1 A Class A ground-fault circuit-interrupter shall be capable of interrupting the electric circuit to the load when the fault current to ground I is within the range of a minimum of 6 mA through a maximum of (110% of rated V/500 ) mA within the time interval T in accordance with the relationship:

$$T = \left(\frac{20}{I}\right)^{1.43}$$

*in which:*

*T is expressed in seconds, and*
*I is expressed in milliamperes.*

6.7.1.2 The time relationship in 6.7.1.1 shall also be met if the grounded conductor becomes grounded at a point in the load circuit of the ground-fault circuit-interrupter.

6.7.1.3 Interruption of the electric circuit to the load shall not take place if the fault current is less than 4 mA, or 3.5 mA if the ambient air temperature is less than -5°C (23°F) or more than 40°C (104°F).

6.7.1.4 The performance of any ground-fault circuit-interrupter shall not be impaired by any of the following:

a) Any mounting positions.

b) Any cover position likely to occur.

c) Any electrical load within the rating of the interrupter.

d) Any ambient temperature between -35°C (-31°F) and 66°C (151°F).

e) Omission of grounding conductor.

6.7.2 GFCI characteristics

6.7.2.1 A portable ground-fault circuit-interrupter shall comply with the provisions of 6.7.1.1 with and without one or more of the following defects in its power-supply cord:

a) The ungrounded and grounded conductors transposed at the attachment plug terminals.

b) An open circuit in the grounding conductor.

c) An open circuit in any one power conductor.

d) Except if normal operation of the supervisory circuit would provide an indication of trouble, the ungrounded and grounding conductors of the power-supply cord transposed at the attachment plug terminals.

e) For devices having more than one ungrounded conductor, an open circuit in any one ungrounded conductor.

6.7.2.2 A permanently connected ground-fault circuit-interrupter shall comply with the provisions of 6.7.1.1 with and without one or more of the following defects in its power-supply:

a) The ungrounded and grounded conductors transposed at the line terminals.

b) An open circuit in the grounding conductor.

c) For devices having more than one ungrounded conductor, an open circuit in any one ungrounded conductor.

6.7.2.3 In order to determine compliance with the provisions of 6.7.1.1 – 6.7.2.2, a ground-fault circuit-interrupter is to be connected as shown in Figure 6.7.2.1 and tested as described in 6.7.3.1, in the sequence of steps described in Table 6.7.2.1.

**Table 6.7.2.1**
**Test sequence for high-resistance ground faults and false tripping**

| Ambient air temperature[a] | | Operating parameters | Remarks |
|---|---|---|---|
| 1. | 25.0 ±5.0°C (77.0 ±9.0°F) | No voltage applied | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 2. | 25.0 ±2.0°C (77.0 ±3.6°F) | Most adverse[e] | Test per 6.7.2.3 and 6.8.2 as soon as possible to minimize self–heating. |
| 3.[b] | 66.0 ±2.0°C (150.8 ±3.6°F) | Rated voltage[f] and current | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 4.[b] | 66.0 ±2.0°C (150.8 ±3.6°F) | Most adverse[e] | Test per 6.7.2.3 and 6.8.2. |
| 5.[c] | 40.0 ±2.0°C (104.0 ±3.6°F) | Rated voltage[f] and current | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 6.[c] | 40.0 ±2.0°C (104.0 ±3.6°F) | Most adverse[e] | Test per 6.7.2.3 and 6.8.2. |



Table 6.7.2.1 Continued on Next Page

## Table 6.7.2.1 Continued

| Ambient air temperature[a] | | Operating parameters | Remarks |
|---|---|---|---|
| 7. | 25.0 ±5.0°C (77.0 ±9.0°F) | No voltage applied | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 8. | -35.0 ±2.0°C (-31 ±3.6°F) | No voltage applied | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 9. | -35.0 ±2.0°C (-31 ±3.6°F) | Most adverse[e] | Tests per 6.7.2.3 and 6.8.2 as soon as possible to minimize self-heating. |
| 10.[d] | -5.0 ±2.0°C (23 ±3.6°F) | No voltage applied | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 11.[d] | -5.0 ±2.0°C (23 ±3.6°F) | Most adverse[e] | Tests per 6.8.2 as soon as possible to minimize self-heating. |
| 12. | 25.0 ±5.0°C (77.0 ±9.0°F) | Rated voltage[f] and current | Establish thermal equilibrium with at least two hours of exposure. Do not test. |
| 13. | 25.0 ±5.0°C (77.0 ±9.0°F) | Most adverse[e] | Test per 6.7.2.3 and 6.8.2. |

[a] The ambient air temperature is to be changed to each value shown without intentional delay.

[b] In the event that a ground-fault circuit-interrupter is self-protecting such that it trips at this ambient temperature, lower values of load current are to be employed, until the device just continues to operate. The thermal protection may be circumvented for the purposes of this test.

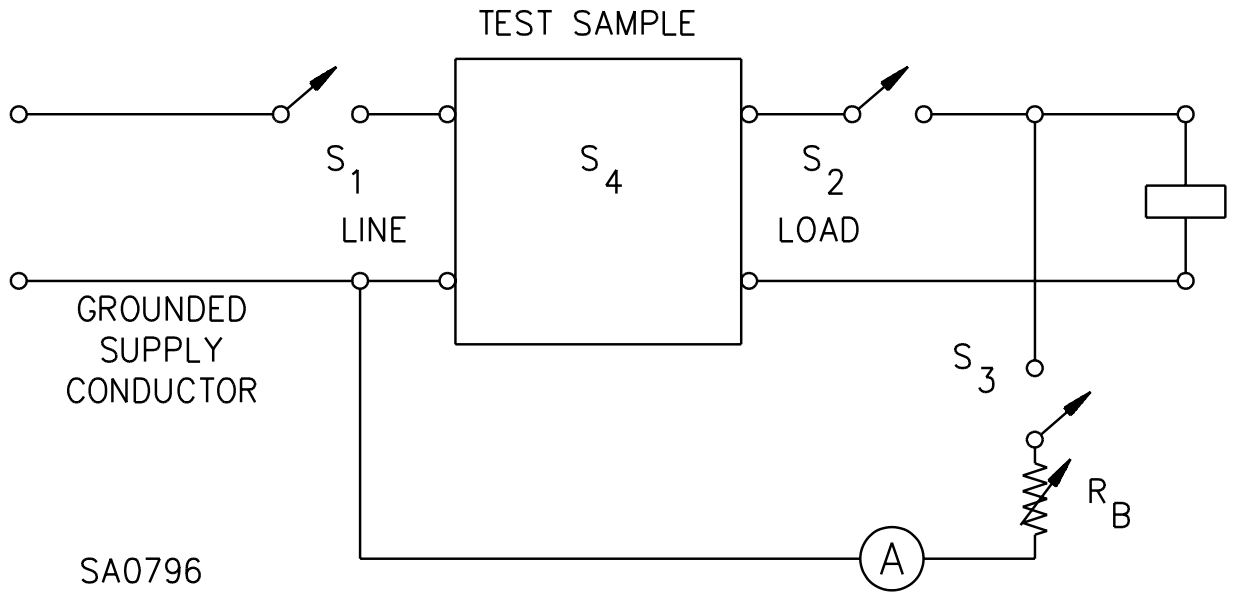
[c] This test is not to be performed if steps 3 and 4 have been performed employing rated current.

[d] This test is not to be performed if product does not trip with less than 4 mA in step 9.

[e] For ″most adverse″ operating parameters, see 6.7.3.3 and 6.7.3.4.

[f] See Table 7.2.1 for rated voltage and corresponding marked values.

**Figure 6.7.2.1**
**High-resistance ground-fault test circuit**




$S_4$ – Integral on-off or other operating switch (not test switch)

6.7.3 High-resistance ground fault test

6.7.3.1 In performing the test mentioned in 6.7.2.3, the resistance $R_B$ is to be varied to obtain the test values of current to be indicated by meter A. The sum of $R_B$ and the resistance of meter A is to be not less than 500 ohms. The test values of current are to include the minimum specified and the maximum possible and one or two additional values as may be considered necessary to assure compliance with the provisions of 6.7.1.1 – 6.7.2.2. Ten measurements of current duration are to be made for each mode of operation described and for each value of test current selected. The average of each group of ten is not to exceed the time allowed. Individual measurements may exceed the time allowed provided that such measurements do not exceed 125 percent of the time allowed. The modes of operation noted in Table 6.7.3.1 are to be performed. For ground-fault circuit-interrupters intended to be used on 120/240 V circuits or 127/220V, the resistance is to be connected between each ungrounded load terminal, in turn, and the grounded conductor of the supply.

**Table 6.7.3.1**
**Modes of operation**

| Precondition of circuit | | Action that starts ground-fault current |
|---|---|---|
| A | Switch $S_1$ closed<br>Switch $S_2$ closed<br>Switch $S_3$ closed<br>Switch $S_4$ open | Switch $S_4$ is to be moved (1) in one continuous motion to its extreme position, and (2) to the position at which the current just starts, and the operating handle held in that position. |
| B | Switch $S_1$ open<br>Switch $S_2$ closed<br>Switch $S_3$ closed<br>Switch $S_4$ closed | Switch $S_1$ closed. |
| C | Switch $S_1$ closed<br>Switch $S_2$ open<br>Switch $S_3$ closed<br>Switch $S_4$ closed | Switch $S_2$ closed. |
| D | Switch $S_1$ closed<br>Switch $S_2$ closed<br>Switch $S_3$ open<br>Switch $S_4$ closed | Switch $S_3$ closed [a] |

[a] In obtaining the minimum value of current specified for the rated class, $R_B$ is to be (1) decreased gradually until tripping occurs, and (2) preset for the desired value.

6.7.3.2 It may be necessary to prevent tripping of the device under test while adjusting for various values of current in resistance $R_B$. Care should then be taken to assure that components that are not continuously energized in normal operation should not be caused to be continuously energized during the adjustment procedure. Attempts to bypass one or more poles of the device will usually produce the condition described.

6.7.3.3 In determining the ″most adverse″ conditions mentioned in Table 6.7.2.1, each of the operating parameters described in items (a) – (d) of this clause is to be varied as described in 6.7.3.4 so as to obtain a combination, if any, considered to be most adverse to the tested function of the ground-fault circuit-interrupter, at room-temperature ambient. The ″most adverse″ condition of an operating parameter is to be learned from operating a representative device. This representative device need not be subjected to any other tests.

a) LINE VOLTAGE – The closed-circuit line voltage is to be adjusted within the range of 85 – 110 percent of rated voltage, at rated load, with the cover(s), if any, of the device closed, and with the device supported in its marked mounting position. If no mounting position is marked on the device, any one position that is considered normal for the device is to be arbitrarily selected. The line voltage to the device is to be obtained from a source having sinusoidal waveform and free from any measurable transient voltage rises or dips.

b) LOAD – The load may have any value of current up to rated and is to be resistive.

c) SUPPLY POLARITY – ″Normal polarity″ is when the representative device is connected as intended. For a 120 volt device the ungrounded supply conductor is connected to the hot terminal, the grounded supply conductor is connected to the white terminal. ″Reverse polarity″ would be when these connections are transposed.

d) MOUNTING POSITION – Except for a permanently connected ground-fault circuit-interrupter marked to specify a mounting position, the device is to be placed in different positions. The mounting position of a permanently connected device that is marked to specify a mounting position is to be varied from the marked mounting position by no more than 10 degrees (for a total range of 20 degrees). Rated load is to be connected and the cover(s), if any, of the device are to be closed.

6.7.3.4 Procedure for determining the ″most adverse″ parameters in a 25°C ambient:

a) Step 1 – Establishing most adverse ″Line Voltage″ – Start with the device in a normal mounting position, no load, normal supply polarity. Make ten readings of trip time for each of the following conditions. Use switch $S_1$ (Table 6.7.3.1 mode B) to turn on the power. Set line voltage at 85% of rated. Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault. Set line voltage at 100% of rated. Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault. Set line voltage at 110% of rated. Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault.

b) Step 1a – Average the trip times for each condition. The ″most adverse″ condition will be the highest average percentage of the allowable trip time (see equation in 6.7.1.1) for the fault that was used.

c) Step 2 – Establishing most adverse ″Load Condition″ – Start with the device in a normal mounting position, most adverse line voltage condition determined from step 1, normal supply polarity. Make ten readings of trip time for each of the following conditions. Use switch $S_1$ (Table 6.7.3.1 mode B) to turn on the power. Connect maximum rated load. Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault. Disconnect load. Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault.

d) Step 2a – Average the trip times for each condition. The ″most adverse″ condition will be the highest average percentage of the allowable trip time for the fault that was used.

e) Step 3 – Establishing most adverse ″Supply Polarity″ – Start with the device in a normal mounting position, most adverse line voltage condition determined from step 1, most adverse load condition from step 2. Make ten readings of trip time for each of the following conditions. Use switch $S_1$ (Table 6.7.3.1 mode B) to turn on the power. Connect with ″Normal supply polarity″ – Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault. Connect with ″Reverse supply polarity″ – Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault.

f) Step 3a – Average the trip times for each condition. The ″most adverse″ condition will be the highest average percentage of the allowable trip time for the fault that was used.

g) Step 4 – Establishing most adverse Mounting Position – Start with the device in a normal mounting position, most adverse line voltage condition determined from step 1, most adverse load condition from step 2, most adverse supply polarity from step 3. Make ten readings of trip time for each of the following conditions. Use switch $S_1$ (Table 6.7.3.1 mode B) to turn on the power. With sample in ″Normal Mounting Position″ No. 1 – Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault. With sample in each possible mounting position No. 2, 3, 4, 5, and 6 as necessary – Test ten times with a 6 mA fault. Test ten times with a 500 ohm fault.

h) Step 4a – Average the trip times for each condition. The ″most adverse″ condition will be the highest average percentage of the allowable trip time for the fault that was used. At this point the most adverse voltage, load, polarity, and mounting position have been determined. Other variables, such as cover position and grounding may also be considered in the same manner.

6.7.4 Grounded neutral test

6.7.4.1 In determining compliance with the provisions of 6.7.1.2, the representative device is to be connected as shown in Figure 6.7.4.1 and tested in the sequence of steps described in Table 6.7.2.1 as described in 6.7.4.3 for the highest and lowest values of $R_N$ and $R_G$ (see Table 6.7.4.1) which are appropriate for the ratings of the representative device. For example, for a representative device rated maximum 20 A, minimum 15 A, 3.307 $mm^2$ (12 AWG) or 2.082 $mm^2$ (14 AWG) wire may be used so the lowest value of $R_N$ and $R_G$ is 0.008 ohms. The highest value of $R_N$ and $R_G$ would be 0.4 and 1.6 ohms. These are the values that would be used for testing. The tests are to be conducted both with $R_L$ open and with $R_L$ adjusted for rated current. The test voltage shall be the most adverse as determined in 6.7.3.3 – 6.7.3.4.

6.7.4.2 When testing as described in 6.7.4.3, additional values of current indicated by meter A and in resistance $R_L$ and other values of resistances $R_N$ and $R_G$ may be employed if necessary to determine compliance with the provisions of 6.7.4.1. Such other values are to be in accordance with the rating of the product and the cable constructions represented in Table 6.7.4.1. Ground fault current values of 6 mA and most adverse voltage divided by 500 ohms are suggested.

6.7.4.3 Grounded neutral trip test procedure (Except as noted in 6.7.4.4):

a) Select the combination of $R_G$ and $R_N$ from Table 6.7.4.1 as required.

b) Open $S_3$ and $S_4$. Close $S_1$ and $S_2$.

c) Using ammeter (A), set the current to 6.0 mA by adjusting $R_B$.

d) With $S_2$ and $S_4$ open and $S_3$ closed, close $S_1$. If the device trips, trip time need not be recorded. If the device does not trip close $S_2$ and record trip time. Repeat 10 times.

e) Repeat step (d) with $S_2$ closed, $S_3$ closed, and close $S_1$ and record trip time.

f) With $S_2$ and $S_4$ open and $S_1$ closed, close $S_3$ and if the device trips, trip time need not be recorded. If the device does not trip close $S_2$ and record trip time. Repeat 10 times.

g) Repeat step (f) with $S_2$ closed, $S_1$ closed, and close $S_3$ and record trip time. Repeat 10 times.

h) Repeat procedure (a) – (f) for the combinations of resistors from Table 6.7.4.1 which apply.

(i) Repeat procedure (a) – (h) with $S_4$ closed (which would switch on the load) and with $R_L$ = to full load current.

6.7.4.4 When testing devices which require that manual setting be activated, the manual setting means will be considered as $S_1$.

**Figure 6.7.4.1**
**Supplementary high-resistance test circuit**

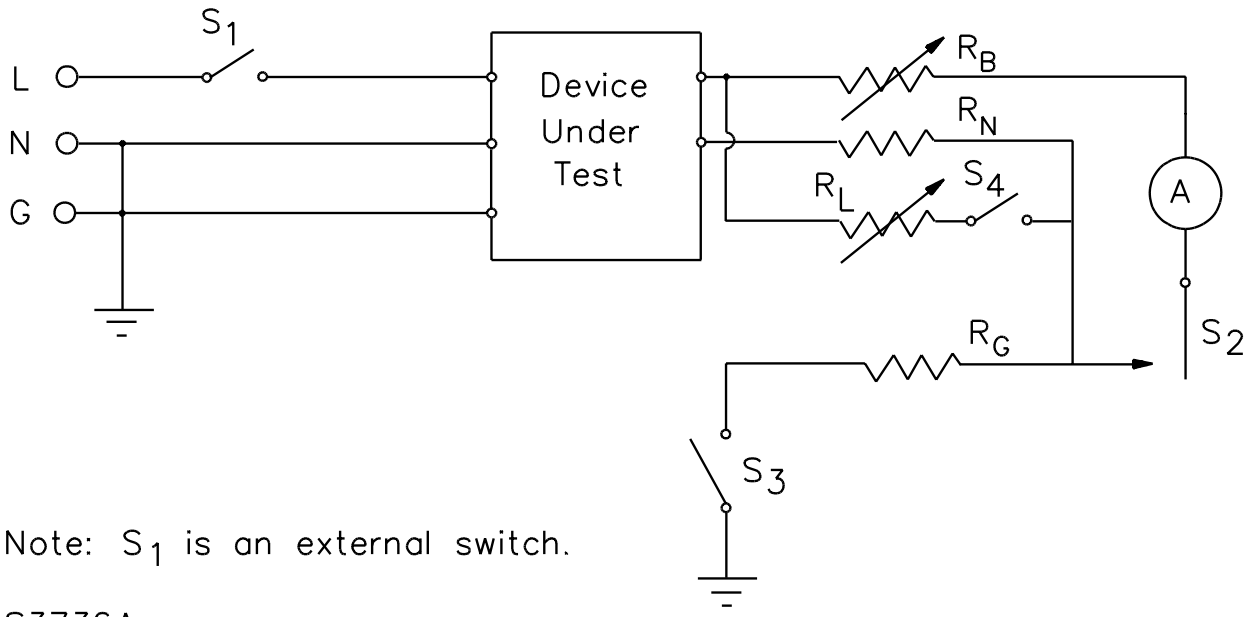



**Table 6.7.4.1**
**Resistance in OHMS[a]**

| Combination | AWG copper wire size of field wiring[b] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2.082 mm² (14 AWG) – 3.307 mm² (12 AWG) | | 5.26 mm² (10 AWG) | | 8.367 mm² (8 AWG) | | 13.30 mm² (6 AWG) | | 21.15 mm² (4 AWG) | |
| | $R_N$ | $R_G$ | $R_N$ | $R_G$ | $R_N$ | $R_G$ | $R_N$ | $R_G$ | $R_N$ | $R_G$ |
| 1 | 0.008 | 0.008 | 0.005 | 0.005 | 0.0032 | 0.0032 | 0.002 | 0.002 | 0.0013 | 0.0013 |
| 2 | 0.08 | 0.20 | 0.05 | 0.13 | 0.0320 | 0.0833 | 0.021 | 0.053 | 0.013 | 0.0337 |
| 3 | 0.4 | 1.0 | 0.25 | 0.65 | 0.1601 | 0.4163 | 0.103 | 0.267 | 0.065 | 0.168 |
| 4 | 0.008 | 0.032 | 0.005 | 0.028 | 0.0032 | 0.0179 | 0.0021 | 0.0115 | 0.0013 | 0.0073 |
| 5 | 0.08 | 0.32 | 0.05 | 0.28 | 0.0320 | 0.179 | 0.021 | 0.115 | 0.013 | 0.073 |
| 6 | 0.4 | 1.6 | 0.25 | 1.4 | 0.1601 | 0.897 | 0.103 | 0.574 | 0.065 | 0.363 |

[a] The combinations shown represent discrete lengths and constructions of cable or flexible cord. Resistances $R_N$ and $R_G$ represent respectively the resistance of the grounded and the grounding conductors of the cable or cord.
[b] See 5.8.1.

### 6.8 Resistance to false tripping test

6.8.1 A ground-fault circuit-interrupter shall have necessary resistance to tripping when connected to load circuits that have:

a) Values of leakage current anticipated in normal service, and

b) Normal transient electrical disturbances such as those caused by switching.

6.8.2 In order to determine compliance with the provisions of 6.8.1, a ground-fault circuit-interrupter is to be connected as shown in Figure 6.8.1 with the impedance Z described in 6.8.3 and tested:

a) As described in 6.8.4, in each of the steps shown in Table 6.7.2.1, and

b) As described in 6.8.5.

Switches $S_1$ and $S_2$ shown in Figure 6.8.1 are to be capable of closing with minimum contact bounce, and opening with minimum clearing time. They may control both conductors if that is more adverse.

6.8.3 Components of impedance Z are to be as indicated in Table 6.8.1.

**Figure 6.8.1**
**False-tripping test circuit**

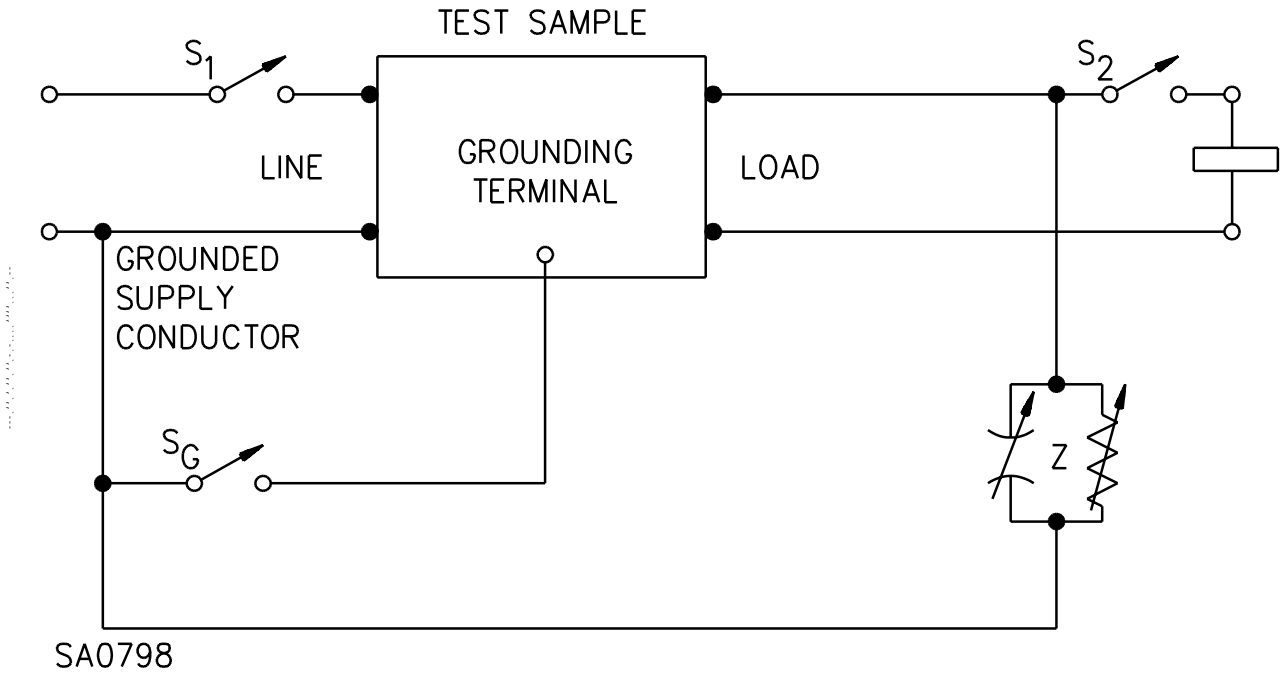


**Table 6.8.1**
**Impedance (Z)**

| Ground-fault circuit-interrupter | Components of Z | |
|---|---|---|
| | Resistance in ohms | Capacitance in microfarads |
| Portable | 80,000 | 0.012 or none |
| Permanent | 64,000 | 0.015 or none |

6.8.4 The tests mentioned in 6.8.2 are as follows:

a) Under the ″most adverse″ conditions described in 6.8.7, the device is not to trip while operating continuously,

b) Under the ″most adverse″ conditions described in 6.8.7, the device is not to trip more than three times in ten operations of each switch $S_1$ and switch $S_2$, and

c) Under the ″most adverse″ conditions described in 6.8.7, a device is not to trip below the fault current mentioned in 6.7.1.3. The impedance Z is gradually reduced until the ground-fault circuit-interrupter trips. The capacitive component of Z is to be disconnected and switches $S_1$ and $S_2$ are to be closed. The procedure is to be conducted three times under each of the ″most adverse″ conditions.

6.8.5 The tests mentioned in 6.8.2 are as follows:

a) Under the ″normal″ conditions described in 6.8.6, the device is not to trip more than three times in 100 operations of each switch $S_1$ and $S_2$, and

b) Under the ″normal″ conditions described in 6.8.6, the device is not to trip more than one time in ten operations of any switch that is an integral part of the device and that controls the electric supply to the load.

6.8.6 Normal conditions are to include rated voltage, ground-lead switch $S_G$ closed, normal mounting position, all doors closed and rated load. The voltage waveform is to be sinusoidal and free from any measurable transient rises or dips.

6.8.7 The ″most adverse″ conditions for this test are different than those determined in 6.7.3.3 – 6.7.3.4. For this test the ″most adverse″ conditions are those that cause the test sample to trip the fastest. The trip times recorded in 6.7.3.4 can be used for this test but for each step, the most adverse condition will be the one with the lowest average percentage of allowable trip time. One additional parameter exists for this test, capacitive leakage for which a value of capacitance may be connected or omitted. See Table 6.8.1.

### 6.9 Immunity to conducted disturbances, induced by RF fields

6.9.1 The GFCI shall operate normally (test and reset) after completion of this test and there shall not be any evidence of a risk of fire or risk of electrical shock. The GFCI shall not trip when subjected to the applied frequency. The test method described in the Standard for Electromagnetic Compatibility (EMC) Part 4: Testing and Measurement Techniques – Clause 6, Immunity to conducted disturbances, induced by radio-frequency fields, IEC 61000-4-6, is to be followed. The representative ground-fault circuit-interrupter is to be subjected to a conducted disturbance at 0.5 V over a frequency range of 150 kHz to 230 MHz.

### 6.10 Normal temperature test

6.10.1 When carrying rated current and with rated voltage applied, a ground-fault circuit-interrupter shall not attain a temperature at any point that is sufficiently high to (1) constitute a fire hazard, (2) affect injuriously any materials used in the device, or (3) exhibit greater rises in temperature at specific points than indicated in Table 6.10.1, based on an assumed average ambient temperature in normal service of 25°C (77°F). A 120/240 V ground-fault circuit-interrupter is to be connected to a 120/240 V supply, or two phases of a 120/208 V supply, adjusted to rated voltage of the supply. A 127/220 V ground-fault circuit-interrupter is to be connected to a 127/220 V supply, adjusted to rated voltage of the supply. Loads are to be connected to the load terminals to cause the load conductors, including the neutral conductor, to carry rated current.

6.10.2 In performing the test described in 6.10.1, parts and circuits that are heated only when there is ground-fault current are to be continuously heated by providing a value of ground-fault current just low enough not to cause tripping.

6.10.3 Coil or winding temperatures are to be measured by thermocouples unless access cannot be gained for mounting a thermocouple (for example, a coil enclosed in sealing compound).

6.10.4 Except at coils, temperature readings are to be obtained by means of thermocouples consisting of wires not larger than 0.2051 $mm^2$ (24 AWG), and a temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change. When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is common practice to employ thermocouples consisting of 0.0507 $mm^2$ (30 AWG) iron and constantan wires and a potentiometer type of indicating instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

6.10.5 Ambient air is to be at any convenient temperature within the range of 20 – 30°C (68 – 86°F).

**Table 6.10.1**
**Maximum acceptable temperature rises**

| Materials and components | | Degrees °C | Degrees °F |
|---|---|---|---|
| 1. | Varnished-cloth insulation | 60 | 108 |
| 2. | Fuses | 65 | 117 |
| 3. | Fiber employed as electrical insulation | 65 | 117 |
| 4. | Wood and other combustible material | 65 | 117 |
| 5. | Surfaces likely to contact the insulation of field wiring | 35 | 63 |
| 6. | A surface upon which a permanently wired unit might be mounted in service and surfaces that might be adjacent to the unit when it is so mounted | 65 | 117 |
| 7. | Class 105 insulation systems on windings of coils: | | |
| | Thermocouple method | 65[a] | 117[a] |
| | Resistance method | 85[a] | 153[a] |
| | Class 130 insulation systems on windings of coils: | | |
| | Thermocouple method | 85 | 153 |
| | Resistance method | 105 | 189 |
| 8. | Molded phenolic composition | 100[b] | 180[b] |
| 9. | Rubber- or thermoplastic-insulated wires and cords | 35[b] | 63[b] |
| 10. | Accessible surfaces | 35 | 63 |
| 11. | Semiconductor junction | c | c |
| 12. | Electrolytic capacitor[d] | 40 | 72 |

[a] See 6.10.3.

[b] The limitations on phenolic composition and on rubber and thermoplastic insulations do not apply to compounds that have been found suitable for higher temperatures.

[c] The temperature $T_J$ at a semiconductor junction is related to the power $P_J$ dissipated at the junction, the thermal resistance $K_{THE}$ from the junction to the cooling medium (generally, the specifications for the semiconductor device will include the thermal resistance), and the temperature $T_M$ of that cooling medium, as shown:

$$T_J = T_M + (K_{THE})\ P_J$$

[d] A capacitor operating at a higher temperature may be accepted on the basis of its marked temperature rating.

## 6.11 Dielectric voltage withstand test

6.11.1 A ground-fault circuit-interrupter shall be capable of withstanding without breakdown the application of 48 – 62 Hz essentially sinusoidal potential as indicated in Table 6.11.1.

**Table 6.11.1**
**Dielectric voltage-withstand**

| Points of application | Potential (volts rms) |
|---|---|
| **For all GFCIs including portable** | |
| Opposite polarity where operating voltage does not exceed 70 V peak | 500 |
| Opposite polarity above 70 V peak (FI) | 1000 + (2 x Rated V) |
| Between line and load circuits with GFCI tripped (FI) | 1000 + (2 x Rated V) |
| Between all live parts and all accessible metal parts including the ground terminal (FI) | 1000 + (2 x Rated V) |
| **For portable GFCIs** | |
| Between line circuits and grounding circuit (SI) | 2500 |
| Between load circuit and grounding circuit (SI) | 2500 |
| Between line circuit and enclosure or foil (RI) | 4000 |
| Between load circuit and enclosure or foil (RI) | 4000 |
| Between grounding circuit and enclosure or foil (FI) | 1000 + (2 x Rated V) |
| (FI) = Functional insulation<br>(SI) = Supplementary insulation<br>(RI) = Reinforced insulation<br>Note: Opposite polarity testing will not be possible if electronic circuits are connected to the points in question. | |

6.11.2 Functional insulation and spacings inherent in a component need not withstand the test potentials mentioned in 6.11.1 if the component in question complies with the requirements applicable to the component.

6.11.3 In order to determine compliance with the provisions of 6.11.1, the insulation and spacings are to be subjected to potentials increased from zero to the values specified and maintained for a period of one minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with the value of the applied potential being correctly indicated by the voltmeter.

6.11.4 Where the construction of the ground-fault circuit-interrupter is such as to deny access to the insulation to be tested, suitable subassemblies may be employed.

6.11.5 In the application of test potentials to insulating surfaces, metal foil may be used providing that care is taken to avoid flashover at the edge of the insulation.

### 6.12 Overload and motor starting test

6.12.1 A ground-fault circuit-interrupter shall have necessary interrupting capacity and shall not trip as a result of motor starting.

6.12.2 In order to determine compliance with the provisions of 6.12.1, a ground-fault circuit-interrupter shall be caused to switch an inductive impedance adjusted for a value of load current equal to six times the ampere rating of the device and a power factor within the range of 0.45 – 0.50.

6.12.3 Reactive components of the impedance mentioned in 6.12.2 may be paralleled with each other if they are of the air-core type. An air-core reactor is to be paralleled with resistance adjusted to dissipate approximately one percent of the total power dissipated in the impedance without such resistance.

6.12.4 The value of paralleled resistance R in ohms mentioned in 6.12.3 may be obtained by calculation from the relationship in which E is the closed-circuit voltage at the load and I is the load current in amperes, without resistance R.

$$R = \frac{163E}{I}$$

6.12.5 The supply circuit for the test mentioned in 6.12.2 is to have the capacity to provide a closed-circuit voltage not less than 85 percent of the rated voltage of the ground-fault circuit-interrupter. The open-circuit voltage is to be in the range of 100 – 105 percent of the rated voltage of the ground-fault circuit-interrupter except when a higher value is agreed upon by those concerned. A 1-A fuse is to be connected between the grounded conductor of the supply circuit and accessible conductive parts of the ground-fault circuit-interrupter. This fuse shall not operate to open the circuit.

6.12.6 In performing the test mentioned in 6.12.2 the device is to be switched ″on″ and, after one second, switched ″off″, except as noted in 6.12.8, at a rate of six cycles per minute for a total of 25 cycles of operation, except as noted in 6.12.7.

6.12.7 If the device operation will not permit these cycle times, times as close as possible to these are to be used.

6.12.8 If it is determined that for a duration less than one second:

a) the device conducts the test current without interrupting the circuit or being adversely affected by heat, and

b) the device contacts are properly seated before the break is initiated as confirmed by oscilloscopic or oscillographic measurements,

the ″on″ time may be reduced to that duration, provided the duration is not less than one-half second.

### 6.13 Low-resistance ground fault test

6.13.1 A ground-fault circuit-interrupter shall operate to interrupt the circuit when a low resistance ground fault is present.

6.13.2 In order to determine compliance with the provisions of 6.13.1 the circuit is to be as described in 6.12.5. The resistance R is to be adjusted for a value of current equal to six times the rating of the ground-fault circuit-interrupter and connected as shown in Figure 6.13.1 so as to simulate a ground fault. The current is to be initiated 25 times, at intervals of 10 seconds, or longer if necessary to reset the device. The 1-A fuse (shown in Figure 6.13.1) connected to accessible conductive parts of the device shall not open. Automatic interruption of the fault current is to occur each time in not more than T seconds as determined in accordance with the equation

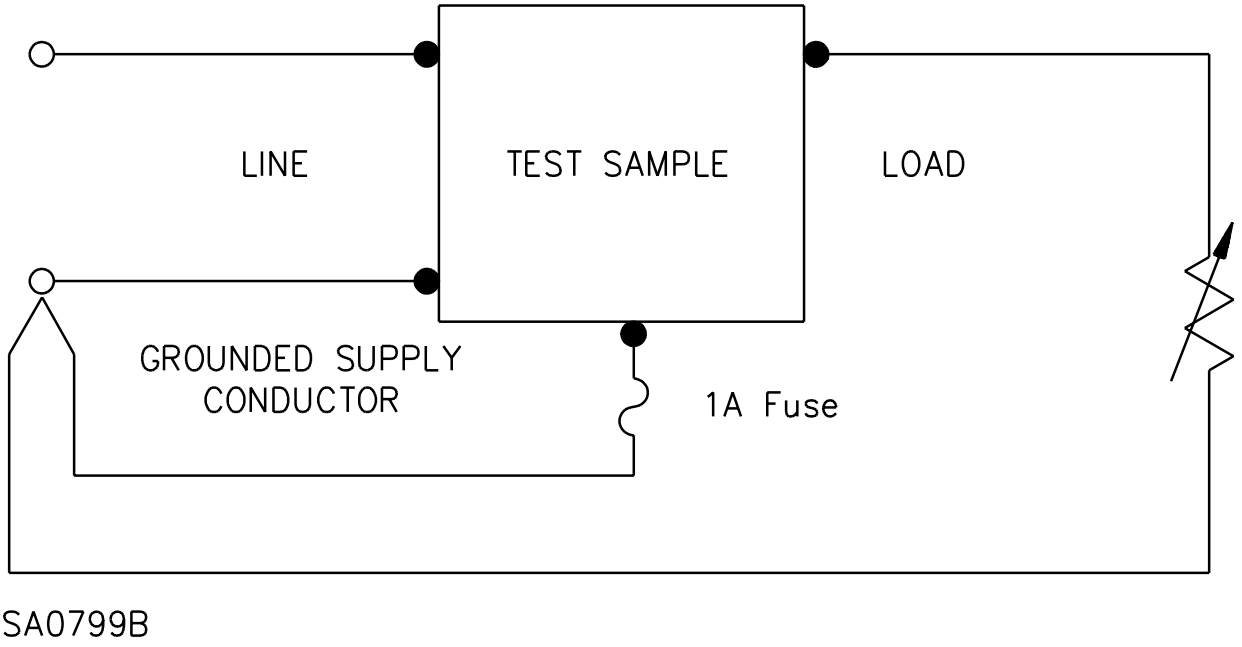
$$T = 1.25\left(\frac{10}{V}\right)^{1.43}$$

and the average value of time for the 25 operations is not to exceed

$$T = \left(\frac{10}{V}\right)^{1.43}$$

The quantity V is the value of closed circuit voltage at the line terminals of the device.

**Figure 6.13.1**
**Low-resistance ground-fault test circuit**




### 6.14 Endurance test

6.14.1 A ground-fault circuit-interrupter shall have the necessary capacity for normal operation.

6.14.2 In order to determine compliance with 6.14.1, a ground-fault circuit-interrupter is to be caused to switch an inductive load adjusted for a value of load current equal to the ampere rating of the device and a power factor within the range of 0.75 – 0.80.

6.14.3 In performing the test described in 6.14.2, the device is to be switched ″on″ and, after one second, switched ″off″ at a rate of approximately 6 cycles of operation per minute for 3000 cycles. This test shall be performed using the supervisory circuit to operate the device. If the GFCI has a manual switching means, it shall be caused to operate an additional 3000 operations.

6.14.4 Reactive components of the load mentioned in 6.14.2 may be paralleled with each other if they are of the air-core type. An air-core reactor is to be paralleled with resistance adjusted to dissipate approximately one percent of the total power dissipated in the load without such resistance.

6.14.5 The value of paralleled resistance R in ohms mentioned in 6.14.4 may be obtained by calculation from the relationship

$$R = \frac{52E}{I}$$

in which E is the closed-circuit voltage at the load and I is the load current in amperes without resistance R.

6.14.6 In performing the test described in 6.14.2, the capacity of the supply circuit is to be such as to allow a closed-circuit voltage not less than 97.5 percent of the rated voltage of the ground-fault circuit-interrupter. Except when a higher value is agreed to by those concerned, the open–circuit voltage is to be in the range of 100 – 105 percent of the rated voltage of the ground-fault circuit-interrupter. A 1-A fuse is to be connected between the grounded conductor of the supply circuit and accessible conductive parts of the ground-fault circuit-interrupter. This fuse shall not operate to open the circuit.

6.14.7 A ground-fault circuit-interrupter shall withstand being tripped by means of the supervisory circuit and reset, at rated voltage without load, 25 times in as rapid succession as practicable.

6.14.8 A representative device that has been subjected to an endurance test shall also be subjected to the dielectric withstand test of 6.11. No other tests are necessary on this representative device.

6.14.9 A ground-fault circuit-interrupter intended to be used as an ″ON″ ″OFF″ control shall be additionally investigated to requirements for miscellaneous motor controllers. The device shall comply with overload, endurance, and dielectric tests in accordance with the applicable requirements of the relevant Standard listed in Annex A, Ref. No. 12. Compliance with these tests is permitted to be indicated with the applicable horse power rating marked on the product and the area near the ″TEST″ and ″RESET″ buttons is permitted to be marked ″OFF″ and ″ON″ respectively.

### 6.15 Abnormal operation test

6.15.1 A ground-fault circuit-interrupter shall not become a shock or fire hazard when operating while in an abnormal condition, such as with a short-circuited or open-circuited component. Each component which has a likelihood of risk of electric shock, risk of fire, or both, shall be tested by imposing a fault on the component which simulates the typical failure mode for the component. Examples of failure modes may include: transistors fail with an emitter to collector short circuit, diodes fail open or short circuit, electrolytic capacitors fail open circuit, or partial short circuit.

6.15.2 A single layer of cheesecloth is to be loosely draped over the ground-fault circuit-interrupter. In addition, a cord-connected device is to rest on white tissue paper supported by a softwood surface. A 1-A fuse is to be connected between the grounded supply conductor and accessible conductive parts of the device.

6.15.3 The cheesecloth mentioned in 6.15.2 is to be bleached cheesecloth running approximately 26 – 28 square meters per kilogram mass (14 – 15 square yards per pound mass), and having for any square centimeter, 13 threads in one direction and 11 in the other direction (what is known in the trade as a ″count of 32 by 28″, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction).

6.15.4 A ground-fault circuit-interrupter operating under abnormal conditions will be considered to have become a hazard if:

a) There is glowing or flaming of the cheesecloth or tissue paper mentioned in 6.15.2, or

b) There is emission of molten metal, or

c) The fuse mentioned in 6.15.2 operates to open the circuit, or

d) Except if the device is likely to be removed from service, there is dielectric failure (see Dielectric voltage withstand test, Clause 6.11), or

e) It is possible to touch a part testing with the articulated probe shown in Figure 6.15.1 while there is a shock hazard at that part (for U.S. and Canada), or (for Mexico, to determine compliance with 6.15.4 item e the articulated probe of Figure 6.15.2 or 6.15.1 shall be used), or

f) There is any other evidence of hazard.

6.15.5 If normal operation of the supervisory circuit after abnormal operation provides an indication of proper functioning of the ground-fault circuit-interrupter, the device shall be capable of complying with the applicable provisions of 6.7.1.1 – 6.7.2.2.

6.15.6 A device that is no longer able to complete the electric circuit to the load will be considered likely to be removed from service.

**Figure 6.15.1**
**Articulated probe**

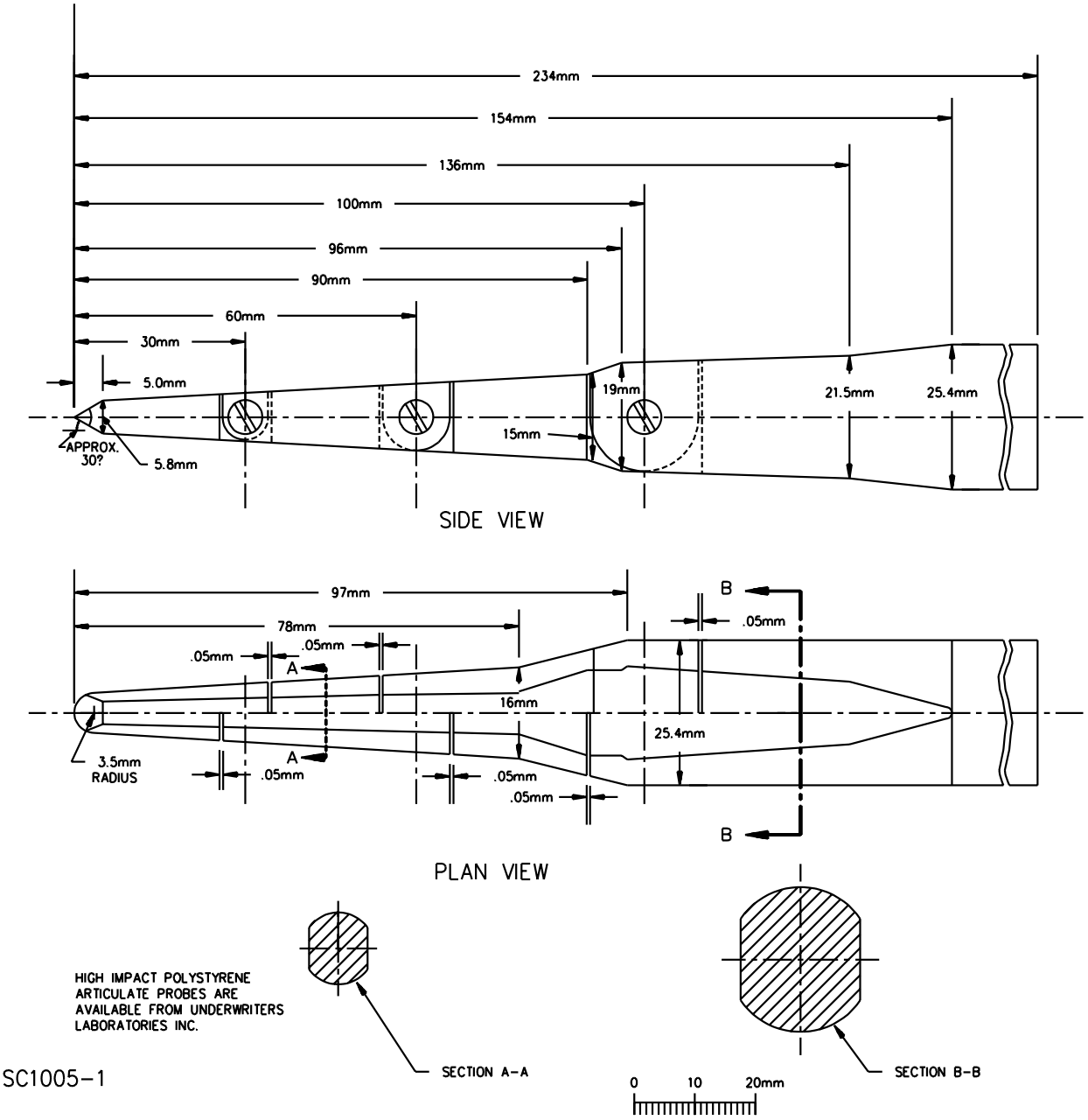
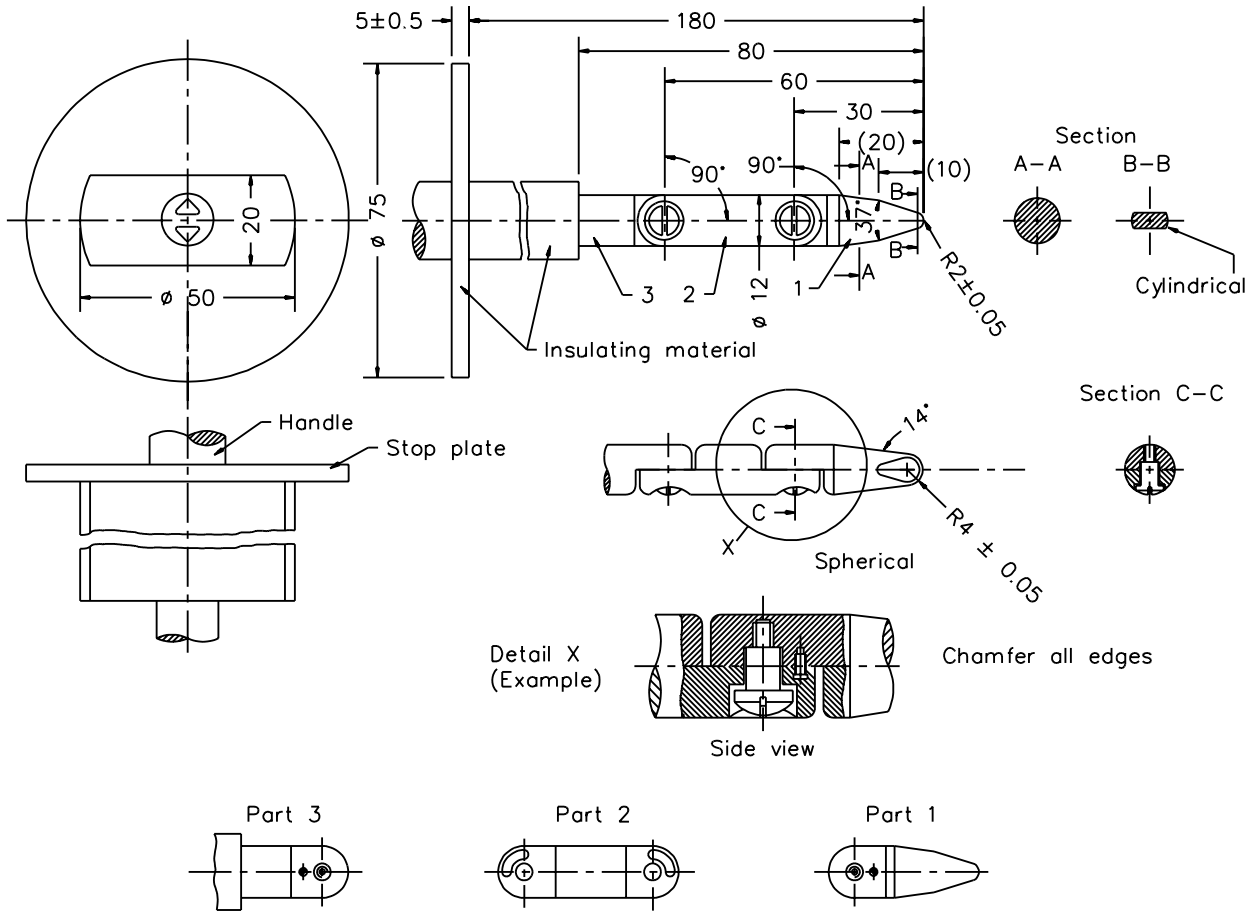


**Figure 6.15.2**
**IEC articulated probe**




SA1788A

Dimensions shown in millimeters

## 6.16 Surge current test

6.16.1 General

6.16.1.1 Each of three previously untested representative devices of the GFCI are to be subjected to the Surge current test in 6.16.2.1 – 6.16.4.1 without demonstrating, either during or after testing:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a rest of the test) in the product.

b) Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth.

c) Ignition of the enclosure.

d) Creation of any openings in the enclosure that results in accessibility of live parts, when judged in accordance with Accessibility of energized parts, Clause 5.7.

6.16.2 Mounting and installation

6.16.2.1 A GFCI shall be placed on a softwood surface covered with a double layer of white tissue paper. Each GFCI is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings (for example, receptacle openings, ventilation openings) where flame, molten metal, or other particles are not prohibited from being expelled as a result of the test. However, the cheesecloth shall not be deliberately pushed into openings. GFCI's that are intended only for use in enclosures shall be tested in their intended enclosure. The enclosure shall be representative of the worst case situation for this test.

6.16.3 Surge parameters

6.16.3.1 A plug-in type ground-fault circuit-interrupter is to be subjected to a surge of 6 kV at 3 kA. A permanently-connected ground-fault circuit-interrupter is to be subjected to a minimum surge of 6 kV at 10 kA. The surge shall be a combination 1.2/50µs, 8/20µs voltage/current surge waveform.

6.16.4 Surge polarity

6.16.4.1 The polarity of the impulses shall be one positive applied at a phase angle of 90 degrees (+0, -15) and one negative applied at a phase angle of 90 degrees (+0, -15).

## 6.17 Abnormal overvoltage tests

6.17.1 General

6.17.1.1 After being tested as described in Full phase voltage-high current abnormal overvoltage test, Clause 6.17.2 and Limited current abnormal overvoltage test, 6.17.3, a ground-fault circuit-interrupter shall not result in any of the following conditions:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a result of the test in the product),

b) Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth,

c) Ignition of the enclosure, and

d) Creation of any openings in the enclosure that results in accessibility of live parts, when judged in accordance with Accessibility of energized parts, Clause 5.7.

6.17.1.2 The representative devices used for each of the tests described in 6.17.2.1 – 6.17.3.2 are to be previously untested.

6.17.1.3 The representative GFCI's shall be placed on a softwood surface covered with a double layer of white tissue paper. The orientation of the representative device shall be such as to create the most severe conditions representative of normal installation. Each representative GFCI is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings (for example, receptacle openings, ventilation openings and any other similar openings) where flame, molten metal, or other particles may be expelled as a result of the test. However, the cheesecloth shall not be deliberately pushed into openings.

6.17.1.4 Cord-connected, direct plug-in, permanently-connected receptacle, and other ground-fault circuit-interrupter types intended for connection to common outlet boxes (such as raceways, multiple outlet assembly types) shall be tested in accordance with Limited current abnormal overvoltage test, Clause 6.17.3 in both normal and reversed polarity.

6.17.1.5 When agreed upon by all concerned parties, fewer representative ground-fault circuit-interrupters than those specified in 6.17.2.1 – 6.17.3.2 shall be used for testing.

6.17.1.6 Following the tests described in Full phase voltage – high current abnormal overvoltage test, Clause 6.17.2 and Limited current abnormal overvoltage test, Clause 6.17.3, the same representative devices are to be subjected to and comply with the Leakage current test, Clause 6.5, for cord-connected and direct plug-in GFCIs, and Grounding, Clause 5.3, for cord-connected, direct plug-in, and permanently-connected receptacle-type GFCIs. The leakage current test shall be conducted within five minutes of the end of the abnormal overvoltage tests.

6.17.1.7 Operation of the ac-power-line circuit breaker, fuse internal or external to the ground-fault circuit-interrupter, or operation of an acceptable overcurrent or overtemperature protective device provided as part of the ground-fault circuit-interrupter is considered acceptable.

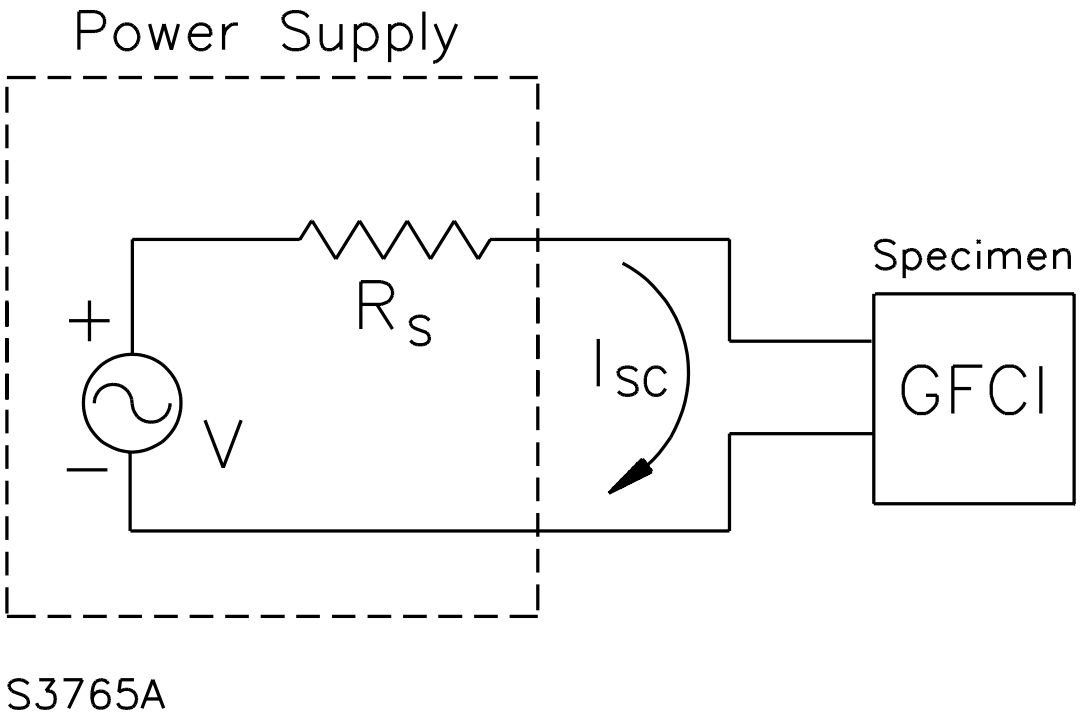
6.17.1.8 Following the tests described Full phase voltage – high current abnormal overvoltage test, Clause 6.17.2 and Limited current abnormal overvoltage test, Clause 6.17.3, the same representative devices are to be subjected to and comply with Grounding, Clause 5.3, for permanently-connected, other than receptacle type, ground-fault circuit-interrupters.

6.17.2 Full phase voltage – high current abnormal overvoltage test

6.17.2.1 Except as noted in 6.17.2.2, after being tested as described in this Clause, a ground-fault circuit-interrupter shall comply with the requirements in 6.17.1.1. One previously untested ground-fault circuit-interrupter, for each combination of conductor pairs that were tested in accordance with the Voltage surge test, Clause 6.6, is to be subjected to the application of the test voltage as specified in Table 6.17.2.2 with a power factor as specified in Table 6.17.2.3. The ac power source shall have an available short-circuit (fault) current (Isc) as specified in Table 6.17.2.2. For each representative device, the overvoltage is to be applied for 7 hours, or until current to, or temperatures within the GFCI attain equilibrium, or until the GFCI becomes disconnected from the ac supply (due, for example, to open circuiting of a thermal or overcurrent protective device). See Figure 6.17.2.1.

6.17.2.2 The testing of 6.17.2.1 is not required for an end-product employing a component or components that have been previously tested and shown not to conduct current nor to exhibit any condition in 6.17.1.6 when subjected to the maximum phase voltage or twice the conductor pair voltage rating as specified in Table 6.17.2.1 for the end-product.

**Figure 6.17.2.1**
**High current abnormal overvoltage**



6.17.2.3 Permanently-connected receptacle and other type GFCIs intended for mounting in boxes shall be tested in the smallest standard metal box in accordance with the National Electrical Code, ANSI/NFPA 70.

**Table 6.17.2.1**
**Test voltage selection table**

| Device rating[a] | Phase | Test voltage (Vac)[a] | Voltage rating of conductor pair to which the test voltage is to be applied |
|---|---|---|---|
| 110 – 120 V | Single | 240 | All |
| 110 – 120V/220 – 240V | Split | 240 | 110 – 120V |
| 120/208V | 3-Wye | 208 | 120V |

[a] For device ratings not specified in this table, the test voltage shall be the maximum phase voltage (if available) or twice the conductor pair voltage rating.

**Table 6.17.2.2**
**Available fault current from source of supply**

| Permanently connected devices | | Cord connected or direct plug-in devices | | |
|---|---|---|---|---|
| Rating A | Available fault current, amperes | Rating volts | Rating, volts times amperes | Available fault current, amperes |
| 100 A or less | 5,000 | 250 ac or less | 1175 or less | 200 |
| 101 – 400 A | 10,000 | | 1176 to 1920 | 1000 |
| Over 400 A | 25,000 | | 1921 to 4080 | 2000 |
| | | | 4081 to 9600 | 3500 |
| | | | More than 9600 | 5000 |
| | | More than 250 ac | 1920 or less | 1000 |
| | | | More than 1920 | 5000 |

**Table 6.17.2.3**
**Power factor**

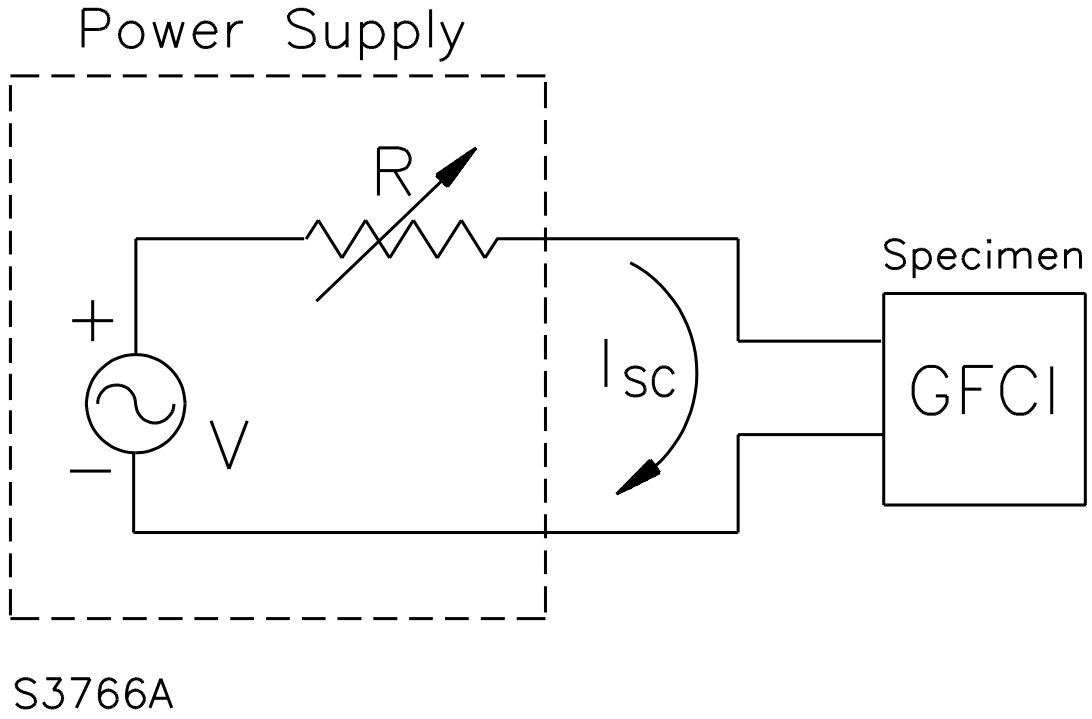
| Available fault current | Power factor |
|---|---|
| 200 A | 0.80 – 1.0 |
| 1000 A | 0.70 – 0.80 |
| 2000 – 10,000 A | 0.40 – 0.50 |
| 10,001 – 20,000 A | 0.25 – 0.30 |
| >20,000 A | 0.20 |

6.17.2.4 Connection of the test circuit in series with a circuit breaker or time delay non-current limiting fuse rated for the maximum ampacity of the circuit in which the GFCI is to be installed, as specified in the National Electrical Installation Code for the country in which the product is to be used, is permitted.

6.17.3 Limited current abnormal overvoltage test

6.17.3.1 Except as noted in 6.17.3.2, after being tested as described in this Clause, a ground-fault circuit-interrupter shall comply with the requirements in 6.17.1.1. Each of four previously untested representative GFCIs for each combination of conductor pairs is to be connected to an ac power supply having an open circuit voltage equal to the test voltage specified in Table 6.17.2.1. The power supply is to incorporate a series variable resistor that can be adjusted to obtain the short-circuit current (Isc) specified below. See Figure 6.17.3.1. No load is to be connected. Except as noted in 6.17.3.3, the variable resistor is to be adjusted such that Isc equals 5 A for the first representative device, 2.5 A for the second, 0.5 A for the third, and 0.125 A for the fourth. The four representative devices are to be energized for 7 hours, or until current to, or temperatures within the GFCI attain equilibrium, or until the GFCI becomes disconnected from the ac supply (due, for example, to open circuiting of a thermal or overcurrent protective device). See Figure 6.17.3.1.

**Figure 6.17.3.1**
**Limited current abnormal overvoltage test circuit**




6.17.3.2 This test is not required for an end-product employing a component or components that have been previously tested and shown not to conduct current nor to exhibit any condition in 6.17.1.6 when subjected to the maximum phase voltage or twice the conductor pair voltage rating as specified in Table 6.17.2.1 for the end-product.

6.17.3.3 When this test is performed at a current level specified above and results in neither:

a) Any condition specified in 6.17.1.6; nor

b) Operation of any overcurrent or thermal device

then the test results are also representative of testing of the device at lower current levels.

6.17.3.4 Permanently-connected receptacle and other type GFCIs intended for mounting in boxes are to be mounted in the smallest standard non-metallic box with faceplate in accordance with the National Electrical Installation Code for the country in which the product is to be used.

**6.18 Extra-low-resistance ground faults test**

6.18.1 A ground-fault circuit-interrupter shall withstand extra-low-resistance ground faults followed by the dielectric withstand test of Clause 6.11.1.

6.18.2 In order to determine compliance with the provisions of 6.18.1, the supply circuit is to have an open-circuit voltage in the range of 100 – 105 percent of the rating of the ground-fault circuit-interrupter. The impedance of the supply is to be such as to provide a prospective current (the current that would result from short-circuiting the supply terminals) shown in 6.18.3, 6.18.4 or 6.18.5.

6.18.3 Except as described in 6.18.4, in testing a permanently connected ground-fault circuit-interrupter, the prospective current is to be 5000 A and the power factor is to be within the range of 0.45 – 0.50.

6.18.4 In testing a receptacle type ground-fault circuit-interrupter, the prospective current is to be 2000 A and the power factor is to be within the range of 0.90 – 1.0.

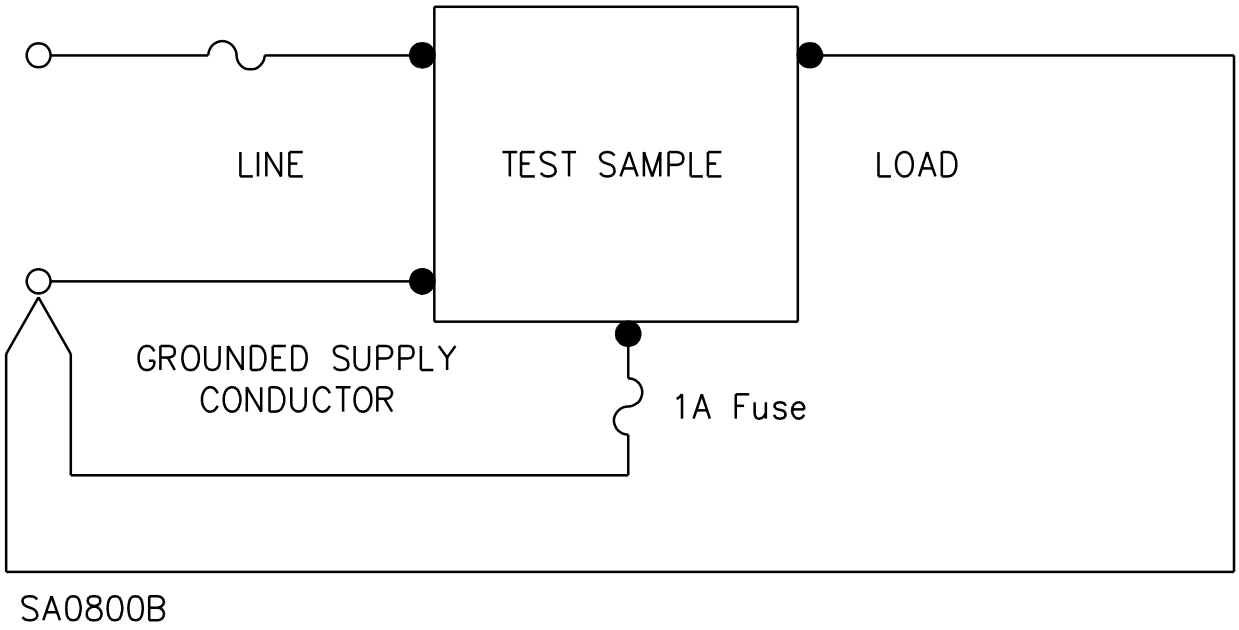
6.18.5 In testing a portable ground-fault circuit-interrupter, the prospective current is to be 2000 A and the power factor is to be within the range of 0.9 – 1.0.

6.18.6 Each line terminal of a ground-fault circuit-interrupter is to be connected to the supply mentioned in 6.18.2 using 1.2 m (4 ft) of insulated wire, both selected in accordance with Table 6.18.1. A fuse is to be connected in series with the ungrounded line conductor. An identical conductor is to be connected between a load terminal and a line terminal of the device so as to represent a ground fault. The device is to be in any position considered to be normal in service. A 1-A fuse is to be connected between the supply terminal representing the grounded circuit conductor and accessible conductive parts of the ground-fault circuit-interrupter. Surgical cotton is to cover openings of the ground-fault circuit-interrupter where flame may be emitted. See Figure 6.18.1.

**Table 6.18.1**
**Fuse and wire**

| Ground-fault circuit-interrupter rating, amperes | | Series fuse amperes | ($mm^2$) AWG conductor size |
|---|---|---|---|
| Cord-connected | Permanently connected | | |
| – | 15 | 15 | (2.082) 14 |
| 15 or 20 | 20 | 20 | (3.307) 12 |
| 30 | 30 | 30 | (5.26) 10 |

**Figure 6.18.1**
**Extra-low-resistance ground-fault test circuit**




6.18.7 For a portable ground-fault circuit-interrupter, conductors are to be attached to the attachment plug blades of the device and to a terminal of a receptacle of the device so as not to be dislodged during the test.

6.18.8 The prospective current is to be initiated once by means of a switch in the supply circuit, and once by means of any control of the ground-fault circuit-interrupter, providing that a single sample need not experience more than one current initiation. The 1-A fuse shall not operate to open the circuit, and there shall be no flaming of the cotton, both mentioned in 6.18.6.

### 6.19 Short circuit test

6.19.1 A ground-fault circuit-interrupter shall withstand short circuits followed by the dielectric withstand test of Clause 6.11.1.

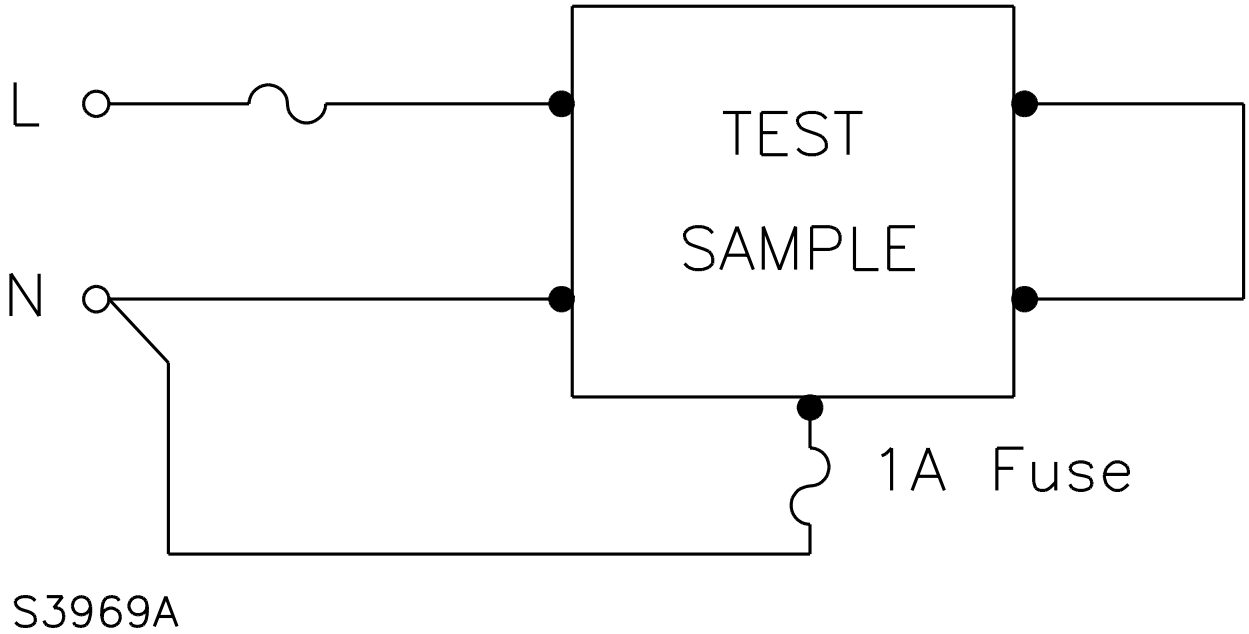
6.19.2 In order to determine compliance with the provisions of 6.19.1, conditions are to be as described in 6.18.2 – 6.18.6, except that:

a) The ground fault described in 6.18.6 is not to be connected, and

b) A 0.51 m (20 inch) length of wire of the same construction as the line conductors is to be connected between load terminals. See Short-circuit test diagram, Figure 6.19.1.

6.19.3 The test current is to be initiated by means of a switch in the supply circuit. The 1-A fuse shall not operate to open the circuit and there shall be no flaming of the cotton, both mentioned in 6.18.6.

**Figure 6.19.1**
**Short-circuit test diagram**




### 6.20 Dust test

6.20.1 To determine compliance with footnote b in Tables 5.12.2.1 and 5.12.2.2, six samples, each mounted in a different mounting orientation, are to be placed, deenergized, in an air-tight chamber having an internal volume of at least 0.09 $m^3$ (3 cubic feet).

6.20.2 A 0.06 kg (two oz) quantity of cement dust, maintained at a relative humidity of 20 – 50 percent and capable of passing through a 200 mesh screen, is to be circulated for 15 minutes by means of compressed air or a blower so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of approximately 0.25 m/s (50 fpm).

6.20.3 Following the exposure to dust, the sample exterior shall be carefully cleaned. The sample is then to be opened and examined for the presence of dust. If there is no evidence of dust within the interior, the sample can be considered ″closed-in″ for spacing purposes. See Tables 5.12.2.1 and 5.12.2.2.

6.20.4 As an alternative to the dust test procedure (cement dust) in 6.20.1 – 6.20.3, a ground-fault circuit-interrupter may be subjected to the dust test (talcum) for first characteristic numeral 5 as specified in Table VII Annex A, reference item No. 14.

**6.21 Corrosion test**

6.21.1 A ground-fault circuit-interrupter shall operate as intended after being subjected to the corrosive atmosphere test described in 6.21.2 – 6.21.3. The representative ground-fault circuit-interrupter is to be tested for trip threshold prior to exposure to the corrosive atmosphere.

6.21.2 One representative GFCI is to be placed in a 200 liter or larger test chamber on a platform approximately 50.8 mm (2 inches) above the bottom of the chamber. The temperature in the chamber is to be maintained at 30 ±2°C (86 ±3°F) and the relative humidity at 70 ±2 percent (measured directly in the chamber). The temperature and humidity are to be checked daily. Because of the corrosive atmosphere a set of wet and dry bulb thermometers shall be used for measurement of relative humidity.

6.21.3 The following gas mixture in air is to be supplied to the chamber at a rate sufficient to achieve an air exchange in the chamber of about five times per hour, for a period of 3 weeks: 100 ±10 parts per billion (ppb) (parts per billion = parts per $10^9$ by volume) hydrogen sulfide ($H_2S$) plus 20 ±5 ppb chlorine ($Cl_2$) plus 200 ±50 ppb nitrogen dioxide ($NO_2$). The air inside the chamber is to be circulated by a single fan, with flow upwards from the bottom. See 6.21.4.

6.21.4 Trip threshold measurements following the exposure to the corrosive atmosphere shall not cause false tripping and shall comply with the trip threshold requirements of this Standard. The trip threshold levels are to be measured in accordance with High-resistance ground fault test, Clause 6.7 and Resistance to false tripping test, Clause 6.8, giving consideration to the most adverse conditions described in 6.7.2.3. The measurements are to be performed at room temperature.

### 6.22 Visual inspection test

6.22.1 To determine compliance with internal wiring construction requirements in Clause 5, representative ground-fault circuit-interrupters shall be examined. This may require disassembly of the ground-fault circuit-interrupter or obtaining representative subassemblies from the manufacturer.

### 6.23 Reverse line-load miswire test

6.23.1 A previously untested receptacle type ground-fault circuit-interrupter shall interrupt the electric circuit to the receptacle face and line terminals when a supply circuit is wired to the load terminals of the device.

6.23.2 Under the conditions described in 6.23.3 and 6.23.4 the ground-fault circuit-interrupter shall interrupt the electric circuit to the receptacle face and line terminals or not permit power to be applied to the receptacle face and line terminals when the power is first applied to the load terminals, and each time the reset is operated.

6.23.3 For this test, the supply line voltage is to be set at 85 percent of the rated voltage. The ground-fault circuit-interrupter is to be switched on unless it is shipped from the manufacturer in the tripped condition and cannot be reset until properly installed. If shipped in the tripped condition, to verify the ground-fault circuit-interrupter cannot be reset until properly installed, attempt to engage reset by first pressing the reset button and then by pressing the test and reset buttons simultaneously. This is to be performed before and after load terminals are connected to supply voltage. Power is to be applied to the load terminals, and the reset shall be operated ten times in rapid succession.

6.23.4 The test described in 6.23.2 is to be repeated on the same device, with the supply line voltage set at 110 percent of the rated voltage.

### 6.24 Supplemental voltage surge immunity test

6.24.1 General

6.24.1.1 The line side terminals of the Line-Neutral and Line-Line terminals that are protected by the representative ground-fault circuit-interrupter shall be subjected to this test.

6.24.1.2 The ground-fault circuit-interrupter is to be connected to a supply of rated voltage. The grounding lead or terminal of the ground-fault circuit-interrupter (if provided) is to be connected to the supply conductor serving as the neutral. The ground-fault circuit-interrupter is to be in the ″ON″ condition with no load connected. GFCIs that are intended only for use in enclosures shall be tested in their intended enclosure for the tests referenced in 6.24.1.1. The enclosure shall be representative of the worst case situation for the tests.

6.24.2 Surge immunity test (combination wave)

6.24.2.1 The GFCI shall be subjected to the Surge immunity test without demonstrating, either during or after testing:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product,

b) Ignition of the enclosure, or

c) Creation of any opening in the enclosure that results in accessibility of energized parts, when judged in accordance with Accessibility of energized parts, Clause 5.7.

6.24.2.2 The test method is to be conducted in accordance with the testing methods described in IEC 61000-4-5 Electromagnetic Compatibility (EMC) Part 4-5: Testing and Measurements Techniques – Surge Immunity Test.

6.24.2.3 The surges shall be superimposed on the ac power with the GFCI energized and applied at phase angles of 90 and 270 electrical degrees.

6.24.2.4 Only the surge impulse test levels in Table 6.24.2.1 shall be used. Using a separate representative GFCI for each surge impulse test level meets the intent of the requirement.

**Table 6.24.2.1**
**Surge impulse test level impulse[a]**

| Peak voltage (kV p) | Peak current (kA p) |
|---|---|
| 2 | 1 |
| 6 | 3 |

[a] Combination 1.2/50 s, 8/20 s Voltage/Current surge waveform. For specifications and tolerances, refer to IEC 61000-4-5 Electromagnetic Compatibility (EMC) – Part 4-5: Testing and Measurements Techniques – Surge Immunity Test.

6.24.2.5 The GFCI is permitted to trip during surge immunity testing. If the GFCI trips, it is to be reset prior to the next surge application.

6.24.2.6 After the 2 kV test the same GFCI shall be in condition to comply with the High-resistance ground fault and the Dielectric voltage withstand tests.

6.24.2.7 After the 6 kV test, the same GFCI shall comply with either a or b:

a) The GFCI shall be in condition to comply with the High-resistance ground fault test, Clause 6.7, and the Dielectric voltage-withstand test, Clause 6.11, or

b) The GFCI shall trip as a result of the surge test and render itself incapable of delivering power after attempting reset. Reset shall be attempted 5 times as fast as possible with rated voltage applied.

### 6.25 Operating mechanism test

6.25.1 Unless the electronics are connected to the line side of the contacts it will be necessary to verify compliance with 5.14.1 by testing the ground-fault circuit-interrupter as follows:

a) The ground-fault circuit-interrupter is to be connected as shown in Figure 6.7.2.1,

b) The resistance $R_B$ is to be adjusted to obtain a ground fault current of 6 mA,

c) Switches $S_1$, $S_2$, are closed, and switch $S_3$ is open,

d) The 6 mA current is passed by closing switch $S_3$ the GFCI having been closed and the operating means being held in the closed position. The GFCI shall trip.

6.25.2 The test in 6.25.1 is then repeated by moving the operating means of the GFCI slowly over a period of approximately 1 second to a position where the current starts to flow. Tripping shall occur without further movement of the operating means.

6.25.3 Both the test in 6.25.1 and 6.25.2 are to be performed three times, at least once on each pole intended to be connected to a phase.

### 6.26 GFCI receptacle end of life test

6.26.1 A ground-fault circuit-interrupter receptacle that has reached its end of life shall meet the requirements of 5.15.5.

6.26.2 GFCI receptacle end of life simulation – In order to determine compliance with the provisions of 6.26.1, one representative GFCI is to be subjected to an end of life simulation.

6.26.3 One representative GFCI shall be altered with a single modification to the GFCI circuitry in the form of a short circuit or open circuit such that the GFCI is incapable of responding in the normal manner to a line to ground, ground-fault. The representative GFCI shall then be evaluated in accordance with 6.26.5.

6.26.4 If the GFCI is designed to repeatedly trip at end of life, the following end of life simulation may be used as an alternative to 6.26.3. One representative GFCI shall be altered with a single modification to the GFCI that results in the trip solenoid being in an energized state. The single modification can be a short circuit connected across an appropriate electrical component, or an appropriate electrical component is to be open circuited. The representative GFCI shall then be evaluated in accordance with 6.26.5.

6.26.5 The representative GFCI, having been subjected to an end of life simulation, is to be correctly connected to rated line voltage and allowed to stabilize. The internal test function is to be performed, after which the reset button is to be operated. Each representative GFCI shall be considered as meeting the requirements of Clause 6.26 if one of the following conditions is met:

a) The GFCI visually or audibly indicates if it does not interrupt the electric circuit to the receptacle face and load terminals.

b) The GFCI interrupts the electric circuit to the receptacle face and load terminals or does not permit power to be applied to the receptacle face or load terminals, each time the reset is operated.

## 7 Markings

### 7.1 Permanence of marking

7.1.1 A label as mentioned in 8.1.4 and 8.2.2 shall comply with the requirements specified in Annex A, Ref. No. 13.

7.1.2 Labels required by 8.2.2 that come in contact with uninsulated live parts shall be of a nonconductive material that complies with requirements for polyvinyl chloride, polyethylene, and rubber insulating tape in Annex A, Ref. No. 5.

7.1.3 For the purpose of these requirements, a water transfer or the equivalent located in a depression at least 0.8 mm (0.031 inch) deep may be considered as permanent subject to investigation.

### 7.2 Marking

*Advisory Note: For products intended for use in Canada, markings shall be at least in English and caution and warning markings shall be at least in French and English. For products intended for use in Mexico, all markings shall be at least in Spanish. For products intended for use in the United States, all markings shall be at least in English. See Annex B and Annex C for suitable translations.*

7.2.1 All interrupters shall be plainly marked in a permanent manner with at least the following:

a) Manufacturer's name, trademark, tradename, or other recognized symbol of identification;

b) Amperes or other necessary indication of current-carrying capacity, the load-capacity marking of a cord connected ground-fault circuit-interrupter shall include watts;

c) Except as noted in 7.2.1(d), voltage and frequency shall be marked as follows: rated voltage followed by V ~ 60Hz. Alternative markings are rated voltage followed by ~ 60 Hz, by V 60Hz, or by VAC, 60 Hz. See 7.2.7.

d) In Mexico, acceptable markings are rated voltage followed by V ~ 60Hz, V 60 Hz, or Vc.a. 60 Hz.

e) For Canada, the catalogue number or type must appear on the product or the smallest unit of packaging.

7.2.2 All terminals to which line, load or grounding conductors are intended to be connected shall be clearly identified.

7.2.3 A ground-fault circuit-interrupter shall be legibly and permanently marked with the date or other dating period of manufacture not exceeding any three consecutive months. The date of manufacture may be abbreviated, or may be in a conventional code, or in a code affirmed by the manufacturer, provided that the code does not repeat in less than 20 years, and does not require reference to the production records of the manufacturer to determine when the product was manufactured.

7.2.4 If the enclosure has been suitably evaluated for environmental Types 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 12K, or 13, it shall be marked in accordance with the requirements for enclosures, Annex A, Ref. No. 4.

7.2.5 Class A interrupters shall be marked in a permanent manner where the marking will be readily visible after installation (e.g., with a cover plate removed) with the following wording or a suitable equivalent: ″GROUND FAULT CIRCUIT INTERRUPTER CLASS A″. Note: Except as noted in 7.2.6, an abbreviation of this marking such as ″GFCI CL A″, ″Class A″, ″CL A″, or ″GFCI A″ is considered to be a suitable equivalent in those cases where the areas available for marking make the complete text impracticable.

7.2.6 The abbreviation ″ICFT″ is considered a suitable equivalent marking for a GFCI intended for use in Mexico only.

7.2.7 A ground-fault circuit-interrupter shall be legibly and permanently marked with the voltage as indicated in Table 7.2.1 below.

**Table 7.2.1**
**Rated voltage and corresponding marked voltage(s)**

| Rated Voltage | Marked Voltage(s) |
|---|---|
| 120 V | 120 V |
| 127 V | 127 V |
| 120-127 V | 120, 127 V |
| 120/240 V | 120/240 V |
| 208 Y/120 V | 208 Y/120 V |
| 220 Y/120-127 V | 220 Y/120-127 V |
| 208 Y/120, 220 Y/127 V | 208 Y/120, 220 Y/127 V |

### 7.3 Permanently connected ground-fault circuit-interrupters

7.3.1 Except as noted in 7.3.2, a ground-fault circuit-interrupter employing terminal leads shall be marked with the gauge of the leads on the device.

7.3.2 A GFCI with suitable wire connectors need not comply with the requirement in 7.3.1.

7.3.3 Unless a permanently connected ground-fault circuit-interrupter has been found suitable for use where it may be exposed to rain, it shall be marked where visible during installation in letters 3.2 mm (1/8 inch) high with the words: ″Do not use where exposed to rain″, or the equivalent, except as noted in 7.3.4.

7.3.4 The marking specified in 7.3.3 is not required on a receptacle type GFCI provided with installation instructions specified in 8.1.2.

7.3.5 A ground-fault circuit-interrupter that has been found suitable for connection to a conduit which extends directly to an underwater pool light forming shell may be so marked.

7.3.6 A permanently connected ground-fault circuit-interrupter shall have its terminals legibly and permanently marked ″Line″ (Linea) and ″Load″ (Carga), and ″Hot″ (Fase) and ″White″ (Neutral) as appropriate for the country it is intended to be used. If a permanently connected ground-fault circuit-interrupter is provided with leads, the location where the leads exit the ground-fault circuit-interrupter, shall be legibly and permanently marked ″Line″ (Linea) and ″Load″ (Carga), and ″Hot″ (Fase) and ″White″ (Neutral) or ″Gray″ (Gris) as appropriate for the country it is intended to be used.

**7.4 Portable ground-fault circuit-interrupters**

7.4.1 A portable ground-fault circuit-interrupter shall be marked in letters at least 3.2 mm (1/8 inch) high, with the word ″WARNING″ and the following or equivalent wording, ″To reduce the risk of electric shock the supervisory circuit must be operated before an appliance is plugged into any receptacle on the device″. The marking shall describe the indication given by operation of the supervisory circuit and inform the user that, in the event of an indication of improper functioning, the cause of the malfunction is to be corrected before further use of the device.

7.4.2 A portable device shall be marked with a statement to the effect that the device does not guard against electric shock resulting from:

a) Some possible defects or faults in an extension cord or other wiring supplying the ground-fault circuit-interrupter, or

b) Contact with both circuit conductors.

7.4.3 The points within the ground-fault circuit-interrupter intended for the termination of power-supply-cord conductors as mentioned in 5.10.8, shall be plainly identified to show the proper connection of the conductors of a replacement cord, and to indicate that the grounding conductor shall not be connected to accessible metal parts of the unit. This marking is to be discernible only after access is obtained to the terminations, except that if there is safe, convenient provision for cord replacement, reference to such replacement may be discernible from outside the ground-fault circuit-interrupter also.

7.4.4 A cord-connected ground-fault circuit-interrupter not provided with a permanently attached cord 1.83 m (6 ft) or longer in length, provided with a recessed inlet plug, shall be marked with the following or equivalent wording ″This product should be used only with a three-conductor, 120 volt, 15, 20, or 30 ampere supply cord set of a type which complies with the requirements for hard usage or extra-hard usage in accordance with Table 11 of the Canadian Electrical Code, Part I, or hard service or junior hard service cords in accordance with Table 400-4 of the National Electrical Code, ANSI/NFPA 70, or NMX J436, Electrical Products, Wire and Cables, Heavy Duty and Extra Heavy Duty Flexible Cords, up to 600 V. In event of cord set damage, it should be replaced only with an equivalent cord set″. See 5.10.1.

7.4.5 Unless a cord-connected ground-fault circuit-interrupter has been found suitable for use in wet locations, it shall be marked ″CAUTION – Do not use where water is likely to enter case″ or the equivalent.

7.4.6 A portable interrupter having a detachable cord set shall be marked in a permanent manner with ″CAUTION – REPLACE ONLY WITH CORD SET NUMBER ____″; where in the blank is to be filled in with the replacement cord set part number.

7.4.7 All two-wire portable ground-fault circuit interrupters shall be marked ″Double Insulated″.

## 8 Installation Instructions

### 8.1 General

*Advisory Note: For products intended for use in Canada, instructions shall be at least in English and caution and warning instructions shall be at least in French and English. For products intended for use in Mexico, all instructions shall be at least in Spanish. For products intended for use in the United States, all instructions shall be at least in English. See Annex B and Annex C for suitable translations.*

8.1.1 There shall be plain, legible, and durable instructions for effective use of a ground-fault circuit-interrupter. Whenever possible, such instructions are to appear on the device, and be so located that they may be readily viewed without the use of tools, and while a permanently-connected device is operating normally. A GFCI that can not accommodate legible instructions, due to the size of the instructions, the size of the device, or both, may have the required instructions supplied on ″stuffer sheets″ provided with the GFCI. A receptacle-type GFCI shall be provided with an installation instruction sheet as specified in 8.1.2.

8.1.2 Each receptacle-type GFCI shall be provided with the installation instructions shown in Annex E, Figures 1 – 6. The installation instruction sheet, containing the detail of all six figures, shall not be smaller than 216 mm (8 – 1/2 inches) high x 419 mm (16 – 1/2 inches) long, consisting of 12 panels (for folding), except as noted in 8.1.3, each no smaller than 108 mm (4 – 1/4 inches) high x 70 mm (2 – 3/4 inches) long. The front of the installation instructions shall contain the manufacturer's name, cautionary note, back view, and steps 1 – 6 as shown in Annex E, Figures 1 – 3. The back of the installation instruction sheet shall contain steps 7 and 8 as shown in Annex E, Figures 4 – 6. The only modifications that may be made to the content of the instructions are those necessary for including the manufacturer's name, model, end of life explanation, explanation of reverse line load miswire condition, and warranty information, and any product configurations different from those represented in the figures. Separate installation instructions sheets following the above format may be included in other languages.

8.1.3 The installation instruction sheet specified in 8.1.2 may consist of more than 12 panels in order to accommodate additional warranty information, special instructions for unique features, or both.

8.1.4 If the instructions in 8.1.1 are included on an adhesive-backed label, the label shall comply with the requirements of 7.1.1.

8.1.5 Except as noted in 8.1.6, a statement to the effect that the device does not guard against electric shock resulting from contact with both circuit conductors shall appear on a ground-fault circuit-interrupter or in literature packed with the device.

8.1.6 A receptacle type GFCI provided with instructions as described in 8.1.2, need not comply with 8.1.5.

## 8.2 Permanently connected ground-fault circuit-interrupters

8.2.1 Those installation instructions required to be on a permanently connected ground-fault circuit-interrupter shall be either continuously exposed to view, or shall become exposed to view when the field-wiring terminals are exposed to view.

8.2.2 A receptacle type GFCI shall be provided with an adhesive label that either covers the load terminals or is wrapped around the load leads. For products intended for use in Mexico and the USA, the label shall be safety yellow in accordance with the pantone matching system, Pantone 108 C, (see Annex D, Reference Publications, Product Safety Signs and Labels) or an equivalent yellow, with black lettering and shall contain the following wording or equivalent: ″ATTENTION″ [in letters at least 2.4 mm (3/32 inch) high] ″The load terminals under this label are for feeding additional receptacles. Miswiring can leave this outlet without ground fault protection. Read instructions prior to wiring.″ For products intended for use in Canada, the color of the above label shall be red or yellow.

8.2.3 Except as noted in 8.2.4, a permanently connected ground-fault circuit-interrupter shall be provided with installation instructions that include the following either in written text or pictorial form:

a) A description of how to differentiate ″Line″ conductors from ″Load″ conductors, and a description of the proper method of connecting the conductors to the GFCI, and

b) A description of how to determine whether the GFCI has been wired properly and how to determine whether it functions properly after it has been wired.

8.2.4 A receptacle type GFCI provided with instructions as described in 8.1.2, need not comply with 8.2.3.

8.2.5 A permanently connected ground-fault circuit-interrupter shall be clearly marked so as to minimize the occurrence of miswiring of the conductors to the means of termination provided. See 5.9.5.

8.2.6 In determining compliance with the provisions of 8.2.5, consideration is to be given to:

a) Wire gauge,

b) Whether conductors are copper or aluminum,

c) Whether terminals are for grounded, grounding, line, or load connection, and

d) Whether conductors are solid or stranded.

8.2.7 There is to be suitable reference on a ground-fault circuit-interrupter to the location of any of the instructions mentioned in 8.1.1, that are not on the device.

8.2.8 Except as noted in 8.2.9, for a permanently connected ground-fault circuit-interrupter, there shall be instructions to operate the supervisory circuit upon installation and at least as frequently as monthly and including directions to be followed in case the test shows the device is not operating correctly. Part of these instructions may be omitted from the device when complete instructions are provided on literature packaged with the device.

8.2.9 A receptacle type GFCI provided with instructions as described in 8.1.2, need not comply with 8.2.8.

8.2.10 The instructions mentioned in 8.2.8 shall include a description of the indication given during the normal operation of the supervisory circuit.

No Text on This Page

# SUPPLEMENT SA - OPTIONAL 10 KA SHORT CIRCUIT CURRENT TEST FOR OUTLET-BOX TYPE GROUND-FAULT CIRCUIT-INTERRUPTERS

## INTRODUCTION

### SA1 Scope

SA1.1 These requirements in this supplement cover an optional test procedure for a ground-fault circuit-interrupter.

SA1.2 These requirements are intended to verify the optional 10 kA short circuit current capabilities for a ground-fault circuit-interrupter employed in applications such as power outlets, where higher currents are available.

SA1.3 The ground-fault circuit-interrupter mentioned in SA1.2 shall comply with the applicable requirements of this Standard, except as modified by the requirements contained in this supplement.

SA1.4 The requirements of this supplement do not apply to a portable ground-fault circuit-interrupter.

## PERFORMANCE

### SA2 General

SA2.1 Representative outlet-box type ground-fault circuit-interrupters shall be subjected to the Extra-low-resistance ground fault test in Clause 6.18 and the Short circuit test in Clause 6.19 except the prospective current is to be 10,000 rms Symmetrical Amperes and the power factor in the range of 0.45 to 0.50.

SA2.2 In the tests mentioned in SA2.1 each representative device tested shall be operational after each test. Operation shall be verified by the supervisory circuit remaining operable upon completion of each test. The representative devices tested shall also comply with Dielectric voltage withstand test, Clause 6.11. See also 6.4.2 for representative device selection.

## MARKINGS

### SA3 General

SA3.1 A ground-fault circuit-interrupter that complies with SA2.1 and SA2.2 shall not be marked to indicate the ability to withstand a 10 kA short circuit current as a result of these tests.

## Annex A (Normative)
## Reference Standards

### A1 Reference Standards

A1.1 These Standards shall be considered to refer to the latest edition and all amendments published to that edition.

| Ref. No. | Component Type | UL | CSA | ANCE |
|---|---|---|---|---|
| 1 | Male and female contact devices such as plugs, connectors, current taps, and receptacles | UL 498 Attachment Plugs and Receptacles | C22.2 No. 42-99 (R2002) General Use Receptacles, Attachment Plugs, and Similar Wiring Devices | NMX-J-508 Wiring Devices – Safety requirements – Specifications and Test Methods. |
| 2 | Bonding Circuit Components | NA | C22.2 No. 0.4 Bonding of Electrical Equipment | a |
| 3 | Enclosures | UL 50 Enclosures for Electrical Equipment | C22.2 No. 144 Ground Fault Circuit Interrupters | NMX-J-235 Enclosures – Enclosures for electrical equipment – Part 1: General requirements – Specifications and Test Methods. Part 2: Specific requirements – Specifications and Test Methods. |
| 4 | Environmental Rating Requirements | UL 50 Enclosures for Electrical Equipment | CAN/CSA C22.2 No. 94-M91 (R2001) Special Purpose Enclosures | NMX-J-235 Enclosures – Enclosures for electrical equipment – Part 1: General requirements – Specifications and Test Methods. Part 2: Specific requirements – Specifications and Test Methods. |
| 5 | Adhesive Applied Insulation | UL 510 Polyvinyl Chloride, Polyethylene, and Rubber Insulating | C22.2 No. 197-M1983 (2003) PVC Insulating Tape | a |
| 6 | Investigation of Conformal Coatings applied to printed wiring boards | UL 746C Polymeric Materials – Use in Electrical Equipment Evaluations | *C22.2 No. 0.2-93 (R1999) Insulation Coordination | a |
| 7 | Insulation Coordination – Clearance and Creepage Distances | UL 840 Insulation Coordination | C22.2 No. 0.2-93 (R1999) Insulation Coordination | a |



Table Continued on Next Page

## Table Continued

| Ref. No. | Component Type | UL | CSA | ANCE |
|---|---|---|---|---|
| 8 | Mold Stress Distortion Test | UL 746C Polymeric Materials – Use in Electrical Equipment Evaluations | CAN/CSA C22.2 No. 0.17-00 Evaluation of Properties of Polymeric Materials | a |
| 9 | Requirements for polymeric enclosures and enclosures with polymeric parts | UL 746C Polymeric Materials – Use in Electrical Equipment Evaluations | C22.2 No. 144 Ground Fault Circuit Interrupters | a |
| 10 | Investigation of adhesives | UL 746C Polymeric Materials – Use in Electrical Equipment Evaluations | Clause 17 of C22.2 No. 60065-03 Audio, Video and Similar Electronic Apparatus – Safety Requirements | a |
| 11 | Transient Voltage Surge Suppressors | UL 1449 Transient Voltage Surge Suppressors | NA | a |
| 12 | Motor Controllers | UL 508 Industrial Control Equipment | C22.2 No. 14-95 (R2001) Industrial Control Equipment | a |
| 13 | Label Requirements | UL 969 Marking and Labeling Systems | C22.2 No. 0.15-01 Adhesive Labels | a |
| 14 | Degrees of Protection Provided by Enclosures (IP Code) | IEC 60529 Degrees of Protection Provided by Enclosures (IP Code) | C22.2 No. 60529–05 Degrees of Protection Provided by Enclosures (IP Code) | NMX-J-529-ANCE |

[a] To address Mexico's certification needs, UL and CSA component requirements will be duplicated in an Annex that appears only in Mexico's version of this Standard.

# Annex B (Informative)
# French Translations and Markings

## B1 French Translations and Markings

This Annex is provided for information only.

| Clause | English | French |
|---|---|---|
| 7.3.3 | Do not use where exposed to rain | Ne pas utiliser dans un emplacement mouillé |
| 7.4.1 | WARNING | AVERTISSEMENT |
| | To reduce the risk of Electric shock, the Supervisory circuit must be operated before an appliance is plugged into any receptacle on the device. | Afin de réduire le risque de choc électrique, le circuit de supervision doit être actionner avant de brancher un appareil dans une des prises de courant du dispositif. |
| 7.4.6 | CAUTION | ATTENTION |
| | Replace only with cord set number ___ | Remplacer uniquement par un cordon amovible numéro ___ |
| 8.2.2 | ATTENTION | ATTENTION |
| | The load terminals under this label are for feeding additional receptacles. Miswiring can leave this outlet without ground fault protection. Read instructions prior to wiring. | Les bornes de charge sous cette étiquette servent à l'amentation de prises additionnelles. Un câblage erroné peut laisser cette sortie sans protection de défaut à la terre. Lire les directives avant de procéder au câblage. |
| Figure 1 | CAUTION | ATTENTION |
| | To prevent severe shock or electrocution, always turn the power OFF at the service panel before working with wiring. | Pour éviter de graves chocs électriques ou l'electrocution, coupez toujours l'alimentation au panneau de service, avant de travailler sur le câblage. |
| | Use this GFCI receptacle with copper or copper-clad wire. Do not use it with aluminum wire. | Utilisez toujours cette prise de courant détection de défaut la terre GFCI avec des fils de cuivre ou enveloppe de cuivre. N'utilisez pas avec des fils d'aluminium. |
| | Do not install this GFCI receptacle on a circuit that powers life support equipment because if the GFCI trips it will shut down the equipment. | N'installez pas cette prise détection de défaut la terre GFCI sur un circuit alimentant des appareils de survie car lorsque le détecteur de défaut déclenche l'appareil se ferme. |
| | For installation in wet locations, protect the GFCI receptacle with a weatherproof cover that will keep both the receptacle and any plugs dry. | Pour l'installation dans des endroits mouillés, protégez la prise par un courvercle anti-intempéries qui va garder la prise at toutes les fiches au sec. |
| | Must be installed in accordance with national and local electrical codes. | Doit être installé selon les codes électriques nationaux et locaux. |

# Annex C (Informative)
# Spanish Translations and Markings

## C1 Spanish Translations and Markings

This Annex is provided for information only.

| Clause | English | Spanish |
|---|---|---|
| 7.3.3 | Do not use where exposed to rain | No usar donde se exponga a la lluvia |
| 7.4.1 | WARNING<br>To reduce the risk of electric shock, the supervisory circuit must be operated before an appliance is plugged into any receptacle on the device. | ADVERTENCIA<br>Para reducir el riesgo de choque elctrico, el circuito de prueba debe ser operanado antes de conectar el aparato elctico a cualquier receptculo. |
| 7.4.6 | CAUTION<br>Replace only with cord set number ___ | PRECAUCION<br>Reemplace solo por el mismo tipo de cordón numero ___ |
| 8.2.2 | ATTENTION<br>The load terminals under this label are for feeding additional receptacles. Miswiring can leave this outlet without ground fault protection. Read instructions prior to wiring. | ATENCION<br>Las terminales de carga debajo de esta etiqueta son para alimentar receptculos adicionales. Un alambrado erróneo puede dejar esta salida sin protección contra falla a tierra. Lea el instructivo antes de alambrar. instrucciones. |
| Figure 1 | CAUTION<br>To prevent severe shock or electrocution, always turn the power OFF at the service panel before working with wiring.<br>Use this GFCI receptacle with copper or copper-clad wire. Do not use it with aluminum wire.<br>Do not install this GFCI receptacle on a circuit that powers life support equipment because if the GFCI trips it will shut down the equipment.<br>For installation in wet locations, protect the GFCI receptacle with a weatherproof cover that will keep both the receptacle and any plugs dry.<br>Must be installed in accordance with national and local electrical codes. | PRECAUCION<br>Para prevenir choques elctricos o electrocución, siempre desconecte el tablero de servicio antes de trabajar en el cableado.<br>Use este ICFT tipo receptculo con alambre de cobre. No lo use con alambres de aluminio.<br>No instale este ICFT tipo receptculo en circuitos que alimentan equipos para salvaguardar la vida, ya que si el ICFT dispara, desconectar este equipo.<br>Para instalaciones en lugares hmedos, proteja el ICFT tipo receptculo con una cubierta a prueba de agua que mantenga secos tanto al receptculo como a las clavijas.<br>Debe ser instalado de acuerdo con los reglamentos elctricos nacionales y locales. |

## Annex D (Informative)
## Reference Publications

### D1 Reference Publications

Where reference is made to CSA, or UL Standards, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this Standard was approved.

**ANCE/MEXICAN Standards**

NMX-J-010
*Electrical Products – Wires and Cables – Polyvinyl Chloride Insulated Conductors for Installations up to 600 V – Specifications*

NMX-J-102
*Electrical Products – Wires and Cables – Polyvinyl Chloride Insulated Flexible Cords Type SPT for Installations up to 300 V – Specifications*

NMX-J-170
*Connectors – Overhead Compression Type Connectors – Specifications and Test Methods*

NMX-J-235/1
*Enclosures - Enclosures for electrical equipment – Part 1: General requirements – Specifications and Test Methods*

NMX-J-235/2
*Enclosures - Enclosures for electrical equipment – Part 2: Specific requirements – Specifications and Test Methods*

NMX-J-266/ANCE
*Electrical Products Molded Case Circuit Breakers, Specifications and Test Methods*

NMX-J-292
*Electrical Products – Wires and Cables – Thermoplastic Jackets for Electrical Cables – Specifications and Test Methods*

NMX-J-298
*Wires and Cables – Thermoplastic Insulated Conductors Flat Twin Configuration for Installations up to 600 V – Specifications*

NMX-J-300
*Electrical Products – Wires and Cables – Control Cables Thermoplastic or Thermosetting Insulation, for 600 V and 1 000 V A.C. and Maximum Conductor Temperature of 75 °C and 90 °C – Specifications*

NMX-J-383
*Electrical Products – Connectors – Mechanical Type Aluminum Connectors – Specifications and Test Methods*

NMX-J-395
*Electric Industry – Connectors – Mechanical Type Copper Connectors – Specifications and Test Methods*

NMX-J-436
*Electrical Products, Wire and Cables, Heavy Duty and Extra Heavy Duty Flexible Cords, up to 600 V*

NMX-J-508
*Wiring Devices – Safety requirements – Specifications and Test Methods*

NMX-J-529
*Electrical Products, Enclosures, Degrees of Protection*

NOM-001-SEDE
*Electrical Installations*

NOM-003-SCFI
*Safety Requirements for Household and Similar Appliances*

**CSA Standards**

C22.1-02
*Canadian Electrical Code, Part I*

C22.2 No. 0-M91 (R2001)
*General Requirements – Canadian Electrical Code, Part II*

C22.2 No. 0.1-M1985 (R2003)
*General Requirements for Double-Insulated Equipment*

C22.2 No. 0.15-01
*Adhesive Labels*

C22.2 No. 0.4-04
*Bonding of Electrical Equipment*

C22.2 No. 0.17-00
*Evaluation of Properties of Polymeric Materials*

C22.2 No. 5-02
*Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

C22.2 No. 14-95 (R2001)
*Industrial Control Equipment*

C22.2 No. 18-98 (R2003)
*Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware*

C22.2 No. 29-M1989 (R2000)
*Panelboards and Enclosed Panelboards*

C22.2 No. 42-99 (R2002)
*General Use Receptacles, Attachment Plugs and Similar Wiring Devices*

C22.2 No. 65-03
*Wire Connectors*

C22.2 No. 75-03
*Thermoplastic Insulated Wires and Cables*

C22.2 No. 89-1976 (R1999)
*Swimming Pool Luminaires, Submersible Luminaires and Accessories*

C22.2 No. 94-M91 (R2001)
*Special Purpose Enclosures*

C22.2 No. 158-1987 (R1999)
*Terminal Blocks*

C22.2 No. 197-M1983 (R2003)
*PVC Insulating Tape*

C22.2 No. 198.1-99
*Extruded Insulating Tubing*

CAN3-C235-83 (R2000)
*Preferred Voltage Levels for AC Systems 0 to 50 000 V*

**UL Standards**

UL 50
*Enclosures for Electrical Equipment*

UL 83
*Thermoplastic-Insulated Wires and Cables*

UL 224
*Extruded Insulating Tubing*

UL 486A-486B
*Wire Connectors*

UL 486E
*Wiring Terminals, Equipment, for Use With Aluminum and/or Copper Conductors*

UL 489
*Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

UL 498
*Attachment Plugs and Receptacles*

UL 510
*Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating*

UL 746C
*Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 840
*Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 969
*Marking and Labeling Systems*

UL 1241
*Junction Boxes for Swimming Pool Luminaires*

**ANSI Standards**

ANSI MC96.1-1982
*Temperature-Measurement Thermocouples*

ANSI/NFPA[1] 70
*National Electrical Code*

ANSI Z535.4
*Product Safety Signs and Labels*

**ASTM[2] Standards**

D149-87
*Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies*

D257-1990
*DC Resistance or Conductance of Insulating Materials*

D648-82 (1988)
*Deflection Temperature of Plastics Under Flexural Load*

[1] National Fire Protection Association.

[2] American Society for Testing and Materials.

# Annex E (Normative in Canada and the United States; informative in Mexico)
# Installation Instructions – Configuration Drawings

## E1 Installation Instructions – Configuration Drawings

**Figure 1**
**Installation instructions**

# Manufacturer's Name

# Installing and Testing a GFCI Receptacle

**Please read this leaflet completely before getting started.**

## ⚠ CAUTION

- To prevent severe shock or electrocution, always turn the power OFF at the service panel before working with wiring.
- Use this GFCI receptacle with copper or copper-clad wire. Do not use it with aluminum wire.
- Do not install this GFCI receptacle on a circuit that powers life support equipment because if the GFCI trips it will shut down the equipment.
- For installation in wet locations, protect the GFCI receptacle with a weatherproof cover that will keep both the receptacle and any plugs dry.
- Must be installed in accordance with national and local electrical codes.

## 3. Should you install it?

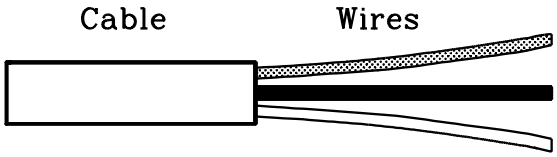
Installing a GFCI receptacle can be more complicated than installing a conventional receptacle.

Make sure that you:

- Understand basic wiring principles and techniques
- Can interpret wiring diagrams
- Have circuit wiring experience
- Are prepared to take a few minutes to test your work, making sure that you have wired the GFCI receptacle correctly

## 4. LINE vs. LOAD

A cable consists of 2 or 3 wires.




**LINE cable:**
Delivers power from the service panel (breaker panel or fuse box) to the GFCI. If there is only one cable entering the electrical box, it is the LINE cable. This cable should be connected to the GFCI's LINE terminals only.

**LOAD cable:**
Delivers power from the GFCI to another receptacle in the circuit. This cable should be connected to the GFCI's LOAD terminals only. The LOAD terminals are under the yellow sticker. Do not remove the sticker at this time.

**Figure 2**
**Installation instructions**

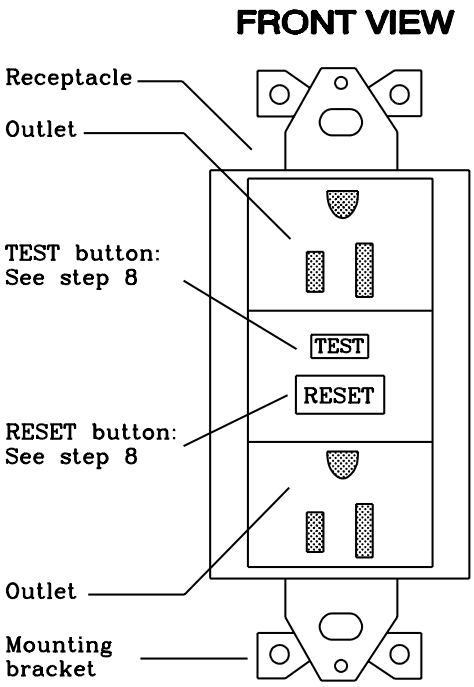
# 1. What is a GFCI?

A GFCI receptacle is different from conventional receptacles. In the event of a ground fault, a GFCI will trip and quickly stop the flow of electricity to prevent serious injury.

**Definition of a ground fault:**
Instead of following its normal safe path, electricity passes through a person's body to reach the ground. For example, a defective appliance can cause a ground fault.

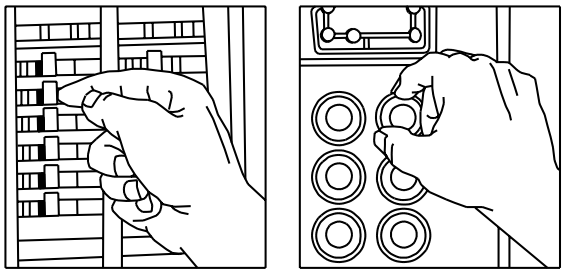
A GFCI receptacle does not protect against circuit oveloads, short circuits, or shocks. For example, you can still be shocked if you touch bare wires while standing on a non–conducting surface, such as a wood floor.

# 2. The GFCI's features —




# 5. Turn the power OFF

Plug an electrical device, such as a lamp or radio, into the receptacle on which you are working. Turn the lamp or radio on. Then, go to the service panel. Find the breaker or fuse that protects that recep–tacle. Place the breaker in the OFF position or completely remove the fuse. The lamp or radio should turn OFF.



Next, plug in and turn ON the lamp or radio at the receptacle's other outlet to make sure the power is OFF at both outlets. If the power is not OFF, stop work and call an electrician to complete the installation.

# 6. Identify cables/wires —

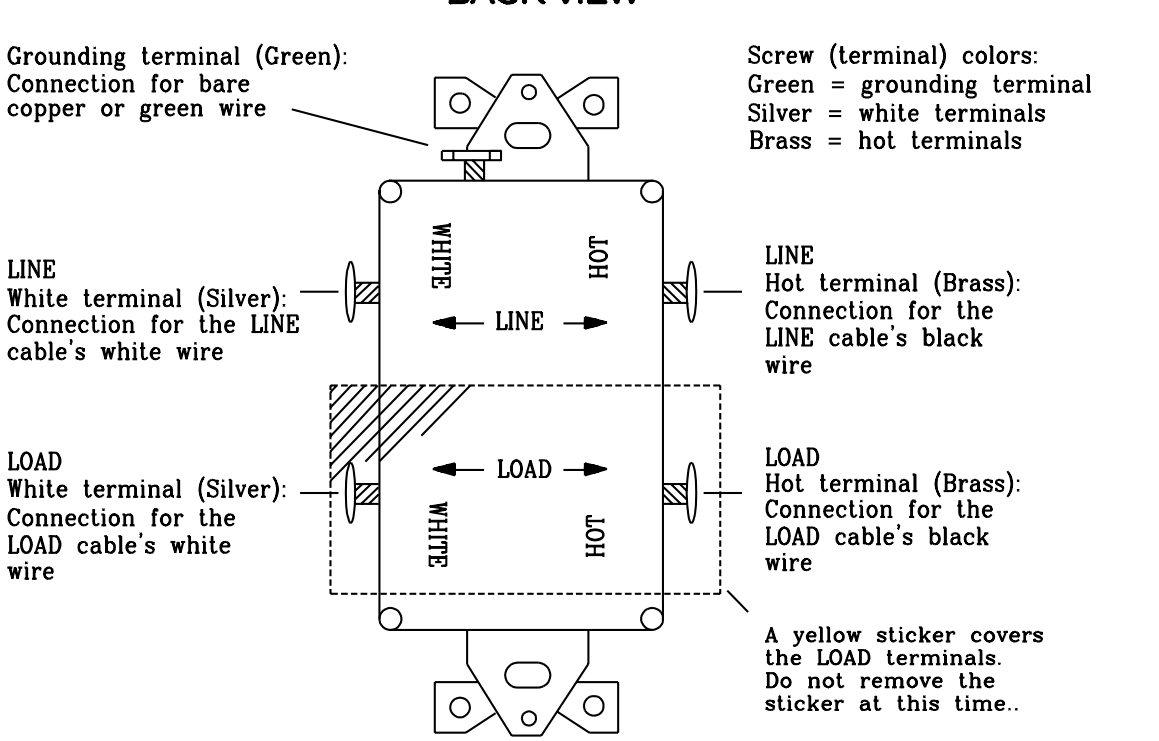
**Important:**
Do not install the GFCI receptacle in an electrical box containing (a) more than 4 wires (not including the grounding wires) or (b) cables with more than two wires (not including the grounding wire). Contact a qualified electrician if either (a) or (b) is true.

If you are replacing an old receptacle, pull it out of the electrical box without disconnecting the wires.

• If you see one cable (2–3 wires), it is the LINE cable. The receptacle is probably in position C (see diagram to the right). Remove the receptacle and go to step 7A.

• If you see two cables (4–6 wires), the receptacle is probably in position A or B (see diagram to the right). Follow steps a–e of the procedure to the right.

**Figure 3**
**Installation instructions**




**Procedure: box with two cables (4-6 wires)**

**(a)** Detach one cable's white and hot wires from the receptacle and cap each one separately with a wire connector. Make sure that they are from the same cable.

**(b)** Re–install the receptacle in the electrical box, attach the faceplate, then turn the power ON at the service panel.

**(c)** Determine if power is flowing to the receptacle. If so the capped wires are the LOAD wires. If not the capped wires are the LINE wires.

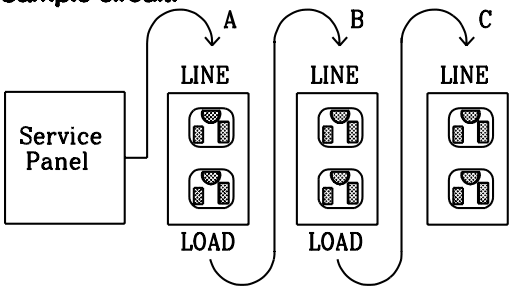
**(d)** Turn the power OFF at the service panel, label the LINE and LOAD wires, then remove the receptacle.

**(e)** Go to step 7B.

**Placement in circuit:**

The GFCI's place in the circuit determines if it protects other receptacles in the circuit.

**Sample circuit:**

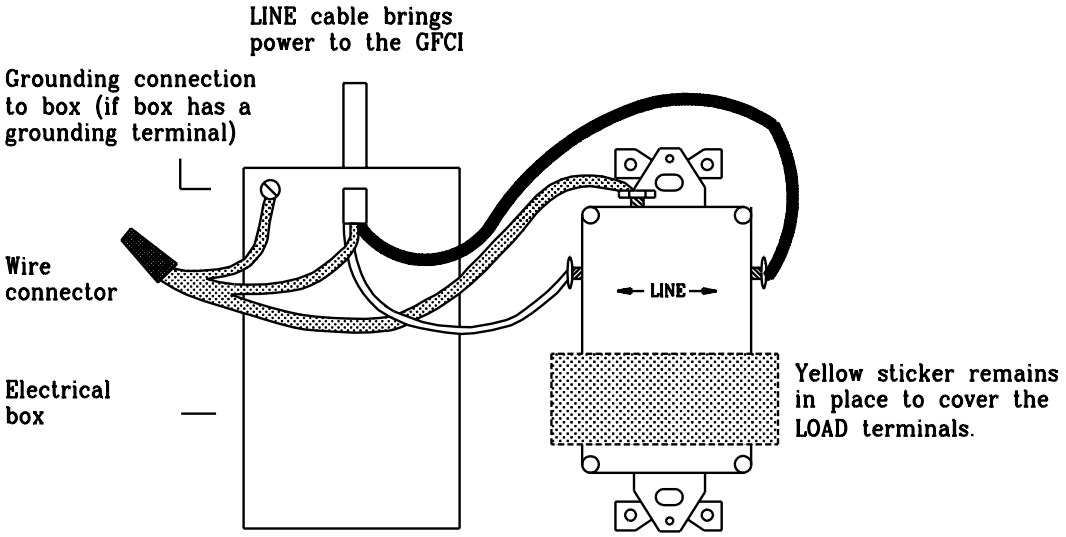



Placing the GFCI in position A will also provide protection to "load side" receptacles B and C. On the other hand, placing the GFCI in position C will not provide protection to receptacles A or B. Remember that receptacles A, B and C can be in different rooms.

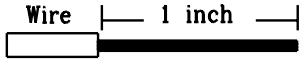
**Figure 4**
**Installation instructions**

## 7. Connect the wires (choose A or B) ... only after

## A: One cable (2 or 3 wires) entering the box




### About wire connections:




Clockwise, 2/3 of the way around screw

### Connect the LINE cable wires to the LINE terminals:

- The white wire connects to the White terminal (Silver)
- The black wire connects to the Hot terminal (Brass)

### Connect the grounding wire (only if there is a grounding wire):

- For a box with no grounding terminal: (diagram not shown) Connect the LINE cable's bare copper (or green) wire directly to the grounding terminal on the GFCI receptacle.
- For a box with a grounding terminal: (diagram shown above) Connect a 6-inch bare copper (or green) 12 or 14 AWG wire to the grounding terminal on the GFCI. Also connect a similar wire to the grounding terminal on the box. Connect the ends of these wires to the LINE cable's bare copper (or green) wire using a wire connector. If these wires are already in place, check the connections.

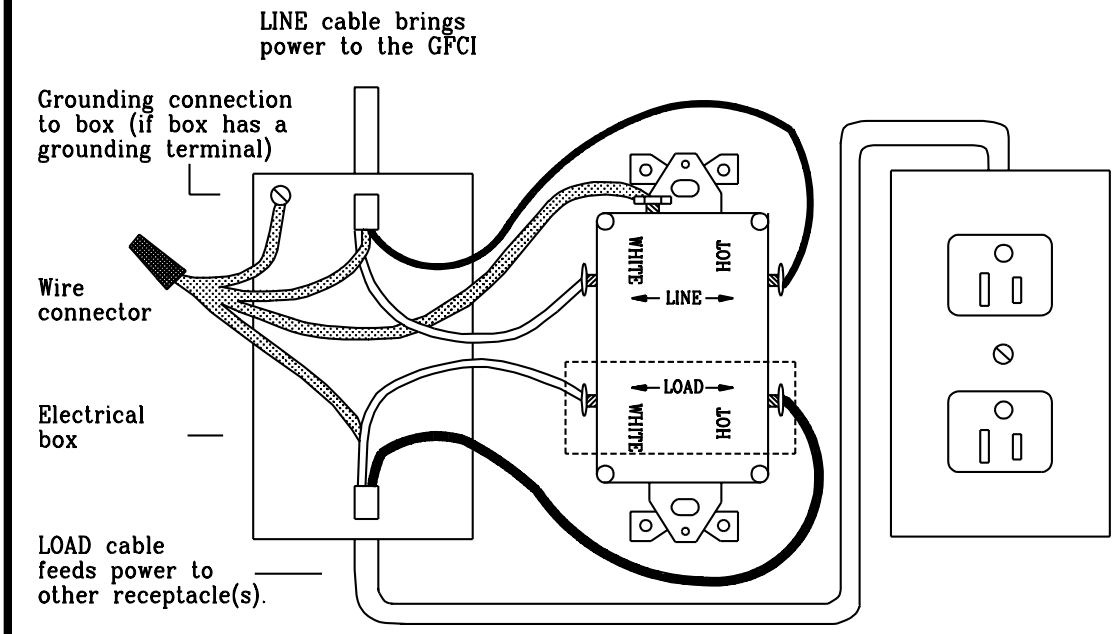
### Complete the installation:

- Fold the wires into the box, keeping the grounding wire away from the White and Hot terminals. Screw the receptacle to the box and attach the faceplate.
- Go to step 8.

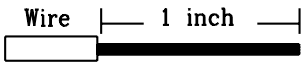
**Figure 5**
**Installation instructions**

reading other side completely

R B: Two cables (4 or 6 wires) entering the box




**About wire connections:**




Clockwise, 2/3 of the way around screw

**Connect the LINE cable wires to the LINE terminals:**

- The white wire connects to the White terminal (Silver)
- The black wire connects to the Hot terminal (Brass)

**Connect the LOAD cable wires to the LOAD terminals:**

- Remove the yellow sticker to reveal the LOAD terminals
- The white wire connects to the White terminal (Silver)
- The black wire connects to the Hot terminal (Brass)

**Connect the grounding wires as shown above (only if there is a grounding wire):**

- Connect a 6–inch bare copper (or green) 12 or 14 AWG wire to the grounding terminal on the GFCI. If the box has a grounding terminal, also connect a similar wire to the grounding terminal on the box. Connect the ends of these wires to the LINE and LOAD cable's bare copper (or green) wire using a wire connector. If these wires are already in place, check the connections.

**Complete the installation:**

- Fold the wires into the box, keeping the grounding wire away from the White and Hot terminals. Screw the receptacle to the box and attach the faceplate.
- Go to step 8.

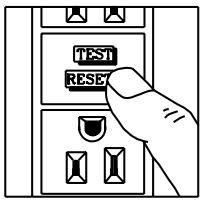
**Figure 6**
**Installation instructions**

# 8. Test your work

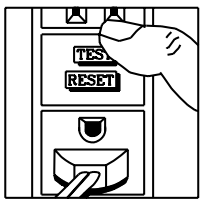
## Why perform this test?

- If you miswire the GFCI it may not prevent personal injury or death due to a ground fault (electrical shock).
- If you mistakenly connect the LINE wires to the LOAD terminals, the GFCI will still operate like an ordinary receptacle, but it will not interrupt a ground fault.

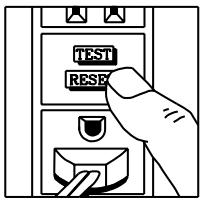
## Procedure:




(a) Turn the power ON at the service panel. Press the RESET button fully. Plug a lamp or radio into the GFCI (and leave it plugged–in) to verify that the power is ON. If there is no power, go to Trouble–shooting.




(b) Press the blue TEST button in order to trip the device. This should stop the flow of electricity, making the radio or lamp shut OFF. Note that the red RESET button will pop–out. If the power stays ON, go to Troubleshooting. If the power goes OFF, you have installed the GFCI receptacle correctly. To restore power, press the RESET button.




(c) If you installed your GFCI using step 7B, plug a lamp or radio into surrounding receptacles to see which one(s), in addition to the GFCI, lost power when you pressed the TEST button. Do not plug life saving devices into any receptacles that lost power. Place a "GFCI Protected" sticker on every receptacle that lost power.

(d) Press the TEST button (then RESET button) every month to assure proper operation.

## TROUBLESHOOTING

Turn the power OFF and check the wire connections against the appropriate wiring diagram in step 7A or 7B. Make sure that there are no loose wires or loose connections. Also, it is possible that you reversed the LINE and LOAD connec–tions. LINE/LOAD reversal will be indicated by power remaining ON at the GFCI after you press the GFCI's TEST button. Reverse the LINE and LOAD connections if necessary. Start the test from the beginning of step 8 if you rewired any connec–tions to the GFCI.

## General Information

GFCI receptacle rating:
The receptacle's ratings go here.

Contact:
The manufacturer's address and telephone number go here.

Warranty:
A condensed manufacturer's warrantly statement goes here.