

UL 1778

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Uninterruptible Power Systems

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

UL Standard for Safety for Uninterruptible Power Systems, UL 1778

Fourth Edition, Dated September 15, 2005

Summary of Topics

This fourth edition of ANSI/UL 1778 has been issued to incorporate several revisions from the technical harmonization committee (THC), UL, and CSA.

The new requirements are substantially in accordance with UL's Bulletin(s) on this subject dated August 31, 2004 and June 15, 2005. The bulletin(s) is now obsolete and may be discarded.

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.

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://ulstandardsinfo.net/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.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the 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that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.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, Recognized, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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

Page	Date
1-66.....	September 15, 2005

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Canadian Standard Association
CSA C22.2 No. 107.3-05
Second Edition



Underwriters Laboratories Inc.
UL 1778
Fourth Edition

Uninterruptible Power Systems

September 15, 2005



ANSI/UL 1778-2005

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Commitment for Amendments

This Standard is issued jointly by 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 CSA or UL at any time. Revisions to this Standard will be made only after processing according to the standards development procedures of 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.

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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 1778 as an American National Standard (ANSI) occurred on August 12, 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>.

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Preface

This is the common CSA and UL Standard for Uninterruptible Power Systems (UPS). It is the second edition of CSA C22.2 No. 107.3 and the fourth edition of UL 1778. This edition of CSA C22.2 No. 107.3 supersedes the previous edition published in 2003. This edition of UL 1778 supersedes the previous editions published in 2003, 1994, and 1989.

This common Standard was prepared by the Canadian Standards Association (CSA) and Underwriters Laboratories Inc. (UL). The efforts and support of the National Electrical Manufacturers Association (NEMA) and Electro-Federation Canada (EFC) are gratefully acknowledged. The Standard is intended to be used in conjunction with the applicable requirements of CAN/CSA-C22.2 No. 60950-1-03 and UL 60950-1, first edition, which is referred to in this Standard as the Reference Document (RD). Compliance will be determined by the requirements located in CAN/CSA-C22.2 No. 60950-1-03 and UL 60950-1, first edition, with deviations presented in the second edition of CSA C22.2 No. 107.3 and the fourth edition of UL 1778.

The requirements in this document have been developed from existing UL and CSA requirements for UPS plus the European Norme EN 50091-1-1:1996, *Specification for Uninterruptible Power Systems*.

This Standard was reviewed by the CSA Subcommittee on Uninterruptible Power Systems, 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 processed and reviewed in accordance with the method of development, revision, and implementation of UL Standards for safety.

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.

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 is published as an equivalent standard for CSA and UL. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Interpretations

The interpretation by the standards development organization (SDO) 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 SDO. 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 SDOs to more accurately reflect the intent.

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CSA Effective Date

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

UL Effective Date

Between September 15, 2005, and March 31, 2006, new product submittals to UL may be evaluated under all requirements in this Standard or, if requested in writing, evaluated using the requirements in other existing applicable Standards for the product.

After March 31, 2006, products that were previously evaluated by UL to the requirements in other existing applicable standards may continue to be approved until March 31, 2011, without further investigation, provided no significant changes or revisions are made to such products.

As of April 1, 2011, all products, including those previously evaluated by UL, must comply with this Standard.

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Uninterruptible Power Systems

1 General

This clause of the RD applies as applicable, except as follows:

1.1 Scope

Replace this clause of the RD with the following:

1.1.1 Equipment covered by this standard

This Standard applies to UNINTERRUPTIBLE POWER SYSTEMS (UPS). The primary function of the UPS for this Standard is to ensure continuity of an alternating power source. The UNINTERRUPTIBLE POWER SYSTEM may also serve to improve the quality of the power source by keeping it within specified characteristics. This Standard is applicable to movable, stationary, fixed, and built-in UPS for distribution systems up to 600 V a.c. This equipment is designed to be installed in accordance with the Canadian Electrical Code, Part I, CSA C22.1, or the National Electrical Code, ANSI/NFPA 70, and, unless otherwise identified, the Standard for the Protection of Electronic Computer Data-Processing Equipment, ANSI/NFPA 75.

This Standard specifies requirements intended to ensure safety for the OPERATOR and, where specifically stated, for SERVICE PERSONNEL.

This Standard is intended to reduce the risk of fire, electric shock, or injury to persons from installed equipment, both as a single unit or as a system of interconnected units, subject to installing, operating, and maintaining the equipment in the manner prescribed by the manufacturer.

1.1.2 Additional requirements

In addition to the requirements in this Standard, a UPS is to comply with the UPS-relevant requirements of Information Technology Equipment Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1 / UL 60950-1, first edition, (RD), as applicable for the country where the product will be used. Wherever there is a conflict between the requirements of this document and the RD, the requirements of this Standard will prevail.

Engine-driven d.c. power generators intended to provide backup power for the battery supply circuit of UPS units are investigated for compliance with the requirements of the Standard for Stationary Engine-Generator Assemblies, UL 2200, and the CSA Standard for Motors and Generators, C22.2 No. 100.

UPS that employ hospital grade components identified by the markings "Hospital Only", "Hospital Grade", or a green dot on the body of the component, or otherwise implying suitability for medical use are evaluated to the requirements of this Standard and Medical Electrical Equipment, Part 1: General Requirements for Safety, CAN/CSA-C22.2 No. 601.1 / UL 60601-1.

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1.1.3 Exclusions

These requirements do not cover UPS units for use as emergency systems or as legally required standby systems, described in Articles 700 and 701, respectively, of the National Electrical Code, ANSI/NFPA 70, and Section 46 of the Canadian Electrical Code, Part I, CSA C22.1.

Where considered appropriate, revision of requirements will be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

NOTE 1: For equipment subject to transient overvoltages exceeding those for Category II according to IEC 60664, additional protection might be necessary. Such additional protection may be located in the mains supply to the equipment or in the equipment as an integral design feature.

NOTE 2: Where the additional protection is an integral part of the equipment insulation requirements, CREEPAGE DISTANCES and CLEARANCE distances from the mains through to the load side of the additional protection may be judged as Category III or IV as required. All insulation requirements, CREEPAGE DISTANCES, and CLEARANCE distances on the load side of the additional protection may be judged as Category I or II as required.

This Standard does not cover all types of UPS, but it may be taken as a guide for such equipment. Requirements additional to those specified in this Standard are in some cases necessary for specific applications, e.g.:

- a) equipment intended for operation while exposed, for example, to extremes of temperature; to excessive dust, moisture, or vibration; to flammable gases; to corrosive or explosive atmospheres; and
- b) UPS equipment based on rotary machinery.

1.1.101 Normative References

Any undated reference to a code or a standard appearing in the requirements in this Standard is interpreted as referring to the latest edition of that code or standard. Annex II lists CSA and UL standards used for the evaluation of components and features of products covered by this Standard or referenced in this document.

When compliance with multiple countries' codes or standards is required, but the product is not intended for use in all countries, the product need only comply with the codes or standards for the country or countries in which it is intended to be used.

For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0, General Requirements – Canadian Electrical Code, Part II.

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1.2 Definitions

Addition:

For the purpose of this Standard, the following definitions apply. Where the terms “voltage” and “current” are used, they imply the rms values, unless otherwise specified.

NOTE: Care should be taken that measuring instruments give a true rms reading in the presence of non-sinusoidal signals.

Definitions in alphabetical order

Active output power, rated	1.2.1.109
Active power	1.2.1.106
Apparent output power	1.2.1.105
Apparent output power, rated	1.2.1.108
Backfeed	1.2.1.110
Backfeed protection	1.2.1.111
Battery, valve-regulated	1.2.2.104
Battery, vented	1.2.2.105
Branch circuit	1.2.8.101
Bypass	1.2.1.102
Load, linear	1.2.2.101
Load, non-linear	1.2.2.102
Load, normal	1.2.2.1
Power factor	1.2.1.107
Power failure	1.2.1.103
Primary power	1.2.1.104
Stored energy mode	1.2.2.103
Uninterruptible power system (UPS)	1.2.1.101

1.2.1 Equipment electrical ratings

Additional definitions:

1.2.1.101 UNINTERRUPTIBLE POWER SYSTEM (UPS) : Combination of converters, switches, and energy storage devices (such as batteries), constituting a power system for maintaining continuity of power to load in case of input POWER FAILURE.

1.2.1.102 BYPASS : Power path alternative, either internal or external, to the UPS.

1.2.1.103 POWER FAILURE : Any variation in power supply that can cause unacceptable performance of the load equipment.

1.2.1.104 PRIMARY POWER : Power that is normally available, as supplied by an electrical utility company or by a USER's generator.

1.2.1.105 APPARENT OUTPUT POWER : The product of the rms output voltage and rms current. It is given for a load in VA or kVA, with a specified power factor.

1.2.1.106 ACTIVE POWER : Sum of the electrical power at the fundamental frequency and the powers of each harmonic component from the output terminals, in W or kW.

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1.2.1.107 POWER FACTOR : Characteristic of an a.c. load expressed as the ratio of ACTIVE POWER to apparent power.

1.2.1.108 RATED APPARENT OUTPUT POWER : Apparent output power as declared by the manufacturer.

1.2.1.109 RATED ACTIVE OUTPUT POWER : Active output power as declared by the manufacturer.

1.2.1.110 BACKFEED : The condition in which HAZARDOUS VOLTAGE or energy available within the UPS is fed back to any of the input terminals, either directly or by a leakage path.

1.2.1.111 BACKFEED PROTECTION : The method used to reduce the risk of electric shock due to BACKFEED.

1.2.2 Operating conditions

Replace this definition of the RD with the following:

1.2.2.1 NORMAL LOAD : The mode of operation which approximates as closely as possible the rated conditions of normal use in accordance with the manufacturer's operating instructions.

NOTE: For examples of NORMAL LOAD conditions for UPS equipment, see Annex BB.

Additional definitions:

1.2.2.101 LINEAR LOAD : A load in which the current drawn from the supply is defined by the relationship:

$$I = U/Z$$

where:

I = load current

U = supply voltage

Z = load impedance

1.2.2.102 NON-LINEAR LOAD : A load in which the parameter Z (load impedance) is no longer a constant but is a variable dependent on other parameters, such as voltage or time (see Annex BB).

1.2.2.103 STORED ENERGY MODE : The operation of the UPS when supplied by the following conditions:

- a) PRIMARY POWER is disconnected or is out of a given tolerance;
- b) battery is being discharged;
- c) load is within the given range; and
- d) output voltage is within the given tolerance.

1.2.2.104 BATTERY, VALVE-REGULATED : A battery in which the venting of the products of electrolysis is controlled by a reclosing pressure-sensitive valve. Also known as "maintenance-free, starved electrolyte".

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1.2.2.105 **BATTERY, VENTED** : A battery in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. Also known as "flooded" or "wet".

1.2.8 Circuits and circuit characteristics

Additional definitions:

1.2.8.101 **BRANCH CIRCUIT** : The portion of the building wiring system beyond the final overcurrent protective device on the power-distribution panel that protects the circuit to the field-wiring terminals in a permanently connected unit or to the receptacle outlet for a cord-connected unit.

1.3 General requirements

Additional subclause:

1.3.101 The frame or chassis of the equipment shall not be used to carry current other than the allowable touch current as determined in the test specified in 5.1 of the RD.

NOTE: The frame or chassis connected to protective earth may carry current during the abnormal operating and fault conditions described in 5.3 and those abnormal tests in Annexes B and C of the RD and Annex AA of this Standard.

1.4 General conditions for tests

1.4.1 Application of tests

Addition:

Where it is specified in this Standard that compliance of materials, components, or subassemblies is checked by inspection or by testing of properties, compliance may be confirmed by reviewing any relevant data or previous test results that are available instead of carrying out the specified type tests.

Only the leakage current and heating tests shall be performed at input tolerances. Except as noted in other Clauses of the Standard, tests shall be conducted at nominal input voltages.

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1.4.10 Loading configuration of the EUT

Addition to first paragraph:

- loads due to recharging batteries;

1.5 Components

1.5.1 General

Add the following text to the last paragraph of this subclause:

Except as indicated in 1.5, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex II for a list of Standards covering components generally used in the products covered by this Standard. A component shall comply with the Canadian Standards Association or the Underwriters Laboratories Inc. standards, as appropriate for the country where the product is to be used.

Additional subclauses:

1.5.101 Oil-filled and inverter storage capacitors shall comply with the requirements of Annex AA.

1.5.102 Batteries shall comply with the requirements of 4.3.8.101.

1.5.103 Power switching devices shall comply with the requirements of Annex AA.

1.5.104 Relays shall comply with the requirements of Annex AA.

1.5.105 Static transfer devices shall comply with the requirements of Annex AA.

1.5.106 BYPASS/maintenance BYPASS devices shall comply with the requirements of Annex AA.

1.5.107 Capacitors connected across the mains shall comply with the requirements for across-the-line capacitors in UL 1414 / CSA C22.2 No. 1, UL 810 / CSA C22.2 No. 190, UL 1283 / CSA C22.2 No. 8, or the test specified in 5.2.101.

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1.6 Power interface

1.6.2 Input current

Addition:

1.6.2.101 While supplying rated output under each of the conditions described in (a) – (d), the input current shall not be more than 110 percent of the rated value:

- a) Recharging Mode – The UPS shall receive power from the utility line while delivering maximum rated alternating current power and the battery charging current.
- b) Stored Energy Mode – For a UPS used with a remote battery, while simulating utility power outage, the inverter portion of the UPS shall receive power from either a fully charged battery bank or an external dc source of supply and allowed to deliver maximum rated alternating current power. The input dc current shall be measured.
- c) Bypass Mode – The transfer switch shall be positioned to allow the utility power for the output load to bypass the rectifier/charger and inverter sections of the UPS and be delivered directly to the load adjusted to draw maximum rated alternating current power.
- d) Normal Mode – With a fully charged battery, the UPS shall receive power from the primary or normal power source and deliver maximum rated alternating current power.

1.6.2.102 With reference to 1.6.2.101(a), the battery charging circuit shall be connected to one of the following:

- a) a resistive-capacitive (rc) load having capacitance of 1000 microfarads per output dc ampere rating of the battery supply;
- b) a battery supplemented with a resistive load bank; or
- c) if requested by the manufacturer, a battery having an ampere-hour and voltage rating corresponding to that which is intended to be used with the UPS.

1.6.2.103 If a battery load is used as described in 1.6.2.101(c), then the battery shall be prepared for charging by first connecting it to the proper load and then discharging it to the low-voltage disconnect (LVD) potential, or 80 percent of the float charging voltage rating of the battery for a UPS having a low-voltage disconnect lockout, at a rate not exceeding the discharge rate assigned by the battery manufacturer.

1.7 Markings and instructions

Additional Note:

NOTE 101: In Canada, there are two official languages: English and French. Annex JJ provides French translations of the markings specified in this Standard. Markings required by this Standard may have to be provided in other languages to conform with the language requirements of the country where the product is to be used.

1.7.1 Power rating

Additional paragraph:

The marking shall include the following:

- a) number of phases unless intended for single phase only;
- b) RATED ACTIVE OUTPUT POWER, in W or kW;
- c) RATED APPARENT OUTPUT POWER, in VA or kVA;
- d) rated output voltage;
- e) rated output current; and
- f) rated output frequency.

New subclauses:

1.7.1.101 One of the following markings shall be placed on units that exceed the maximum output voltage harmonics when measured in accordance with Annex DD:

- a) NOTICE: The output of this device is not purely sinusoidal. It has a nominal total voltage harmonic distortion of ____ percent, with the nominal value of the largest single voltage harmonic of ____ percent.
- b) NOTICE: For use with ____ loads.

For marking b) the generic type of load shall be inserted in the blank space provided. Examples of such generic load types include computer loads and information processing loads.

1.7.1.102 For units designed with additional separate automatic BYPASS/maintenance BYPASS, additional input a.c. supply, or external batteries, relevant supply ratings shall be allowed to be specified in the accompanying installation instructions. Where this is done, the following instruction shall appear on or near the point of connection:

SEE INSTALLATION INSTRUCTIONS BEFORE CONNECTING TO THE SUPPLY

Compliance is determined by inspection.

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1.7.1.103 Industrial type output receptacles with standard configurations according to the CEC and NEC may have output voltage, frequency, or types of current different from the rating of the receptacles, provided a highly visible marking, indicating the voltage, frequency, and current, is permanently applied adjacent to each output receptacle or group of output receptacles such that no hazard will result from a misunderstanding of the intended output rating.

1.7.2 Safety instructions

Additional subclauses:

1.7.2.101 The maximum ambient operating temperature shall be indicated.

1.7.2.102 Signaling circuits

Information shall be provided in the installation instructions as to the purpose and connection of any signaling circuits, relay contacts, emergency power off (EPO) circuits, etc. Attention should be drawn to the necessity of maintaining the security of any SELV CIRCUIT when connected to other equipment.

1.7.2.103 Internal circuit configuration

Installation instructions shall carry sufficient information, including the basic internal circuit configuration of the UPS, to emphasize its compatibility with power distribution systems (see Annex V in the RD).

Special attention shall be given to compatibility with the relevant wiring rules and to bypass circuits.

1.7.7 Wiring terminals

Additional subclause:

1.7.7.101 Terminals for batteries

Terminals intended for connection of batteries shall indicate the polarity or be so constructed as to prevent improper connection.

1.7.8.3 Symbols

Additional paragraph:

Safety symbols and their meanings are shown in Annex CC.

1.7.15 Replaceable batteries

Additional subclauses:

1.7.15.101 Batteries replaceable by SERVICE PERSONNEL

Battery cabinets or compartments shall be provided with the following, clearly legible, information, fixed upon the battery cabinet or compartment of stationary batteries, in such a position that it can be clearly seen by SERVICE PERSONNEL before accessing the battery compartment:

- a) battery type or catalogue number and number of batteries;
- b) nominal voltage of total battery string;
- c) nominal capacity of total battery string;
- d) a caution label denoting an energy and chemical hazard and reference to the maintenance handling and disposal instructions for the safety of SERVICE PERSONNEL; and
- e) a label indicating the battery type.

1.7.15.102 Instructions

1.7.15.102.1 In the case of an internally mounted battery,

- a) instructions shall carry sufficient information to enable the replacement of the battery with a suitable recommended type;
- b) safety instructions to allow access by SERVICE PERSONNEL shall be stated in the installation/service handbook; and
- c) if batteries are to be installed by SERVICE PERSONNEL, instructions for interconnections, including terminal torque, shall be provided.

1.7.15.102.2 In the case of an externally mounted battery,

- a) installation instructions shall state voltage, ampere-hour rating, charging regime, and method of protection required on installation to coordinate with UPS protective devices, where the battery is not provided by the UPS manufacturer; and
- b) instructions for the battery cells shall be provided by the battery manufacturer.

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1.7.15.103 External battery cabinets

External battery cabinets supplied with the UPS shall have adequate installation instructions to define cable sizes for connection to the UPS. Installation instructions for the battery shall be provided by the UPS battery manufacturer.

1.7.15.104 Replacement of batteries located in an OPERATOR ACCESS AREA

The batteries shall be of a sealed or valve-regulated type.

Reverse connection of the terminals shall be prevented if reverse connection could result in a hazard within the meaning of this Standard.

The OPERATOR manual shall include the following instructions:

When replacing batteries, replace with the same number of the following battery: _____ (the blank space shall be filled with the manufacturer's name and model number of the batteries used with the equipment).

CAUTION: Risk of Energy Hazard, _____ V, _____ Ampere-hour battery. Before replacing batteries, remove conductive jewelry such as chains, wrist watches, and rings. High energy through conductive materials could cause severe burns.

CAUTION: Do not dispose of batteries in a fire. The batteries may explode.

CAUTION: Do not open or mutilate batteries. Released material is harmful to the skin and eyes. It may be toxic.

1.7.15.105 Replacement of batteries located in a SERVICE ACCESS AREA

Bare parts that involve an energy hazard shall be located, enclosed, guarded, or provided with a barrier to take into account the unintentional bridging by conductive materials that might be present during service operations.

Bare parts operating at a HAZARDOUS VOLTAGE level shall be located or guarded such that unintentional contact with such parts is unlikely during servicing operations involving other parts of the equipment.

The service manual shall include the following instructions:

Servicing of batteries should be performed or supervised by personnel knowledgeable about batteries and the required precautions.

When replacing batteries, replace with the same type and number of batteries or battery packs.

CAUTION: Do not dispose of batteries in a fire. The batteries may explode.

CAUTION: Do not open or mutilate batteries. Released electrolyte is harmful to the skin and eyes. It may be toxic.

CAUTION: A battery can present a risk of electrical shock and high short-circuit current. The following precautions should be observed when working on batteries:

- a) Remove watches, rings, or other metal objects.

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