UL 1778

STANDARD FOR SAFETY

Uninterruptible Power Systems

UL Standard for Safety for Uninterruptible Power Systems, UL 1778

Fifth Edition, Dated June 13, 2014

Summary of Topics

This revision of ANSI/UL 1778 dated April 3, 2024 is issued as an editorial update to reflect a title change for a referenced standard in 4.3.8.101.0 and Annex III.

As noted in the Commitment for Amendments statement located on the back side of the title page, ULSE and CSA Group are committed to updating this harmonized standard jointly. However, the revision pages dated April 3, 2024 will not be jointly issued by ULSE and CSA Group as this publish reflects an editorial update by ULSE.

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

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UL 1778
Fifth Edition

Uninterruptible Power Systems

June 13, 2014

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ANSI/UL 1778-2023

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as “CSA Group”) and UL Standards & Engagement Inc. (ULSE). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or ULSE at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and ULSE. CSA Group and ULSE 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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This Standard is subject to review five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through April 3, 2024. The most recent designation of ANSI/UL 4778 as an American National Standard (ANSI) occurred on April 28, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Preface

This is the harmonized CSA Group and ULSE standard for Uninterruptible Power Systems (UPS). It is the third edition of CSA C22.2 No. 107.3 and the fifth edition of UL 1778. This harmonized standard has been jointly revised on April 28, 2023. For this purpose, CSA Group and ULSE are issuing revision pages dated April 28, 2023.

This harmonized Standard was prepared by CSA Group and ULSE Inc. (ULSE). The efforts and support of the National Electrical Manufacturers Association (NEMA) and Electro-Federation Canada (EFC) are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

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.

Application of Standard

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

The Standard is intended to be used in conjunction with the applicable requirements of CAN/CSA-C22.2 No. 60950-1-07 and UL 60950-1, March 2007, second 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. 60950-1-07 and UL 60950-1, March 2007, second edition, with deviations presented in the third edition of CSA C22.2 No. 107.3 and the fifth edition of UL 1778.

Level of Harmonization

This Standard is published as an equivalent standard for CSA Group and ULSE. 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 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.

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Uninterruptible Power Systems

1 General

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 CAN/CSA-C22.2 No. 60950-1/UL 60950-1, March 2007, second edition, *Information Technology Equipment – Safety – Part 1: General requirements* (RD), as applicable for the country where the product will be used. Wherever there is a conflict between the requirements of this Standard 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 UL 2200, and CSA 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 CAN/CSA-C22.2 No. 60601-1/UL 60601-1.

Requirements additional to those specified in this Standard may be necessary for equipment intended for use where ingress of water is possible; for guidance on such requirements and on relevant testing, see Annex LLL and Annex T/RD.

1.1.3 Exclusions

These requirements do not cover UPS units for use as legally required standby systems, described in Article 701 of the *National Electrical Code*, ANSI/NFPA 70, and emergency power supply described in Section 46 of the *Canadian Electrical Code, Part I*, CSA C22.1. See Annex LLL.

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 AC 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.

1.1.4 Additional applications

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 to conditions such as extremes of temperature; excessive dust, moisture, or vibration; flammable gases; or corrosive or explosive atmospheres;

b) UPS equipment based on rotary machinery;

c) UPS equipment meeting emergency lighting and power requirements as specified in UL 924; and central power system described in CSA C22.2 No 141-10.

Additional subclause:

1.1.101 Normative references

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

Products covered by this Standard are to comply with the reference installation codes and standards as noted (in Annex III) as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product is to comply with the installation codes and standards for all countries where it is intended to be used.

For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0.

1.2 Definitions

The provisions of 1.2/RD apply, together with the following:

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

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.

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, when operating in the STORED ENERGY MODE with PRIMARY POWER disconnected.

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

1.2.1.112 ELECTRONIC BACKFEED PROTECTION : BACKFEED PROTECTION that does not employ an air gap.

1.2.1.113 FIELD-INSTALLABLE ACCESSORY EQUIPMENT : Equipment intended to modify the UPS construction or function. Such equipment is typically installed in the field by service personnel.

1.2.2 Operating conditions

Replace this definition of the RD with the following:

1.2.2.1 NORMAL LOAD : The mode of operation that 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 BBB.

Delete this definition in the RD:

1.2.2.3 RATED RESTING TIME

This definition is not applicable. Any reference to RATED RESTING TIME in the RD is not applicable.

Additional definitions:

1.2.2.101 LINEAR LOAD : A load in which the current drawn from the supply is defined by the following 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 BBB).

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 stored energy source 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.

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 of PERMANENTLY CONNECTED EQUIPMENT or the receptacle outlet of PLUGGABLE EQUIPMENT TYPE A or PLUGGABLE EQUIPMENT TYPE B.

1.2.13 Miscellaneous

Additional definitions:

1.2.13.101 CONTROLLED ENVIRONMENT : An environment that is an indoor, temperature-regulated location such as a computer room, office, or factory floor that is relatively free of conductive contaminants such as carbon dust and the like.

1.2.13.102 SHORT-CIRCUIT WITHSTAND RATING : The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

NOTE: Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepower or locked rotor current.

1.2.13.103 BRACE : A mechanical assembly that is secured to bus bars to restrict relative motion between the bus bars.

1.2.13.104 SUPPORT : A mechanical assembly that is secured to bus bars and that is further secured to a rigid structural member such as the enclosure or a separate member secured to the framework.

1.3 General requirements

The provisions of 1.3/RD apply, together with the following:

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 5.101/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 the abnormal tests in Annexes B/RD and C/RD and Annex AAA of this Standard.

1.4 General conditions for tests

The provisions of 1.4.1/RD, 1.4.2/RD, 1.4.3/RD, 1.4.4/RD, 1.4.5/RD, 1.4.6/RD, 1.4.7/RD, 1.4.8/RD, 1.4.10/RD, 1.4.11/RD, 1.4.12/RD, 1.4.13/RD, 1.4.14/RD and 1.4.15/RD apply, together with the following:

1.4.1 Application of tests

Addition:

Only the leakage current (TOUCH 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.

1.4.10 Loading configuration of the EUT

Addition to first paragraph:

– loads due to recharging batteries;

Additional subclause:

1.4.15.101 Routine tests

Each production unit shall be subjected to the test requirements specified in Annex PPP.

1.5 Components

The provisions of 1.5.1/RD, 1.5.2/RD, 1.5.3/RD, 1.5.4/RD, 1.5.5/RD, 1.5.6/RD, 1.5.7/RD, 1.5.7.1/RD, 1.5.7.2/RD, 1.5.7.3/RD, and 1.5.8/RD apply, together with the following:

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 III for a list of Standards covering components generally used in the products covered by this Standard. A component shall comply with CSA Group or 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 AAA.

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 AAA.

1.5.104 Relays shall comply with the requirements of Annex AAA.

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

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

1.5.107 Capacitors or EMI filters connected across the AC MAINS SUPPLY shall comply with the requirements for across-the-line capacitors in UL 60384-14 or CSA E60384-14 , UL 810 or CSA C22.2 No. 190, and UL 1283 or CSA C22.2 No. 8, or the test specified in 5.2.101 of this Standard.

1.5.108 FIELD-INSTALLABLE ACCESSORY EQUIPMENT

1.5.108.1 FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall be constructed so that it does not present any hazard specified in this Standard. FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall be installed per manufacturer instructions and, once installed, shall not present any hazard specified in this Standard.

1.5.108.2 The installation of FIELD-INSTALLABLE ACCESSORY EQUIPMENT by an operator shall be restricted to an arrangement that can be accomplished mechanically a tool not provided by the manufacturer and electrically by means of plug-in connections to receptacles available on the basic unit or as a part of the building wiring.

1.5.108.3 The installation of FIELD-INSTALLABLE ACCESSORY EQUIPMENT by qualified service personnel shall be such that:

a) The mechanical positioning can be accomplished by means of regular tools normally available at installation or by means of special tools provided as a part of the installation kit by the organization responsible for the product; and

b) The electrical connections can be readily accomplished by making use of existing terminals and connections in the unit wherever possible.

1.5.108.4 The requirement in 1.5.108.3 does not preclude the addition or removal of components or insulated conductors or rerouting of insulated conductors to accomplish the desired change as long as the alterations in the unit wiring:

a) Can be accomplished by the use of materials and reference to instructions, both of which are furnished as part of the accessory equipment kit and conversion-unit kit; and

b) Do not require the use of makeshift or substitute parts not used in the basic construction of the system.

1.5.108.5 All wiring provided as a part of an item of FIELD-INSTALLABLE ACCESSORY EQUIPMENT or related to its installation shall be acceptable for use at the highest voltage and temperature that can be encountered in the area in which the wire is to be installed.

1.5.108.6 FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall meet the applicable construction and performance requirements of this Standard.

1.5.108.7 FIELD-INSTALLABLE ACCESSORY EQUIPMENT marking

1.5.108.7.1 Each piece of FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall be marked with the manufacturer's name, trademark, or other descriptive marking by means of which the organization responsible for the product can readily be identified and with a distinctive catalogue number or equivalent identification. Alternatively, the marking for a piece of FIELD-INSTALLABLE ACCESSORY EQUIPMENT may be on the package.

1.5.108.7.2 FIELD-INSTALLABLE ACCESSORY EQUIPMENT intended to be installed by an operator shall be marked to indicate the unit for which it is intended or shall be marked with a reference to an instruction manual that tabulates the units for which it is intended. Additionally, FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall include instructions on or packed with the equipment such that the FIELD-INSTALLABLE ACCESSORY EQUIPMENT can be properly mounted on and interconnected with the basic unit.

1.5.108.7.3 FIELD-INSTALLABLE ACCESSORY EQUIPMENT intended to be installed by service personnel and FIELD-INSTALLABLE ACCESSORY EQUIPMENT shall include instructions either on or packed with each piece of FIELD-INSTALLABLE ACCESSORY EQUIPMENT. The instructions shall provide a detailed sequence of the mechanical and electrical steps that are necessary for proper installation and operation.

1.6 Power interface

The provisions of 1.6.1/RD, 1.6.2/RD, and 1.6.4/RD apply, together with the following:

Additional subclause:

1.6.1.101 Telecommunication UPS intended for either permanent or cord connection to single or polyphase 600 V nominal or less ac supply

1.6.1.101.1 All pole-mounted CATV UPS enclosures shall have provision for connecting three 6 AWG copper bonding or grounding conductors as follows:

a) bonding to the cable suspension strand or support wire on the pole;

b) bonding to the ac input power-system grounded neutral; and

c) grounding to the ground rod.

1.6.1.101.2 All pedestal-mounted CATV UPS enclosures shall have provision for connecting two 6 AWG copper bonding or grounding conductors as follows:

a) bonding to the ac input power-system grounded neutral; and

b) grounding to the ground rod.

1.6.2 Input current

Additional subclauses:

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

a) Recharging mode: The UPS shall receive power from the PRIMARY POWER source 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 PRIMARY 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 shall be 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 PRIMARY 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 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) a battery having an ampere-hour (watt or kilowatt) 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 1.6.2.102 (c), 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 % 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

The provisions of 1.7.1/RD, 1.7.2/RD, 1.7.4/RD, 1.7.5/RD, 1.7.6/RD, 1.7.7/RD, 1.7.8/RD, 1.7.9/RD, 1.7.10/RD, 1.7.11/RD, 1.7.12/RD, 1.7.13/RD, and 1.7.14/RD apply, together with the following:

Additional Note:

NOTE 101 In Canada, there are two official languages: English and French. Annex JJJ provides examples of French translations of the on-product 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;

f) rated output frequency;

g) where applicable, short-circuit withstand rating (see 5.101); and

h) if appropriate, the unbalanced load capability.

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 DDD:

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.

c) NOTICE: Only for use with manufacturer: _____; model: _____.

For the marking in item (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.

1.7.1.103 Industrial-type output receptacles with standard configurations according to the CEC, Part I and the NEC may have output voltage, frequency, or types of current different from the rating of the receptacles, provided that 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. See Annex LLL.

1.7.1.104 The date of manufacture shall be plainly and permanently marked on a unit such that the date is readily visible after installation of the unit. This date may be abbreviated, or in a code affirmed by the manufacturer, provided that the code does not

a) repeat in less than 20 years; and

b) require reference to the production records of the manufacturer to determine when the unit was manufactured.

1.7.1.105 In Canada, when a CATV UPS is used by public utilities, the following marking or equivalent shall appear on the UPS:

“This UPS is for use with telephone equipment in accordance with section 60 of the *Canadian Electrical Code, Part I*, and is subject to inspection by an inspector”.

The following marking shall appear on all CATV UPS:

“This unit is intended for connection to pole-mounted or underground amplifiers”.

CATV UPS that are not provided with a separate enclosed service switch or circuit breaker complying with CSA C22.2 No. 4 or CSA C22.2 No. 5 shall be marked with the following or equivalent:

“In order to comply with the *Canadian Electrical Code, Part I*, disconnecting means for the CATV UPS shall be marked as being suitable for use as service equipment”.

1.7.1.106 Terminals intended for connection of batteries shall indicate the polarity according to IEC 60417, or be so constructed as to prevent improper connection.

1.7.2 Safety instructions and marking

Additional subclauses:

1.7.2.101 Ambient temperature

The maximum ambient operating temperature shall be indicated in the instruction manual.

1.7.2.102 Signalling circuits

Information shall be provided in the installation instructions as to the purpose and connection of any signalling 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/RD).

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

1.7.2.104 General instructions

The information in items (a) – (s), as appropriate, shall be provided for a UPS, a remote battery supply/cabinet assembly, and a maintenance BYPASS cabinet assembly. A single installation manual may be used for a UPS investigated in combination with a remote battery supply/cabinet or maintenance BYPASS cabinet assembly. The information in items (c) – (s) may be marked on the unit in lieu of providing it in the instruction manual.

IMPORTANT SAFETY INSTRUCTIONS

a) SAVE THESE INSTRUCTIONS – This manual contains important instructions for Models _____ that should be followed during installation and maintenance of the UPS and batteries. (*Blank space is to be filled in with appropriate model numbers.*)

NOTE: If the instructions are exactly the same for all models, specific model numbers need not be specified.

b) If pressure terminal connectors or the fastening hardware is not provided on the UPS as shipped, the instruction manual shall indicate which pressure terminal connector or component terminal assemblies are for use with the UPS.

c) With reference to item (b), the terminal assembly packages and the instruction manual shall include information identifying wire size and manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified.

d) If a pressure terminal connector provided in the unit or in a terminal assembly for a field installed conductor requires the use of other than an ordinary tool for securing the conductor, identification of the tool and any necessary instructions for using the tool shall be included in the instruction manual.

e) A unit provided with a wire connector for field installed wiring shall be provided with instructions specifying that the connector provided is to be used in making the field connection.

f) A unit employing pressure terminal connectors for field wiring connections shall be provided with instructions specifying a range of values or a nominal value of tightening torque to be applied to the clamping screws of the terminal connectors.

NOTE: The torque range of connectors investigated to the following standards are assumed to apply:

i) UL 486A-486B and CSA C22.2 No. 65; or

ii) UL 486E or CSA C22.2 No. 65.

g) The instruction manual for stationary and portable units having multiple input voltage ratings shall include information indicating the type of attachment plug that is to be used for connection to a voltage supply other than what the UPS is set for when it is shipped from the factory.

h) The instruction manual for a UPS that exceeds the temperature limits of Table 4C/RD shall specify that the unit is to be installed so that it is not likely to be contacted by people.

i) The instruction manual for a UPS shall contain complete instructions concerning proper selection of the power supply cord when the UPS is intended for use with an appliance coupler and is not provided with a detachable power cord.

j) Instructions for field assembly of modules of a modular unit, including an interconnection wiring diagram, shall be either

1) packaged with the modules; or

2) contained in the instruction manual, provided that the marking on the module makes reference to the instruction manual.

k) Remote dc sources, including batteries, not provided with overcurrent protection, shall include a statement in the installation instruction manual indicating that overcurrent protection is to be provided by others. See 2.7.101.

l) UPS with permanently connected ac outputs, not provided with overcurrent protection, shall include a statement in the installation instruction manual indicating that overcurrent protection is to be provided by others.

m) The instruction manual shall include information identifying the number of conductors and range of conductor sizes for a unit having a single equipment field-wiring terminal that is intended for connection of more than one conductor.

n) For a unit provided with field-wiring terminals or leads, the instruction manual shall include the information indicated in Row 1, 2, 3, or 4 of Table 1.7.2.104 , or with equivalent wording, if it is

1) intended for use on a supply circuit rated 110 A or less; or

2) intended for field connection with 1 AWG (42.4 mm^2) or smaller conductors.

Table 1.7.2.104
Termination markings

Temperature rating of wire that is intended to be used for connection of the unit	Copper conductors only	Aluminum conductors or copper-clad conductors
60 or 75 °C	"Use either ____ AWG, 60 °C or ___ AWG, 75 °C copper wire "	Row 1
		"Use 60 °C wire, either ___ AWG copper or ___ AWG aluminum; or 75 °C wire, either ___ AWG copper or ___ AWG aluminum"
60 °C	"Use ___ AWG, 60 °C copper wire "	Row 2
		"Use 60 °C wire, either ___ AWG copper or ___ AWG aluminum"
75 °C	"Use ___ AWG, 75 °C copper wire "	Row 3
		"Use 75 °C wire, either ___ AWG copper or ___ AWG aluminum"
90 °C	"Use ___ AWG, 90 °C copper wire"	Row 4
		"Use 90 °C wire, either ___ AWG copper or ___ AWG aluminum "

o) For a unit provided with field-wiring terminals or leads, the instruction manual shall include the information indicated in Row 3 or 4 of Table 1.7.2.104 , or with equivalent wording, if it is

1) intended for use on a supply circuit rated more than 110 A; or

2) intended for field connection with conductors larger than 1 AWG (42.4 mm^2).

p) If applicable, the instruction manual shall include a statement indicating that Class 1 wiring methods are to be used for field wiring connections to terminals of a Class 2 circuit.

q) the instruction manual for a unit investigated for use in a CONTROLLED ENVIRONMENT shall indicate that the unit is intended for installation in a temperature-regulated, indoor area that is relatively free of conductive contaminants.

r) If an abnormal test is terminated by operation of the intended BRANCH CIRCUIT overcurrent protective device; or if the a.c. input overcurrent protection is relied upon for protection of an a.c. output receptacle, the instruction manual for a unit thus described shall include the word "CAUTION" and the following or equivalent: "To reduce the risk of fire, connect only to a circuit provided with _____ A maximum branch circuit overcurrent protection in accordance with the *National Electrical Code*, ANSI/NFPA 70 and the *Canadian Electrical Code, Part I*, C22.1". (*The blank space is to be filled in with the appropriate ampere rating of BRANCH CIRCUIT overcurrent protection*).

s) Instructions shall be provided that explain how to install a remote shunt-trip circuit breaker for a unit that is intended to be used with this type of breaker.

t) The instruction manual for a UPS intended to be used with a remote battery supply that is not provided with the UPS shall make reference to the battery manufacturer's installation manual for battery installation and maintenance instructions.

1.7.2.105 Installation instructions for CATV UPS

The instruction manual for a UPS intended to supply power to cable TV equipment shall include the instructions for proper installation. The text of these instructions shall appear under the heading “Installation Instructions”.

1.7.2.106 Installation instructions for modular units

Individual modules of a modular unit may be of the open construction type – either no enclosure or a partial enclosure is supplied – provided that when the modules are assembled together in the field as intended, the unit enclosure complies with the requirements in this Standard and in the RD. Identification of the modules and instructions for assembling shall be provided.

1.7.8 Controls and indicators

1.7.8.3 Symbols

Additional paragraph:

Safety symbols and their meanings are shown in Annex CCC.

1.7.13 Replaceable batteries

Additional subclauses:

1.7.13.101 Marking requirements for batteries located in a SERVICE ACCESS AREA

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 manufacturer name, 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;

e) for a UPS having a battery supply without transformer isolation, a label containing the word "CAUTION" and the following warning or equivalent: "Risk of Electric Shock – Battery Circuit is not isolated from ac input, hazardous voltage may exist between battery terminals and ground. Test before touching."

1.7.13.102 Instructions

1.7.13.102.1 Internally mounted battery

Instructions shall carry sufficient information to enable the replacement of the battery with a suitable manufacturer and catalogue number.

Safety instructions to allow access by SERVICE PERSONNEL shall be stated in the installation/service handbook.

If batteries are to be installed by SERVICE PERSONNEL, instructions for interconnections, including terminal torque, shall be provided.

1.7.13.102.2 Externally mounted battery

Installation instructions shall state voltage, ampere-hour (watt or kilowatt) rating, charging information, method of protection, and maximum fault current required on installation to coordinate with UPS protective devices.

Where the battery is not provided by the UPS manufacturer, the installation and maintenance instructions shall be provided by the battery manufacturer.

1.7.13.103 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.

1.7.13.104 Installation or 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 for battery replacement and disposal:

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

CAUTION: Risk of energy hazard, _____ V, _____ Ampere-hour (watt or kilowatt) 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.

1.7.13.105 Installation or 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 for battery replacement and disposal:

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. Contact with any part of a grounded battery can result in electrical shock. The following precautions should be observed when working on batteries:

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

b) Use tools with insulated handles.

c) Wear rubber gloves and boots.

d) Do not lay tools or metal parts on top of batteries.

e) Disconnect charging source and load prior to installing or maintaining the battery.

f) Remove battery grounds during installation and maintenance to reduce likelihood of shock. Remove the connection from ground if any part of the battery is determined to be grounded.

1.7.13.106 VENTED BATTERIES

UPS having VENTED BATTERIES shall have an additional caution in the manual describing the safe methods of handling VENTED BATTERIES.

2 Protection from hazards

The provisions of 2/RD apply, together with the following.

2.1 Protection from electric shock and energy hazards

The provisions of 2.1.1/RD, 2.1.1.1/RD, 2.1.1.2/RD, 2.1.1.3/RD, 2.1.1.4/RD, 2.1.1.5/RD, 2.1.1.6/RD, 2.1.1.7/RD, 2.1.1.8/RD, 2.1.2/RD, and 2.1.3/RD apply, together with the following additions.

Additional subclauses:

2.1.101 BACKFEED PROTECTION

HAZARDOUS VOLTAGE and/or energy shall not appear on the a.c. input terminals under the condition of a single fault on a component (such as in the control circuit) upon loss of the a.c. input voltage.

For fixed-installation UPS, BACKFEED PROTECTION may be provided internally or externally to the UPS in the a.c. input line.

When a BACKFEED PROTECTION isolator is external to the UPS, the supplier shall specify in the installation instructions the suitable isolating device to be used.

The UPS shall be tested as specified in 2.1.102. No shock hazard shall exist at the a.c. input when measured 1 s after de-energization of the a.c. input line if the equipment is PLUGGABLE TYPE A, or 15 s if permanently connected or PLUGGABLE TYPE B.

2.1.102 The UPS shall be operated with an a.c. power output current at no load and full load and with a single fault applied to the component being investigated. The fault placed on the component shall simulate the failure mode of that component. The a.c. input line shall then be disconnected and any BACKFEED measured.

Compliance is checked by inspection of the equipment and relevant circuit diagram and by simulating fault conditions according to 5.3.7/RD and other sections of this Standard, such as Annex FFF.

2.1.103 In the United States the following applies:

A UPS provided with a marking indicating that it is suitable for use in a computer room shall comply with Annex NAE 3.4.11/RD.

2.6 Provisions for earthing and bonding

2.6.3 Protective earthing conductors and protective bonding conductors

2.6.3.3 Size of protective bonding conductors

Replace Table 2D/RD with the following:

Table 2.6.3.3
Minimum size of conductors for bonding

Ampacity of largest ungrounded conductor in the circuit or equivalent for multiple parallel conductors, A	Size of bonding conductor	
	Copper wire, AWG or kcmil	Aluminum wire, AWG or kcmil
20	14	12
30	12	10
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250 kcmil
1600	4/0	350 kcmil
2000	250 kcmil	400 kcmil
2500	350 kcmil	500 kcmil
3000	400 kcmil	600 kcmil
4000	500 kcmil	800 kcmil
5000	700 kcmil	1000 kcmil
6000	800 kcmil	1250 kcmil

NOTE: Refer to Annex EEE and Annex V/RD for grounding supplied from separately derived a.c. sources.

2.6.3.4 Resistance of earthing conductors and their terminations

Replace item b) of the RD with the following:

b) For equipment powered an AC MAINS SUPPLY, if the PROTECTIVE CURRENT RATING of the circuit under test exceeds 16 A, the test current is 200% of the PROTECTIVE CURRENT RATING, up to a maximum test current of 500 A, and the duration of the test is as shown in Table 2E.

Additional subclause:

2.6.101 Bonding

For Class I PLUGGABLE EQUIPMENT TYPE A, the UPS shall provide sufficient terminals, earthed socket-outlets, or other means to permit, in the final installed system configuration, equipotential protective bonding to the UPS from other Class I equipment, including external UPS battery cabinets, irrespective of whether the UPS primary protective conductor is disconnected from its source. Any special bonding instructions shall be stated in the user's instructions.

Refer to Annex EEE for grounding supplied from separately derived a.c. sources.

A UPS having a separately derived output that is intended to be grounded in the field shall be marked with the following or equivalent words:

"The output a.c. circuit is considered as a separately derived source".

If local codes require grounding of this circuit, use terminal (identify terminal) for bonding this circuit to the ENCLOSURE. Ground the ENCLOSURE to a suitable grounding electrode in accordance with local code requirements.

2.7 Overcurrent and earth fault protection in primary circuits

2.7.1 Basic requirements

Additional paragraphs:

For components in series with the AC MAINS SUPPLY to the equipment, such as the supply cord, appliance coupler, EMI filter, and switch, short-circuit and earth fault protection may be provided by protective devices in the building installation. See Annex LLL.

AC output overcurrent protection shall be provided. Overcurrent protection need not be provided for permanently connected equipment when the overcurrent protection is provided by others in the final installation.

If reliance is placed on protection in the building installation, the installation instructions shall comply with 2.7.1/RD, except that for PLUGGABLE EQUIPMENT TYPE A, the buildings installation shall be regarded as providing protection in accordance with the rating of the wall outlet, and 2.7.1/RD does not apply.

NOTE: Building overcurrent protection is an acceptable method for protecting PLUGGABLE TYPE A UPS.

If the protection against electric shock of the UPS (see 2.1) relies on residual current devices in the building installation circuit and the design of the UPS is such that in any normal or abnormal operating condition a fault current to earth with d.c. component is possible, the installation instructions shall define (an) appropriate building residual current device(s).

Compliance is checked by inspection and functional test.

Additional subclause:

2.7.101 Battery supply circuit overcurrent protection

A battery supply circuit shall be provided with overcurrent and short-circuit protection as follows:

Where the batteries are installed inside the UPS, the battery supply circuit shall be provided with a protective device located adjacent to the battery connecting means before any component that may fail short-circuited, such as capacitors, solid-state devices, or similar components.

Where the batteries are installed outside the UPS, the location of the overcurrent-protective device shall be as indicated above, within the separate cabinet.

The rating of the overcurrent-protective device located internally shall be such as to protect against conditions described in 5.3/RD.

For a UPS to be used with a separated battery supply, the rating of the overcurrent-protective device shall be indicated in the instruction manual.

NOTE: The current rating of the conductors to be connected between the UPS and battery supply is determined from the requirements given in 3.2/RD.

When the overcurrent-protective device is not provided by the manufacturer, suitable installation instructions shall be provided for installation of an overcurrent-protective device.

Compliance is checked by inspection and tests.

2.7.102 Rating of protective device

The rating of the overcurrent protective device located internally shall be such as to protect against conditions described in 5.3.1/RD.

Compliance is checked by inspection and tests

2.7.103 Type and location of overcurrent protective devices

Overcurrent protection located within the UPS or stationary remote battery cabinet may be a supplementary overcurrent protective device or branch circuit protective device. Overcurrent devices in permanently connected battery cabinets shall be branch circuit protective devices.

2.8 Safety interlocks

Additional subclause:

2.8.101 Protection of service personnel

2.8.101.1 General

In addition to the requirements of 2.8/RD, clauses 2.8.101.2 to 2.8.101.8 apply to SERVICE PERSONS who find it necessary to reach over, under, across, and around an uninsulated electrical part or moving part to make adjustments or measurements while the UPS is energized.

2.8.101.2 Covers

Parts at HAZARDOUS VOLTAGE or energy level shall be so arranged and covers so located as to reduce the risk of electric shock or high current levels while covers are being removed and replaced.

2.8.101.3 Location and guarding of parts

Parts at HAZARDOUS VOLTAGE or energy level and moving parts that involve a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by a SERVICE PERSON adjusting or resetting controls, or the like, or performing mechanical functions that may be performed with the UPS energized, such as lubricating a motor, adjusting the setting of a control with or without marked dial settings, resetting a trip mechanism, or operating a manual switch.

2.8.101.4 Parts on doors

Parts at HAZARDOUS VOLTAGE or energy level, located on the rear side of a door, shall be guarded or insulated to reduce the likelihood of unintentional contact of the live parts by a SERVICE PERSON.

Compliance with 2.8.101.2 to 2.8.101.4 is checked by inspection, measurement, and use of the test finger (Figure 2A/RD).

2.8.101.5 Component access

A component that requires inspection, resetting, adjustment, servicing, or maintenance while energized shall be so located and mounted with respect to other components and with respect to grounded metal parts that it is accessible for electrical service functions without subjecting the SERVICE PERSON to the risk of electric shock, HAZARDOUS ENERGY LEVEL, high current, or injury to person by adjacent moving parts. Access to a component shall not be impeded by other components or wiring.

For an adjustment that is to be made with a screwdriver or similar TOOL when the UPS is energized, the requirement in 2.8.3/RD necessitates that protection be provided so that inadvertent contact with adjacent uninsulated hazardous live parts involving a risk of electric shock or HAZARDOUS ENERGY LEVEL is unlikely, taking into consideration that misalignment of the TOOL with the adjustment can result when an adjustment is attempted.

This protection shall be provided by

a) location of the adjustment means away from uninsulated hazardous live parts; or

b) a guard to reduce the likelihood that the TOOL will contact with uninsulated live parts.

Compliance is checked by inspection and, where necessary, by fault simulation.

2.8.101.6 Moving parts

Moving parts that can cause injury to persons during service operations shall be located or protected so that unintentional contact with the moving parts is not likely.

2.8.101.7 Capacitor banks

Capacitor banks shall be fitted with a means of discharge for protection of SERVICE PERSONS. A warning label shall be added if discharge time exceeds 10 s, stating the time taken to reduce the hazard to a safe level (not greater than 5 min) (see 1.2.8.5/RD and 1.2.8.8/RD).

2.8.101.8 Internal batteries

Internal batteries shall be so arranged as to minimize risk of electric shock from inadvertent contact with terminals, and the interconnection method shall be such as to minimize risk of short-circuiting and electric shock during servicing and replacement. See 1.7.13.105.

Compliance with 2.8.101.5 to 2.8.101.8 is checked by inspection.

2.9 Electrical insulation

2.9.1 Properties of insulating materials

Additional subclauses:

2.9.1.101 For PLUGGABLE EQUIPMENT TYPE B or permanently connected equipment intended to be installed by SERVICE PERSONNEL only, and marked as noted in 2.9.1.102, the humidity test in 2.9.2/RD is optional.

2.9.1.102 Equipment on which the humidity test has not been performed shall be labelled "Intended for a CONTROLLED ENVIRONMENT". See 1.7.2.104 (q) for instruction manual requirements.

3 Wiring, connections, and supply

The provisions of 3/RD apply, together with the following:

3.1 General

3.1.4 Insulation of conductors

Additional subclause:

3.1.4.101 Insulated conductors of different circuits within a UPS, including wires in a terminal box or compartment, shall be either separated by barriers or segregated and shall be so separated or segregated from uninsulated live parts connected to different circuits.

NOTE: For insulated conductors of different circuits, if each conductor is provided with insulation acceptable for the highest of the circuit voltages, no barriers or segregation is necessary.

3.2.5 Power supply cords

Additional subclause:

3.2.5.101 Cord-connected power supplies

Power supplies intended to be cord-connected shall be provided with a suitable length of cord having an additional conductor for grounding non-current-carrying conductive parts. The cord shall have an ampacity equal to or greater than the marked input in amperes, and shall be of the hard-usage type except:

a) as required by other clauses of this Standard;

b) a cord for a table-mounted power supply having a mass of 5 kg or less may be Type **SV** (or equivalent) provided that the cord is not longer than 1 m.

3.4 Disconnection from the mains supply

Additional subclause:

3.4.101 Disconnect device – General

A disconnect device shall be provided for the d.c. supply circuits and a.c. power output circuits of a permanently connected UPS and/or a remote supply/cabinet assembly. This disconnect device shall:

a) open all ungrounded conductors;

b) consist of either a manually operated switch or circuit breaker; and

c) employ an operating handle that is either accessible from outside of the enclosure or located under a hinged cover not requiring a tool for opening.

3.4.102 Constructions without additional disconnect means

The following constructions may be provided without additional disconnect means:

a) a UPS or battery supply having either a cord-and-plug or receptacle for connection to the output a.c. or d.c. circuit; and

b) a permanently connected UPS or battery supply provided with an instruction manual indicating that the disconnection means is to be provided by others and the function of the disconnect device marked for its function. See Annex LLL.

3.4.103 Disconnect device installed in a restricted access location

A disconnect device installed in a restricted access location as defined in 1.2.7.3/RD is considered accessible and shall either

a) be marked “This equipment is only to be installed either in a restricted area or an information technology equipment room”; or

b) have the equivalent cautionary statement included in the installation manual.

NOTE: Examples of a restricted access location are

– an electrical equipment room with locked doors accessible only to qualified personnel; and

– an enclosure housing electrical apparatus utilizing removable or sealable covers or bolted doors.

Compliance is checked by inspection.

3.5 Interconnection of equipment

Additional subclause:

3.5.101 Telecommunication connectors

Telecommunication-type connectors and terminals not intended for connection to the telecommunication network may be marked "Not for telecommunication (telephone) network" or an equivalent wording, or with the symbol shown in Annex CCC. The marking shall be located in a readily visible location adjacent to the connector.

4 Physical requirements

The provisions of 4/RD apply, together with the following:

4.1 Stability

Additional paragraph:

This test shall be applied to the unit with and without batteries.

4.3 Design and construction

4.3.8 Batteries

Additional subclause:

4.3.8.101 Battery requirements

4.3.8.101.0 General

Batteries shall comply with the following:

a) UL 1973, the Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications; or

b) UL 1989, the Standard for Valve Regulated or Vented Batteries with Aqueous Electrolytes, for lead acid batteries for UPS less than 70 kWhs.

4.3.8.101.1 Location

Vented batteries shall be contained in a separate enclosure or compartment from the power conversion portion of the UPS. This requirement does not apply to valve-regulated batteries and other sealed cell battery types. Vented batteries may be contained in the overall enclosure of the UPS, provided that a barrier, partition, or the equivalent is used to inhibit the passage of hydrogen gas from the battery area to the area of the enclosure containing the electronic components, switches, contactors, and controls used in the power conversion portion of the UPS.

4.3.8.101.2 General requirements for installation

4.3.8.101.2.1 Accessibility and maintainability

Battery poles (terminals) and battery connectors shall be accessible so that their fixings (hardware) can be tightened with the correct TOOLS. Batteries with liquid electrolyte shall be so located that the battery cell (vent) caps are accessible for electrolyte tests and readjusting of electrolyte levels.

Compliance is checked by inspection and application of the TOOLS and measuring equipment supplied or recommended by the battery manufacturer.

4.3.8.101.2.2 Insulation

Batteries in conductive casings shall be provided with adequate insulation between each other and from cabinets or compartments. Such insulation shall meet the requirements of 2.9/RD.

Compliance is checked by measurement and/or test.

4.3.8.101.2.3 Electrolyte spillage

VENTED BATTERY trays and cabinets shall have an electrolyte-resistive coating.

The ENCLOSURE or compartment housing a VENTED BATTERY shall be constructed so that spillage or leakage of the electrolyte from one battery will be contained within the ENCLOSURE and be prevented from

a) reaching the outer surfaces of the UPS, where contact with the USER is possible;

b) contaminating adjacent electrical components or materials; and

c) bridging required electrical distances.

Compliance is checked by inspection.

4.3.8.101.2.4 Ventilation

The ENCLOSURE or compartment housing a VENTED BATTERY shall be provided with proper ventilation so that any potentially explosive mixtures of hydrogen and oxygen are dispersed safely below non-hazardous levels.

For battery compartments (separate or combined), the method for determining the necessary airflow to ensure adequate dissolution levels is given in Annex HHH.

In combined apparatus of battery and electrical components, attention shall be given to prevent ignition of local concentrations of hydrogen and oxygen by adjacent operational arcing parts, such as contactors and switches close to battery vents/valves. This shall be achieved by the use of fully enclosed components, separation of battery compartments, or adequate ventilation, depending on the technical construction of the UPS and battery.

For battery rooms, proper information on the required flow of air shall be provided in the installation instructions if the battery installation is supplied with the UPS.

NOTE: Valve-regulated batteries require ventilation, although it may be considerably less than that for a vented cell. The battery manufacturer should be consulted for the frequency/rate of gas release in both normal and abnormal operating conditions.

Compliance is checked by inspection, calculation, and measurement.

4.3.8.101.2.5 Charging voltages

Batteries shall be protected against excessive charging voltages under any normal or single fault condition.

Compliance is checked by the tests described in 5.3/RD and 5.3.102 of this Standard.

4.5 Thermal requirements

4.5.3 Temperature limits for materials

Replace Table 4B/RD with the following:

Table 4.5.3.101A
Temperature limits

Part	Maximum temperature by resistance method for motors or windings with embedded thermal couple for motors or windings with embedded thermal couple, °C	Maximum temperature by thermocouple method, °C
Insulation, including winding insulation:		
– of Class A material 105	100[a]	90
– of Class E material 120	115[a]	105
– of Class B material 130	120[a]	110
– of Class F material 155	140[a]	130
– of Class H material 180	165[a]	155
– of Class C material 200	175[a]	165
– of Class N material 220	190[a]	180
– of Class R material 240	210[a]	200
	[see conditions b) and e) of Table 4B in 4.5.3/RD]	[see conditions b) and e) of Table 4B in 4.5.3/RD]

[a]If at the conclusion of the temperature limits test, the results reveal higher temperature limits of that in either column "resistance method/embedded thermal couple method" or "thermocouple method", the following requirements may be used to establish a temperature higher than that in the table. The manufacturer may elect to populate the motor or winding device with multiple embedded thermocouples to fully map out hot spot locations within the device; this could entail upwards of 20 embedded thermocouples to fully map hot spots within the device. However, those hot spot temperatures shall not exceed the material class temperature. For example, a Class N material with the multiple embedded thermocouple's method for hot spot testing shall not exceed 220°C in any single location.

Additional subclause:

4.5.3.101 For UPS with limited STORED ENERGY MODE duration and no provisions for additional batteries, the steady state temperature rise limits shown in Table 4.5.3.101A may be exceeded if the magnetic components meet the following criteria:

a) the magnetic components operate during STORED ENERGY MODE only or operate during other modes but are likely to attain higher temperature rise during STORED ENERGY MODE operation, and duration of STORED ENERGY MODE operation does not exceed 60 min and the recharge time exceeds 8 times the STORED ENERGY MODE duration; and

b) compliance is checked by conducting STORED ENERGY MODE operation immediately following the attainment of steady state temperatures during NORMAL LOAD operation. The maximum temperature rise of the windings measured immediately after expiration of stored energy duration shall not exceed the limits shown in Table 4.5.3.101B.

Table 4.5.3.101B
Permitted temperature limits for magnetic windings at the end of stored energy mode operation

Insulation class (°C)	Temperature by resistance method (°C)	Temperature by thermocouple method (°C)
105	127	117
120	142	132
130	152	142
155	171	161
180	195	185
200	209	199
220	216	206
240	234	224

4.6 Openings in enclosures

4.6.1 Top and side openings

Additional paragraph:

Openings vertically above bare parts at hazardous voltages in the top of a FIRE ENCLOSURE or an electrical ENCLOSURE shall not exceed 5 mm in any dimension unless the construction prevents vertical access to such parts, for example, by means of a tray or similar restriction (see Figure 4B/RD). This requirement does not apply to equipment having openings in the top of an ENCLOSURE with a height exceeding 1.8 m. Requirements to prevent accessibility to hazardous parts apply.

5 Electrical requirements and simulated abnormal conditions

The provisions of 5/RD apply, together with the following:

Additional subclause:

5.101 Short-circuit fault current withstand rating markings

All UPS equipment may be marked with a short circuit withstand rating of 5 kA without any construction evaluation or testing. UPS equipment may be marked with a short circuit withstand rating greater than 5 kA up to 10 kA if it complies with the relevant provisions in Annex NNN. UPS equipment may be marked with a short circuit withstand rating greater than 10 kA up to 200 kA if it complies with the relevant provisions in Annex NNN.

5.2 Electric strength

Additional subclause:

5.2.101 Electric strength test

The terminals of across-the-line capacitors shall withstand without breakdown 1000 volts plus twice rated a.c. voltage, or d.c. equivalent, applied for 1 min. Only capacitors not investigated to the standards listed in Annex III are subject to this test.

An additional pulse current test is under consideration.

5.3 Abnormal operating and fault conditions

Additional subclauses:

5.3.101 Forced ventilation test

5.3.101.1 A UPS having forced ventilation shall be operated in all modes with the rotor of a blower motor or fan locked. For a UPS having more than one blower motor or fan, the test shall be conducted with the rotor of each blower motor or fan locked, either one at a time or simultaneously.

5.3.101.2 A UPS having filters over ventilation openings shall be operated with the openings blocked to represent clogged filters. The test shall be conducted initially with the ventilation openings blocked approximately 50%, and then shall be repeated under fully blocked condition. A single blower or fan with a filter need not be tested under the fully blocked condition.

5.3.101.3 The ventilating means for an ENCLOSURE or a compartment housing a battery shall comply with the requirements in HHH.2, HHH.4, and HHH.5 under blocked blower or fan and clogged filter conditions described in 5.3.101.1 and 5.3.101.2.

5.3.102 Overcharge test

A battery supply that is to be evaluated with the UPS shall be subjected to 7 h of overcharging, connected to a supply circuit adjusted to 106% of nominal voltage, using a fully charged battery. Any OPERATOR-adjustable controls associated with the charger or charging circuit shall be adjusted for the most severe charging rate.

This requirement does not apply to a UPS provided with a regulating circuit preventing an increase in battery charging current and voltage when the a.c. input voltage is increased from rated value to 106% of rated value.

This test can be waived for batteries that comply with the requirements for valve regulated and vented lead-acid and nickel-cadmium batteries in Annex H of UL 1973, the Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications.

5.3.103 Output short-circuit test

5.3.103.1 The direct current battery circuit and the alternating current output circuit of the UPS shall be shorted separately. For the alternating current output circuit, this test shall be conducted in all modes of operation that allow power to be delivered through the UPS. Shorting shall include from line to neutral (if provided) and from line to line.

A battery supply is considered to comply with this requirement if

a) An overcurrent-protection device is employed having a short-circuit interrupting rating not less than the maximum fault current available from the battery supply (this measurement shall be taken at the output of the device, i.e., output terminals or output cable ends, as applicable); and

b) The maximum current from the battery supply during the STORED ENERGY MODE does not exceed the ampacity rating of the conductors connected to the batteries.

5.3.103.2 With reference to the direct current battery circuit mentioned in 5.3.103.1, the test shall be conducted on

a) the battery circuit of a UPS having an integral battery supply;

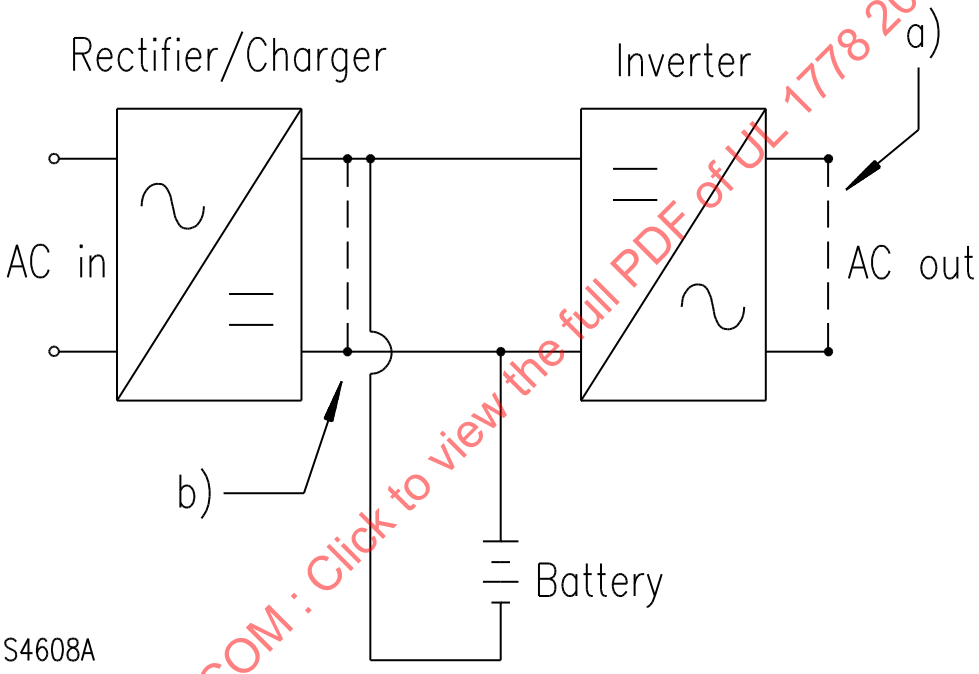
b) the direct current output of a UPS intended to be used with a remote battery supply; and

c) the direct current power circuit of a remote battery supply/cabinet assembly for use with a UPS and investigated under the requirements of this Standard.

During the tests described in items a) and c), batteries intended to be used with the UPS shall be used and shall be fully charged. During the test described in item b), batteries shall not be connected. The tests mentioned in items b) and c) may be combined into one test with the batteries connected. See Figure 5.3.103.2.

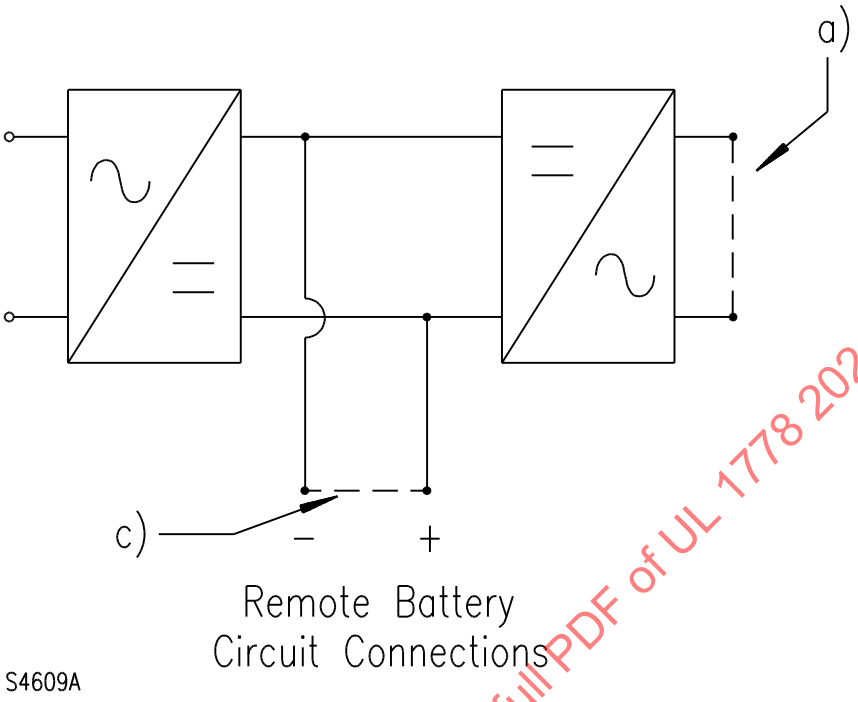
Figure 5.3.103.2

Output short-circuit tests



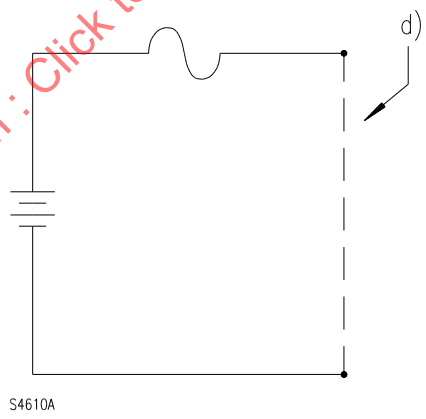
A unit having an integral battery supply in accordance with 5.3.103.2 (a)

Figure 5.3.103.2 (Cont'd)



A unit intended to be used with a remote battery supply in accordance with 5.3.103.2 (b)

Figure 5.3.103.2 (Cont'd)



A remote battery/supply cabinet in accordance with 5.3.103.2 (c)

NOTE 1 Short to be placed across

a) a.c. output terminals;

b) d.c. battery supply;

c) terminals of a UPS for connection to remote battery supply; and

d) terminals of remote battery supply.

NOTE 2 For TNV CIRCUITS, see 6/RD.

5.3.104 Abnormal test

If an abnormal test is terminated by operation of the intended BRANCH CIRCUIT overcurrent protective device or if the a.c. input overcurrent protection is relied upon for protection of an a.c. output receptacle, the instruction manual for such a unit shall include the word "CAUTION" and appropriate safety wording.

5.3.105 Output overload test

5.3.105.1 This test is to be conducted after thermal stabilization is reached during the mode of operation, which allows the output power to be delivered through the power conversion portion of the UPS. While delivering maximum rated output power to an adjustable resistive load connected to the output ac circuit, the UPS is to be subjected to the overload test described in 5.3.105.2.

5.3.105.2 The a.c. load is to be increased in increments of 10 % of the maximum output rating of the UPS and held for 1/2 h at each increment until:

a) Further change as a result of the test condition is not likely; or

b) The UPS transfers to the BYPASS mode.

Alternatively, thermal stabilization may be obtained with a load adjusted to result in maximum obtainable output power without causing operation of overcurrent protective devices, followed by increased incremental loading as described above.

If the output power of a unit is not delivered through the power conversion portion of the unit during the normal mode of operation, the incremental loading is to be conducted in the reserve mode, following temperature stabilization in the NORMAL MODE.

6 Connection to telecommunication networks

The provisions of 6/RD apply.

7 Connection to cable distribution systems

The provisions of 7/RD apply.

Annexes

All Annexes of the RD apply, together with the following:

Additional Annexes:

Annex AAA
(normative)

Additional component requirements

The following component test requirements are in addition to those noted in 5.3/RD. These tests are applied one at a time with the equipment operating at rated input voltage, STORED ENERGY MODE, BYPASS mode, or other mode of operation as required by the specific test. Unless otherwise noted, the test criteria of 5.3/RD apply.

AAA.1 Capacitor surge current test

AAA.1.1 With the input a.c. power to the equipment disconnected, the battery supply fully charged, and the inverter storage capacitors discharged, the battery supply voltage shall be applied to the inverter input circuit by closing the battery supply disconnect switch intended to be used with the equipment. This test is not required for equipment:

a) not having a manually operated battery supply disconnect switch; or

b) having a battery supply disconnect switch that will not close onto the discharged capacitors without a.c. input power applied to the equipment.

AAA.1.2 A d.c. power source other than batteries may be used, provided that the source is capable of delivering an inrush current not less than that available from a fully charged battery supply.

AAA.2 Oil-filled capacitor fault test

AAA.2.1 In equipment having a bottom-ventilated ENCLOSURE containing oil-filled capacitors, the capacitors shall comply with the relevant requirements of UL 810 and CSA C22.2 No. 190.

AAA.2.2 This test is not required for equipment that complies with 4.7/RD.

AAA.3 Electrolytic capacitor fault test

For a UPS having d.c. electrolytic inverter storage capacitors, a fault in one of the capacitors in the inverter storage capacitor bank shall be simulated. This shall be accomplished by connecting the capacitor under test in reverse while the input supply to the equipment is not energized. The equipment shall then be energized. If the inverter is functional, then rated output load shall be applied.

Note: The reverse capacitor test is intended to simulate capacitor failure in the field due to the aging process and is not intended to simulate an error in the manufacturing process.

AAA.4 Control devices

AAA.4.1 If the circuit controlled has a POWER FACTOR of less than 75%, the switch or other control device shall:

a) have a horsepower rating based on the full-load ampere equivalent rating;

b) have a current rating of not less than twice the rated input current; or

c) withstand the overload and endurance tests specified in AAA.4.2 and AAA.4.3.

NOTE Switching devices rated in accordance with Table AAA.1 are considered to comply with this requirement.

Table AAA.1
Horsepower rating versus pilot duty rating

Horsepower rating 1 Phase (120 – 600 V)	Alternating current pilot duty rating, VA
1/10	125 (light duty)
1/2	360 (standard duty)
1	720 (heavy duty)

AAA.4.2 Overload (control devices)

AAA.4.2.1 A control device, except as permitted by AAA.4.2.6, supplied as part of the equipment shall be capable of making and breaking for 50 cycles of operation at intervals of 10 s a current equal to 150% of the maximum load current at the actual POWER FACTOR involved.

AAA.4.2.2 The current-interrupting test of AAA.4.2.1 shall be made at the nominal supply voltage. The open-circuit voltage of the supply circuit shall be not less than 100%, or more than 150%, of the test voltage, except that a higher voltage may be employed if agreeable to those concerned. The current-carrying capacity of the supply circuit shall be such that the closed-circuit voltage with RATED CURRENT flowing is within ±2.5% of the test.

AAA.4.2.3 The ENCLOSURE of equipment designed for use on a system having one conductor grounded shall be connected during the test through a 3 A fuse to the grounded conductor of the circuit. If a power supply is designed for use on other types of systems, the frame shall be connected through such a fuse to the live pole least likely to arc to ground.

AAA.4.2.4 The test cycle shall be 1 s ON and 9 s OFF, if the nature of the switch permits the test to be so made.

AAA.4.2.5 There shall be no electrical or mechanical failure of the switch and no undue pitting, burning, or welding of the contacts, and there shall be no flashover to the ENCLOSURE.

AAA.4.2.6 As an alternative to the overload test specified in AAA.4.2.1, a switch or relay used to control an internal load may be tested by making and breaking for 50 cycles of operation at the rate of 6 cycles per minute the load that it is intended to control, with the equipment operation at 110% of the nominal supply.

AAA.4.3 Endurance (control devices)

AAA.4.3.1 A control device supplied as part of the equipment shall be capable of making and breaking for 6000 cycles of operation at intervals of 10 s, a current equal to the maximum load current at the actual POWER FACTOR involved. There shall be no electrical or mechanical failure of the switch and no undue pitting, burning, or welding of the contacts.

AAA.4.3.2 The conditions for the endurance test shall be the same as the conditions for the overload test as indicated in AAA.4.2.2 to AAA.4.2.4.

AAA.5 Static transfer switches

AAA.5.1 General

AAA.5.1.1 Failure or malfunctioning of a solid state power-switching component shall result in a fail-safe condition (see AAA.5.3.2) under either of the following conditions:

a) failure of a solid state power-switching component and another solid-state component such as in a control circuit; or

b) failure of a solid state power-switching component and a mechanical component (e.g., relay, contactor, or the like) for static switches employing such a device in conjunction with a power-switching semiconductor. Failure analysis of the mechanical device shall not be required if the current through the contacts is the same or less than the RATED CURRENT of the device and the overload test evaluation is performed at six times RATED CURRENT. The control circuit that operates the mechanical device shall be subjected to a component failure analysis.

NOTE The intent of AAA.5.1.1 is to prevent voltage from appearing where it is not expected (such as on the PRIMARY POWER line) upon failure of a power-switching component and another solid-state or mechanical component.

AAA.5.1.2 If a relay is used to transfer from the a.c. input line to the inverter, the overload current rating of the relay contacts shall be greater than the peak current that flows through the relay contacts during the output short-circuit test of 5.3.103. The overload current rating shall be considered to be 150% of the rated load current for devices rated in A and 600% of the rated load current for devices rated in horsepower.

AAA.5.1.3 Overcurrent protection shall be provided for each static switch source in each ungrounded line. If the overcurrent devices are not integral with the equipment, they shall be specified on a label.

AAA.5.2 Isolating means

AAA.5.2.1 Mechanical isolation means shall be provided for servicing the power supply where failure of or leakage through a solid-state device could result in transfer of energy between two or more power sources. The disconnecting means shall be provided as an integral part of the equipment and be connected into the circuit in such a way that when opened it will prevent transfer of energy between the different power sources. To facilitate servicing, barriers (or other suitable means) and/or marking shall be provided for protecting SERVICE PERSONNEL from live parts located ahead of isolating switches.

AAA.5.2.2 Automatic mechanical isolating means shall be provided as an integral part of the equipment to prevent transfer of energy from a single-branch private supply system (such as a battery and inverter) to a branch of a multibranch system (such as a PRIMARY POWER system) upon loss or shutdown of the PRIMARY POWER system unless BACKFEED is not possible when evaluated in accordance with AAA.5.1.1. The isolating means may be a relay, contactor, motorized circuit breaker, or other device with an air gap between contacts.

AAA.5.3 Tests

AAA.5.3.1 Static transfer switches shall be tested as part of the equipment to determine their acceptability for the application.

AAA.5.3.2 Compliance with the requirements of AAA.5.1.1 shall be verified by shorting one power switching component (e.g., SCR) and placing one fault on another component, such as in the control circuit. The fault placed on the component shall simulate the failure mode of that component (e.g., cathode to anode short on SCR, emitter to collector short or open on a transistor, or welding of a relay contact in the control circuit). This analysis shall be performed first with the PRIMARY POWER supply energized and repeated with the PRIMARY POWER supply not energized.

AAA.5.3.3 The electric strength test shall be performed on a static transfer switch with the solid-state devices, or assemblies, normally connected between the systems disconnected.

AAA.6 Transfer switches

AAA.6.1 Failure of a mechanical transfer switch shall not result in transfer of energy from a single-branch private supply system (such as a battery and inverter) upon loss or shutdown of the multibranch system (such as a PRIMARY POWER system). A failure analysis of the mechanical transfer switch shall not be required if the current through the contacts is the same or less than the RATED CURRENT of the switch and the overload test evaluation is performed at six times the RATED CURRENT. The control circuit that operates the mechanical transfer switch shall be subjected to a failure analysis.

AAA.6.2 A BYPASS switch or maintenance BYPASS used to connect the protected load directly to the BYPASS source shall comply with the requirements of AAA.6.3.

AAA.6.3 A BYPASS switch or maintenance BYPASS, when tested in conjunction with a UPS, shall comply with the load transfer test specified in AAA.7 and the applicable requirements of this Standard.

AAA.7 Load transfer

AAA.7.1 For an output transfer switch to be tested in accordance with AAA.6.3, the BYPASS a.c. source shall be displaced from the a.c. output of the equipment by:

a) 120 electrical degrees for a 3-phase supply; or

b) 180 electrical degrees for a single-phase supply.

The transfer switch shall be subjected to one operation of switching the load from the a.c. output of the equipment to a BYPASS a.c. source with the load adjusted to draw maximum rated a.c. power.

AAA.7.2 For equipment employing a BYPASS switch having a control to prevent switching between two a.c. sources out of synchronization, the test shall be conducted under the condition of a component failure if such a condition can result in an out-of-phase transfer between the two a.c. sources of supply. The fault placed on the component shall simulate the failure mode of that component (e.g., cathode to anode short on SCR, emitter to collector short or open on a transistor, or welding of a relay contact in the control circuit).

AAA.7.3 A solid-state BYPASS switch shall continue to operate normally after completion of the test described in AAA.7.1.

AAA.8 Bus bars

AAA.8.1 Each bus bar shall be plated at each joint with tin, silver, or nickel unless

a) the joint is welded or brazed;

b) the current at the joint is 600 A or less; or

c) a suitable oxide-inhibiting compound is used over the joint surfaces.

Other coatings may be used for aluminum bus bars if investigated for the application in accordance with the requirements for current-carrying parts described in AAA.8.13.

AAA.8.2 The bending of a bus bar shall not result in visible cracks, but roughening or slight surface crazing shall be acceptable.

AAA.8.3 Each riveted joint connection shall have a spring washer at one end and either a spring washer or a flat washer at the other end (see AAA.8.5 and AAA.8.6), unless, as an alternative, the connection is investigated in accordance with the applicable requirements of AAA.8.13.

Washers may be omitted in a connection rated 225 A or less employing only copper bus bars.

AAA.8.4 Each bolted joint connection shall employ a spring washer at one end (see AAA.8.6), unless the connection is investigated in accordance with the applicable requirements of AAA.8.13.

A spring washer may be replaced with a split ring lock washer and flat washer if each bus in the joint is copper or if each aluminum bus in the joint has a tensile yield strength of at least 20 000 psi (138 MPa).

A flat washer, a split-ring lock washer, or a bolthead that complies with AAA.8.5 may be used in place of a spring washer if the joint does not include any aluminum or if aluminum bolts are used with aluminum bus bars.

AAA.8.5 The flat washer referenced in AAA.8.3 and AAA.8.4 shall have a thickness of at least one-sixth that of the diameter of the rivet shank or bolt and shall have an outer diameter at least 150% of the rivet shank or bolt and not less than the outer diameter of any adjacent spring washer.

AAA.8.6 The spring washer referenced in AAA.8.3 and AAA.8.4 shall be a dished washer of stainless or hardened and tempered steel, having an outer diameter not less than 150% of the bolt diameter, a thickness not less than one-eighth of the bolt diameter, and dished not less than 3-1/2% of the bolt diameter.

AAA.8.7 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current-carrying part shall not depend on the dimensional integrity of a thermoplastic material.

AAA.8.8 Insulation over bus bars, such as tape or tubing, shall not be provided over a bolted joint, so that tightening of the joint can be accomplished without removal of the insulation.

AAA.8.9 The current density of a bus bar shall not be more than that indicated in Table AAA.8.1 or Table AAA.8.2 unless

a) it has characteristics that will not result in maximum bus bar temperatures exceeding the values specified in Table AAA.8.3; or

b) it is contained in a unit having forced air ventilation that will not result in maximum bus bar temperatures exceeding the values specified in Table AAA.8.3.

AAA.8.10 The cross-section of the bus bar referenced in Table AAA.8.1 or Table AAA.8.2 may be reduced by not more than 5% due to rounding, shaping, or dimensional tolerances.

AAA.8.11 Part of the bus bar material may be removed for slots or holes (whether used or not), provided that the remaining material at any cross-section along the length of the bus bar has at least 70% of the required ampacity in accordance with Table AAA.8.1 or Table AAA.8.2 and AAA.8.10, and provided that:

a) the remaining metal in any 6 in (152 mm) length of bus is at least 93% of the metal of a bus having the required ampacity in accordance with Table AAA.8.1 or Table AAA.8.2 and AAA.8.10. For example, a 1 in (25.4 mm) wide bus could have 9/32 in (7.1 mm) holes on 1 in centres, or a 4 in (102 mm) wide bus could have 13/32 in (10.3 mm) wide slots 3.2 in (81.3 mm) long every 6 in (152 mm); or

b) the bus bar has characteristics that will not result in temperatures exceeding the values specified in Table AAA.8.3.

AAA.8.12 The limitations of current density mentioned in Table AAA.8.1 and Table AAA.8.2 do not apply to

a) a connecting strap, bus, or the like comprising a part of a circuit breaker, switch, or fuseholder employed in the unit; and

b) a portion of a strap, bus, jumper, or the like adjacent and connected to a terminal of a switch, circuit breaker, fuse, or fuseholder, but not more than 1 in (25.4 mm) from the terminal, if a reduced cross-section in that portion is necessary because of the recessing of the terminal or because of barriers adjacent to it.

Table AAA.8.1
Ampacity of single or multiple bus bars and clamped joints

Bus bar material[a]	Current	Current density in A per square in (6.45 cm^2)	
		Bus bar cross-section	Contact area at clamped joints
Copper	0 – 600 A	1000[c]	200
Copper	Over 600	1000[c]	200[d,e]
Aluminum[b]	Any	750[c]	200[d,e]

[a] Multiple bus bars in parallel shall be of the same material.

[b] Minimum conductivity of 55% of International Annealed-Copper Standard.

[c] See also Table AAA.8.2 for 800 A maximum single bus bars.

[d] See AAA.8.1 and AAA.8.10 to AAA.8.12.

[e] Joints bolted and plated with tin, silver, or nickel.

Table AAA.8.2
Rating and sizes of single bus bars – 800 A maximum[a,d]

Current rating, A	Copper bus				Aluminum bus[c]			
	Bus size[b]		Cross-section		Bus size[b]		Cross-section	
	in	mm	in^2	mm^2	in	mm	in^2	mm^2
225	0.125 x 0.875	3.2 x 22.2	0.109	70.3	0.250 x 0.875	6.4 x 22.2	0.219	141.3
400	0.250 x 1.500	6.4 x 38.1	0.375	242.0	0.250 x 2.000	6.4 x 50.8	0.500	322.6
600	0.250 x 2.000	6.4 x 50.8	0.500	322.6	See Table AAA.8.1	See Table AAA.8.1	0.800	518.1
800	0.250 x 3.000	6.4 x 76.2	0.750	483.9	See Table AAA.8.1	See Table AAA.8.1	1.067	688.4

[a] See AAA.8.10 to AAA.8.12. For multiple buses in parallel, refer to Table AAA.8.1. The minimum contact area at a clamped joint shall provide not less than 1 in^2 (6.45 cm^2) per 200 A.

[b] A bus bar having other dimensions may also be acceptable if it has not less than the cross-sectional area specified in the table and if it has equivalent rigidity.

[c] Minimum conductivity of 55% of International Annealed-Copper Standard.

[d] Bolted joints and bus bars plated with tin, silver, or nickel.

Table AAA.8.3
Maximum bus bar temperatures

Component	°C
Bus bar	140[a]

[a]The maximum permitted temperature for copper construction is determined by the temperature limit of support materials or insulation of connecting wires or other components. A maximum temperature of 140 °C is recommended. The bus bar temperature limit requirement shall apply irrespective of the presence or absence of plating of bus bars.

AAA.8.13 Bus bar tests

AAA.8.13.1 An aluminum bus bar employing a coating in accordance with AAA.8.1 or a bus bar that has the alternative clamped joint construction permitted by AAA.8.3 and AAA.8.4 shall be subjected to the tests described in AAA.8.13.2 to AAA.8.13.4.

AAA.8.13.2 The temperature of the bus bar joint shall be measured during the temperature test described in 4.5/RD and shall comply with the maximum temperature specified in Table AAA.8.3.

AAA.8.13.3 The temperature rise at the joint during the five hundredth cycle shall not be more than 15 °C (27°F) higher than the temperature rise at the end of the 25th cycle.

AAA.8.13.4 The test sample shall consist of an assembly of bus bars connected together to form a series circuit. The bus bars shall be clamped together with the joint construction used in actual production. The number and size of the bus bar shall represent the maximum ampere rating and the maximum current density in which the joint construction is employed. This may necessitate more than one test. The length of each bus bar shall be 2 ft (609 mm). The bus bar shall be connected to a power supply by any convenient means that will not affect the joint temperature. The power supply shall be adjusted to deliver a value of current that will result in a temperature of 75 °C (135 °F) above room temperature at the joint. The assembly shall then be subjected to a 500 cycle test. At the end of the 24th cycle, the current shall be readjusted to bring the temperature of the joint to 75 °C (135 °F) above room temperature, and this current value shall be maintained for the remainder of the cycling test. At the end of the 25th and 500th cycle, the temperatures shall be recorded. The temperatures shall be measured on both sides of the joint as close as possible to the bolt or rivet. The cycling rate shall be 3 h ON and 1 h OFF. The ON period during which temperatures are recorded may be extended to more than 3 h if necessary for the joint to attain thermal equilibrium.

NOTE: The length of the bus bar may be less than 609 mm (2 ft) with the concurrence of those concerned.

Annex BBB
(informative)

Examples of NORMAL LOAD conditions

(see Clause 1.2.2.1)

BBB.1 General

BBB.1.1 The UPS is loaded according to the manufacturer's specifications given in the instruction manual.

If the specifications are missing, the following NORMAL LOAD conditions can be used.

A UPS can be loaded with different linear and NON-LINEAR LOADS.

A LINEAR LOAD is defined by the fact that with a sinusoidal voltage supplied to such a load, the current will be sinusoidal also.

A NON-LINEAR load with sinusoidal voltage has non-sinusoidal current.

BBB.1.2 The most common types of LINEAR LOADS are:

a) resistive;

b) inductive-resistive; and

c) capacitive-resistive.

BBB.1.3 A NON-LINEAR LOAD can be:

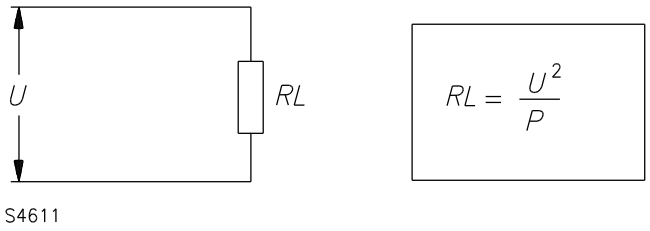
a) rectified capacitive load; or

b) thyristor or transductor controlled load (phase control)

BBB.1.4 In the low power range below 3 kVA, the rectifier in bridge connection with capacitive load is the most common.

BBB.2 For resistive loads, the UPS is loaded with a resistor (RL) up to nominal power.

Figure BBB.2.1



Key:

U is the output voltage in volts (V)

P is the ACTIVE OUTPUT POWER in watts (W)

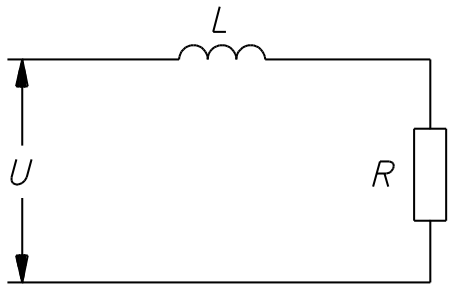
RL is the resistance in ohms (Ω)

BBB.3 For inductive-resistive loads, an inductance is connected in series or in parallel with a resistor.

The resistor (R) and inductance (L) are given by the following formulas:

a) series connection

Figure BBB.3.1



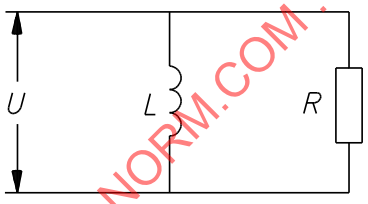
S4612

$$R = \frac{U^2}{S}\lambda \quad (\Omega)$$

$$L = \frac{U^2\sqrt{1-\lambda^2}}{2\pi fS} \quad (H)$$

b) parallel connection

Figure BBB.3.2



S4613

$$R = \frac{U^2}{S\lambda} \quad (\Omega)$$

$$L = \frac{U^2}{2\pi fS\sqrt{1-\lambda^2}} \quad (H)$$

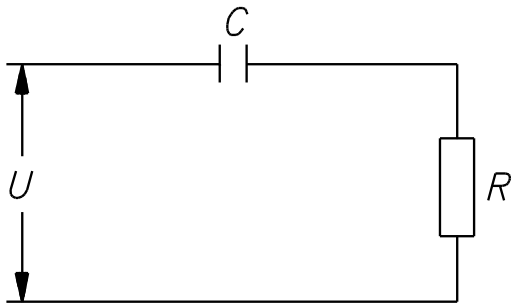
Key:
U is the output voltage in volts (V)
R is the resistance in ohms (Ω)
L is the inductance in henrys (H)
f is the frequency in hertz (Hz)
S is the APPARENT OUTPUT POWER in VA
λ is the POWER FACTOR (P/S)

BBB.4 For capacitive-resistive loads, a capacitance and a resistor are connected either in series or in parallel.

The resistor (R) and capacitance (C) are given by the following formulas:

a) series connection

Figure BBB.4.1



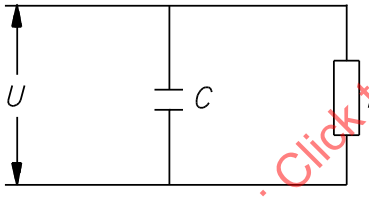
$$R = \frac{U^2 \lambda}{S} \quad (\Omega)$$

$$C = \frac{S}{2 \pi f U^2 \sqrt{1 - \lambda^2}} \quad (F)$$

S4614

b) parallel connection

Figure BBB.4.2



$$R = \frac{U^2}{S \lambda} \quad (\Omega)$$

$$C = \frac{S \sqrt{1 - \lambda^2}}{2 \pi f U^2} \quad (F)$$

S4615

Key:

U is the output voltage in volts (V)

R is the resistance in ohms (Ω)

C is the capacitance in farads (F)

f is the frequency in hertz (Hz)

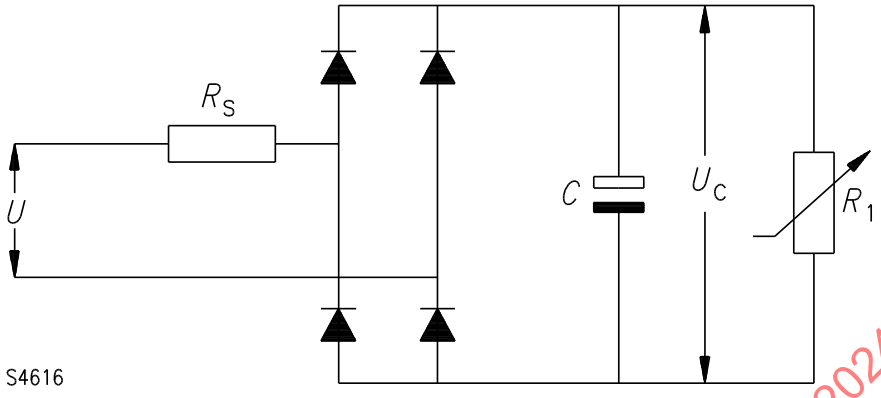
S is the APPARENT OUTPUT POWER in VA

λ is the POWER FACTOR (P/S)

BBB.5 To simulate a rectified capacitive load, the UPS is loaded with a diode rectifier bridge, which has a capacitor and a resistor in parallel on its output.

NOTE The following is related to the frequency of 50 Hz to an output voltage distortion max 8% according to IEC 61000-2-2 and to POWER FACTOR = 0.7 (i.e., 70% of the apparent power S will be dissipated as ACTIVE POWER in the two resistors R_1 and R_s).

Figure BBB.5.1



Key:

U is the output voltage in volts (V)

C is the capacitance in farads (F)

U_c is the rectified voltage in volts (V)

R_1 is the load resistance in ohms (Ω), representing 66% of ACTIVE POWER of the total apparent power S

R_s is the serial line resistance in ohms (Ω), representing 4% of ACTIVE POWER of the total apparent power S (the 4% is according to IEC/TC 64 proposal of voltage drop in power lines)

A ripple voltage, 5% peak to peak of the capacitor voltage U_c, corresponds to a time constant of R_1 x C = 0.15 s.

Observing peak voltage, distortion of line voltage, voltage drop in line cables, and ripple voltage of rectified voltage, the average of the rectified voltage U_c will be as follows:

$U_c = 2 \times 0.92 \times 0.96 \times 0.975 \times U = 1.22 \times U$

and the values of resistors R_s, R_1, and capacitor C will be as follows:

$R_s = 0.04 \times U^2 / S$

$R_1 = U_c^2 / (0.66 \times S)$

$C = 0.15 \text{ s} / R_1$

The voltage drop in the diode bridge is neglected.

Annex CCC
(informative)

Safety symbols and their meanings

Symbol	Description
	Stand–by
	Dangerous voltage
	Attention or consult accompanying documents
	Output
	Input
	Off (power: disconnection from mains) or output disabled
	ON (power: connection to the mains) or output enabled
	Alternating current
	Direct current
N	Connection for the neutral conductor on PERMANENTLY INSTALLED EQUIPMENT
	Earth (ground)

S4619

(Continued)

(Continued)

Symbol	Description
	Protective earth (ground)
	Noiseless (clean) earth (ground)
	Battery check
	Test (check) button
	Battery (mode)
	Variability in steps
	Overload
	Load status
	Alarm silence
	Not for telecommunication (telephone) network
	Recycle
	Do NOT dispose with ordinary trash

S4620B

Annex DDD
(normative)

Harmonic distortion test

DDD.1 When tested as described in DDD.3, the total rms of the harmonic voltages, excluding the fundamental, delivered by a UPS shall not exceed 30% of the fundamental rms output voltage, and the rms voltage of any single harmonic shall not exceed 15% of the fundamental rms output voltage. The specified output voltage distortion levels may be exceeded if the UPS complies with DDD.4.

DDD.2 If the inverter portion of the UPS does not operate to supply output during the normal mode of operation, the UPS shall be operating in STORED ENERGY MODE during this test.

DDD.3 With reference to the requirements in DDD.1, the UPS shall be connected to an adjustable resistive load at rated power. The measurements shall be made at open circuit and with the UPS delivering 25, 50, 75, and 100% of rated power.

DDD.4.1 The tests described in DDD.4.2 and DDD.4.3 shall be conducted to investigate the acceptability of output voltage harmonic distortion exceeding the levels specified in DDD.3.

DDD.4.2 The load shall be energized from the following sources, one at a time:

a) the a.c. output of the UPS while the output is supplied by the inverter portion of the UPS; and

b) a PRIMARY POWER source of sinusoidal voltage adjusted to the same rms value as obtained from the output of the UPS inverter. While energized from each source, temperatures of components that may be affected by harmonic voltages shall be measured. Such components include, but are not limited to,

1) linear transformer winding;

2) d.c. filter capacitor in a switch-mode power supply;

3) across-the-line capacitor in an electromagnetic interference (EMI) filter;

4) continuous duty capacitor start motor winding; and

5) continuous duty shaded pole motor winding.

The maximum temperatures obtained while the load is supplied from the UPS shall not exceed by more than 5 °C (9 °F) the corresponding maximum temperatures obtained when the load is supplied from the PRIMARY POWER source.

DDD.4.3 If the output voltage distortion of the unit varies with the amount of load connected to the UPS, the condition of loading resulting in the highest level of distortion shall be used for this test. To accomplish this, it may be necessary to connect other loads in parallel with the load under test.

Annex EEE
(normative)

Earthing and bonding

(see 2.6.)

EEE.1 General requirements

EEE.1.1 An output a.c. power circuit shall be grounded if the circuit:

a) has no electrical connection to supply conductors originating in another wiring system;

b) is rated 50 to 600 V; and

c) is as follows (other configurations may require grounding):

1) a circuit that is grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 V. This requires that one conductor of each of the following circuits does not exceed 150 V and is grounded:

(i) 120 volts, 2-wire;

(ii) 240/120 volts, single-phase, 3-wire;

(iii) 208/120 volts, two-phase, 3-wire; and

(iv) 208/120 volts, three-phase, 4-wire.

2) a circuit nominally rated 480 wye/277 V, 3-phase, 4-wire, in which the neutral is used as a circuit conductor; and

3) a circuit nominally rated 240/120 V, 3-phase, 4-wire, in which the midpoint of one phase is used as a circuit conductor.

Reference should be made to local electrical codes for other circuits.

EEE.1.2 The conductor to be grounded shall be as follows:

a) single-phase a.c. system, 2-wire: one conductor;

b) single-phase a.c. system, 3-wire: the neutral conductor;

c) multiphase a.c. system having one wire common to all phases: the common conductor; and

d) multiphase a.c. system where one phase is used as a single-phase, 3-wire, a.c. system: the neutral conductor.

EEE.1.3 Grounding of the circuits shall be made by a bonding jumper connected between the grounded conductor and to:

a) the ENCLOSURE of a metal-enclosed unit; or

b) the metal chassis that is bonded to the equipment's protective earthing means of a nonmetallic enclosed unit.

The size of the bonding jumper shall be as specified in column 4 of Table EEE.1.

EEE.1.4 The circuit may be grounded in the field if the following provisions are implemented:

a) A field-wiring terminal is connected to the circuit by a bonding jumper. The size of the terminal and jumper shall not be less than that specified in column 4 of Table EEE.1.

b) The field-wiring terminal is identified as the neutral by a metallic-plated coating substantially white in colour that is readily distinguishable from the other terminals, or proper identification of the terminal, such as a marking on the unit, or an indication on a wiring diagram attached to the unit, or information provided in the instruction manual; and

c) the following marking is provided identifying the circuit as a separately derived source: “The output a.c. circuit is considered as a separately derived source. If local codes require grounding of this circuit, use terminal '_____' for bonding this circuit to the ENCLOSURE. Ground the ENCLOSURE to a suitable grounding electrode in accordance with local code requirements. Refer to the instruction manual”.

EEE.1.5 A fixed unit shall be provided with a terminal that complies with EEE.2 for connection of the grounding electrode conductor to the metal ENCLOSURE or equipment grounding conductor. The terminal shall be:

a) capable of securing a conductor of a size as specified in column 3 of Table EEE.1; and

b) marked with the following words: “Grounding Electrode Terminal”.

For an a.c. output circuit of a unit having a polarized receptacle, lead, or terminal identified as a grounded circuit that is not grounded at the unit itself because of an electrical connection to supply conductors originating in another wiring system, a potential involving risk of electric shock shall not exist between ground and the grounded circuit contact, terminal, or lead.

EEE.1.6 Compliance with the requirements of EEE.1 shall be determined by neutral-to-ground potential measurement. The potential shall not exceed 30 V rms (42.4 V peak) at no-load and full-load conditions.

EEE.2 Wiring terminals

EEE.2.1 Equipment field-wiring terminals shall be marked as follows:

a) "Use Copper Conductors Only" if the terminal is acceptable only for connections to copper wire;

b) "Use Aluminum Conductors Only" or "Use Aluminum or Copper-Clad Aluminum Conductors Only" if the terminal is acceptable only for connection to aluminum wire; and

c) "Use Copper or Aluminum Conductors" or "Use Copper, Copper-Clad Aluminum, or Aluminum Conductors" if the terminal is acceptable for connection to either copper or aluminum wire.

EEE.2.2 Except as provided in EEE.2.3, a wiring terminal shall be provided with a pressure terminal connector that is securely fastened in place; for example, firmly bolted or held by a screw (not a crimping type).

EEE.2.3 A wiring terminal may be provided with a pressure terminal connector that is not securely fastened in place if the construction is one of the following:

a) A wire-binding screw may be employed at a wiring terminal intended for connection of a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs, a cupped washer, or the equivalent is provided to hold the wire in position.

b) A pressure terminal connector, including a crimping type, may be field-installed if all of the following conditions are met:

1) The connector assemblies are available from the unit manufacturer and are specified in the instruction manual.

2) The fastening hardware required for an effective installation is either provided with the unit or specified in the instruction manual.

3) The installation of the connector shall not involve the loosening or disassembly of parts other than a cover. The means for securing the connector shall be readily accessible for tightening before and after the installation of conductors.

4) Instructions are provided identifying the TOOL and procedure for installing the connector if other than an ordinary TOOL is required.

5) Installation of the connector in its intended manner will not result in a risk of hazard as defined by this Standard.

EEE.2.4 A wiring terminal shall be prevented from turning or shifting in position by a means other than friction between surfaces. This may be accomplished by two screws or rivets; square shoulders or mortises; a dowel pin, lug, or offset; a connecting strap or clip fitted into an adjacent part; or an equivalent method.

EEE.2.5 A wiring terminal that secures the wire by crimping need not be prevented from turning if the required creepage and CLEARANCE distances are maintained with the terminal oriented in the position resulting in the least spacing between adjacent terminals or between the terminal and conductive parts.

EEE.2.6 A wire-binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm diameter head) unless

a) a No. 8 (4.2 mm diameter head) screw is used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor or a 16 or 18 AWG (1.3 or 0.82 mm^2) SELV CIRCUIT conductor; or

b) a No. 6 (3.5 mm^2 diameter head) screw is used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) SELV CIRCUIT conductor.

A wire-binding screw shall thread into metal.

A terminal plate tapped for a wire-binding screw shall be of metal with a minimum thickness of 0.050 in (1.27 mm).

A terminal plate tapped for a wire-binding screw may be of metal with a minimum thickness less than 0.050 in (1.27 mm) if the terminal plate is used for a SELV or limited energy circuit and the tapped threads have adequate mechanical strength to withstand the tightening torque test specified in Table EEE.3.

There shall be two or more full threads in the metal of a terminal plate. The metal may be extruded at the tapped hole to provide at least two full threads.

Two or more full threads are not required in the metal of a terminal plate if the terminal plate is used for a SELV or limited energy circuit and the tapped threads have adequate mechanical strength to withstand the tightening torque test specified in Table EEE.3.

EEE.2.7 A terminal for connection of a grounded conductor of an a.c. power circuit shall be identified as the neutral by one of the following methods:

a) a metallic-plated coating substantially white in colour that is readily distinguishable from the other terminals;

b) proper identification of the terminal, such as a marking on the unit, or an indication on a wiring diagram attached to the unit, or information provided in the instruction manual; or

c) if field wiring leads are provided, the lead intended to be grounded shall have a white or gray colour and shall be readily distinguishable from other leads.

Table EEE.1
Size of circuit bonding, equipment-grounding, and grounding electrode conductors

Column 1	Column 2				Column 3			
	Minimum size of grounding electrode conductor AWG or kcmil (mm^2)				Minimum size of output circuit bonding jumper AWG or kcmil (mm^2)[d]			
Maximum current rating[a] (A)	Copper		Aluminum or copper-clad aluminum		Copper		Aluminum or copper-clad aluminum	
20	8	(8.4)	6	(13.3)	8	(8.4)	6	(13.3)
60	8	(8.4)	6	(13.3)	8	(8.4)	6	(13.3)
90	8	(8.4)	6	(13.3)	8	(8.4)	6	(13.3)
100	6	(13.3)	6	(13.3)	6	(13.3)	4	(21.2)
150	6	(13.3)	4	(21.2)	6	(13.3)	4	(21.2)
200	4	(21.2)	2	(33.6)	4	(21.2)	2	(33.6)
300	2	(33.6)	1/0	(53.5)	2	(33.6)	1/0	(53.5)
400	1/0[b]	(53.5)	3/0[b]	(85)	1/0[b]	(53.5)	3/0[b]	(85)
500	2/0	(67.4)	4/0	(107.2)	1/0	(53.5)	3/0	(85)
600	2/0	(67.4)	4/0	(107.2)	2/0	(67.4)	4/0	(107.2)
800	3/0	(85)	250	(127)	2/0	(67.4)	4/0	(107.2)
1000	3/0	(85)	250	(127)	3/0	(85)	250	(127)
1200	3/0	(85)	250	(127)	250[c]	(127)	250	(127)
1600	3/0	(85)	250	(127)	300[c]	(152)	400[c]	(203)
2000	3/0	(85)	250	(127)	400[c]	(203)	500[c]	(253)
2500	3/0	(85)	250	(127)	500[c]	(253)	700[c]	(355)
3000	3/0	(85)	250	(127)	600[c]	(304)	750[c]	(380)
4000	3/0	(85)	250	(127)	700[c]	(355)	1000[c]	(508)
5000	3/0	(85)	250	(127)	900	(456)	1250	(635)
6000	3/0	(85)	250	(127)	1200	(608)	1500	(759)

NOTE 1 See Table EEE.2 for equivalent area of bus.

NOTE 2 The equipment grounding conductor in the cord for a PLUGGABLE TYPE A or B unit may be the same size as the current-carrying conductors.

NOTE 3 Aluminum-grounding conductors are not used in Canada.

Conditions applicable to Table EEE.1

[a] Maximum ampere rating of the output circuit overcurrent protective device described in 3.1/RD and 2.7.101 of this Standard or the input circuit overcurrent protective device as follows: the size of the branch circuit overcurrent protector shall equal 125% of the input current rating, except where this value does not correspond with the standard rating of a fuse or circuit breaker, in which case the next higher standard device rating shall be used.

[b] If the wire terminal connectors for the input or output circuit conductors, as appropriate, are rated for two 3/0 AWG copper or two No. 250 kcmil aluminum conductors but will not accept a No. 600 kcmil conductor, these values may be reduced to 2 AWG copper or 1/0 AWG aluminum.

[c] The cross-section may be reduced to 2.5% of the total cross-section of the largest input or output circuit conductor, as appropriate, of the same material (copper or aluminum) for any phase on units rated 1200 A and above. This applies when the cross-section of the circuit conductors is limited by the wire terminal connectors provided.

[d] The bonding jumper for a PLUGGABLE TYPE A or B unit may be the same size as the current-carrying conductors of the output circuit.

Table EEE.2
Equivalent cross-sectional areas of wires and buses

Wire size (AWG or kcmil)	Minimum cross-section of bus	
	in^2	mm^2
8	0.013	8.39
6	0.021	13.55
4	0.033	21.29
3	0.041	26.45
2	0.052	33.55
1	0.066	42.58
0	0.083	53.55
2/0	0.105	67.74
3/0	0.132	85.16
4/0	0.166	107.10
250	0.196	126.45
300	0.236	152.26
350	0.275	177.42
400	0.314	202.58
500	0.393	253.55
600	0.471	303.87
700	0.550	364.84
750	0.589	380.00
800	0.628	405.16
1000	0.785	506.45
1200	0.942	607.73
1250	0.981	632.90
1500	1.178	760.00

Table EEE.3
Tightening torque for wire-binding screws

Size of terminal screw, number	Wire sizes to be tested, AWG[a]	Tightening torque	
		Pound-inches	Newton-metres
6	16 – 18(ST)	12	1.4
8	14(S) and 16 – 18(ST)	16	1.8
10	10 – 14(S) and 16 – 18(ST)	20	2.3

[a] ST – stranded wire: S – solid wire

Annex FFF
(normative)

BACKFEED PROTECTION test

(see 2.1.101)

FFF.1 General

A UPS shall not allow excessive touch currents to be available between any pairs of input terminals of the UPS during its STORED ENERGY MODE of operation. Where the measured open circuit voltage does not exceed 30 V rms (42.4 V peak, 60 V d.c.), the touch current measurement need not be taken.

The BACKFEED PROTECTION for a stationary UPS, with an output that is not a separately derived system, shall open or de-energize all supply conductors.

Compliance is checked by the tests in described in FFF.2 and FFF.3.

FFF.2 Pluggable type A UPS

While the UPS is in its STORED ENERGY MODE of operation, and with the input terminals or plugs disconnected, the following conditions shall apply for both no-load and full-load conditions:

a) Under normal and any single fault conditions, the current shall not exceed 3.5 mA when measured between any two USER-accessible input terminals, using the circuit shown in Annex D/RD.

b) If such protection is provided by an internal system, such a system shall operate within 1 s of the disconnection of the input terminals.

FFF.3 Permanently connected UPS

The test and conditions shall be as for FFF.2, except the protective conductor shall not be disconnected during the test, the current shall not exceed 3.5 mA for both no-fault and single-fault conditions, and the protection shall operate within 15 s.

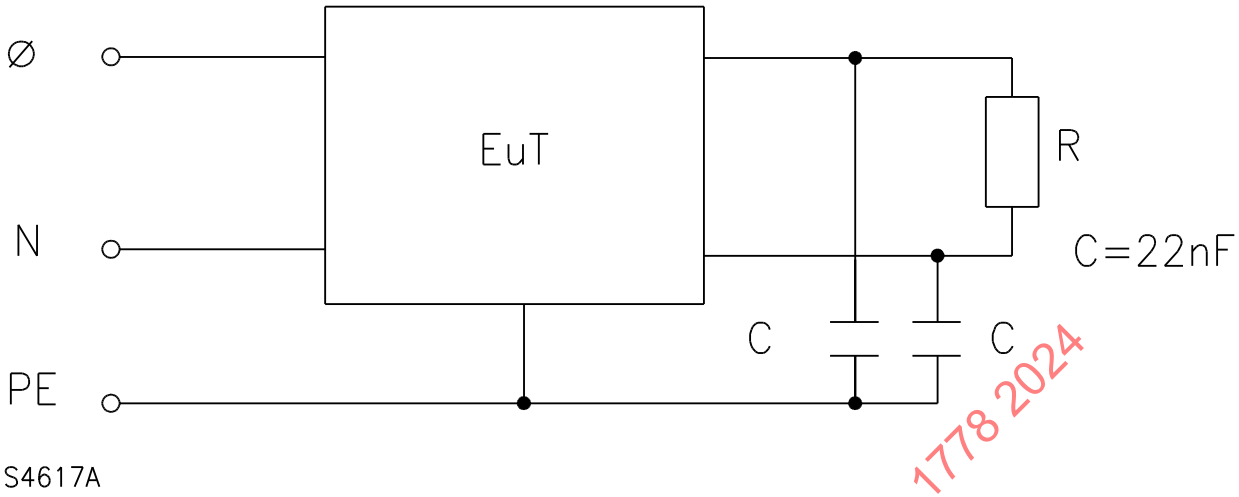
When BACKFEED PROTECTION is provided by others and requires a remote shunt-trip or other means of mechanical disconnection, adequate interconnect information shall be included in the installation instructions.

FFF.4 Single fault conditions

For FFF.2 and FFF.3, single-fault conditions shall be determined by circuit inspection and/or investigation, but shall also include potential load faults such as phase-to-earth isolation failures.

For single-phase output:

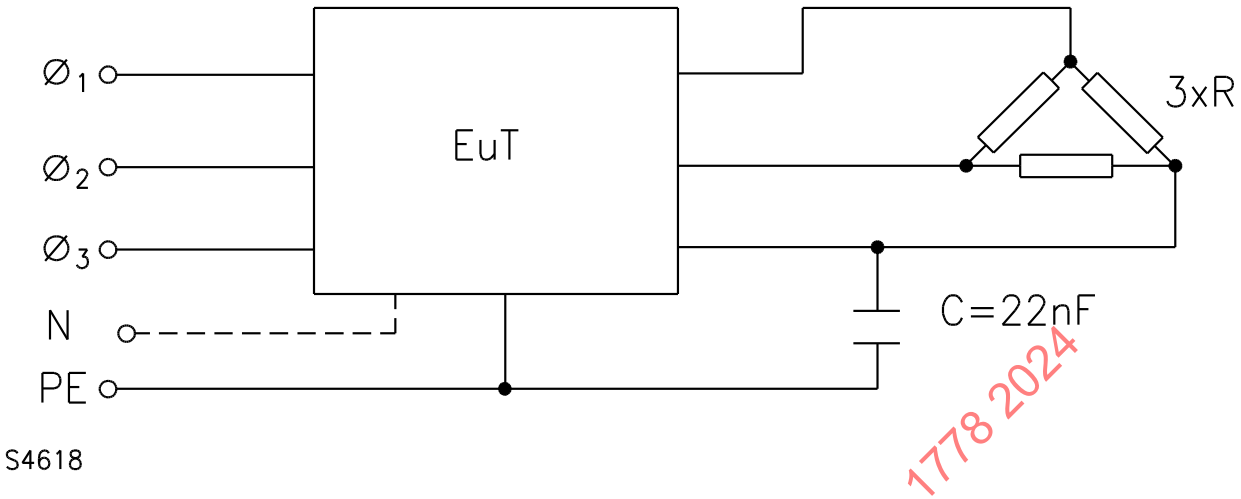
Figure FFF.4.1



EuT = equipment under test

For three-phase output:

Figure FFF.4.2



The value of resistive load R shall be equal to that specified as the maximum load at unit POWER FACTOR by the manufacturer.

FFF.5 Air gap requirements for mechanical disconnect

An air gap is only required when the BACKFEED PROTECTION is mechanical in nature. The air gap is defined as the CLEARANCE distance in accordance with the RD. There are several elements to consider when determining the CLEARANCE requirement:

a) Under normal operation, the space between poles of phases shall meet the requirements for BASIC INSULATION. Reference Tables 2M/RD and 2N/RD.

b) If the unit is operating on inverter, the source is considered to be a secondary supply, which is transient free. Reference Table 2M/RD (last column). For example, circuits less than 150 V rms require 0.7 mm for BASIC INSULATION, and circuits greater than 150 V rms but less than 300 V rms require 1.4 mm for BASIC INSULATION. For a UPS with floating outputs, opening all phases and the neutral using the required CLEARANCE for BASIC INSULATION is considered acceptable. If the output is grounded to the chassis, REINFORCED INSULATION or equivalent is required.

c) CLEARANCE of components meeting an applicable component standard may be further reduced, provided that they meet both the manufacturing quality control program that has at least the same level of assurance as the example given in Annex R.2/RD and the withstand voltage of Table G.2/RD. For example, 0.4 mm is an acceptable air gap for voltages not exceeding 300 V rms.

FFF.6 ELECTRONIC BACKFEED PROTECTION

If the mechanism for BACKFEED PROTECTION relies on electronic controls only, the components of the mechanism shall be able to withstand the effects of transient overvoltages, voltage variations, electromagnetic susceptibility, electrostatic discharge, shipping, storage, thermal cycling, and humidity. See also Annex LLL.

NOTE Examples of such tests can be found in UL 991 and CAN/CSA-E60730-1.

Annex GGG
(informative)

Principles of BACKFEED PROTECTION

GGG.1 General

GGG.1.1 UNINTERRUPTIBLE POWER SYSTEMS store and generate hazardous energy. These energies may be present at the input terminals of the UPS.

BACKFEED PROTECTION is intended to prevent USERS, SERVICE PERSONNEL, or electricians from unforeseeable or unnecessary exposure to such hazards. The control scheme is called BACKFEED PROTECTION. BACKFEED PROTECTION functions when a.c. input power is removed and hazardous energies could otherwise be present at the input terminals of the UPS.

Two levels of protection are assumed:

a) Level 1: OPERATOR ACCESS AREA – BACKFEED PROTECTION is required where USER exposure is likely. An example of this would be any PLUGGABLE EQUIPMENT TYPE A UPS on which the USER could unplug the unit and touch the pins of the line cord plug or appliance coupler of the UPS.

b) Level 2: RESTRICTED ACCESS LOCATION – BACKFEED PROTECTION is required where SERVICE PERSONNEL or electrician exposure is likely, but USER exposure is not likely. An example of this would be a PLUGGABLE EQUIPMENT TYPE B or permanently connected UPS on which the only access to BACKFEED would be internal to the unit or in the service panel supplying power to the UPS.

The USER is protected within one second from disconnection for PLUGGABLE EQUIPMENT TYPE A devices, and SERVICE PERSONNEL and electricians must be protected within 15 s for PLUGGABLE EQUIPMENT TYPE B or permanently connected devices. This time includes any time necessary to discharge filter capacitors.

BACKFEED PROTECTION can be mechanical or electronic.

Mechanical BACKFEED PROTECTION should meet a minimum air gap requirement. If not, the mechanical device (contacts) may be forced closed, and this will not be counted as a fault.

ELECTRONIC BACKFEED PROTECTION includes a mechanism to determine that it is functioning properly. This mechanism is intended to be single-fault-tolerant. The BACKFEED PROTECTION operates with any and all semiconductor devices in any single phase of the PRIMARY POWER path failed.

NOTE Reference Annex FFF for additional testing requirements.

Where the UPS is supplied with more than one a.c. source, such as in a BYPASS condition, the BACKFEED PROTECTION will disconnect all primary source connection points from the internal hazardous energy of the UPS.

BACKFEED PROTECTION works under any normal operating condition. This should include any output load or input source condition deemed normal by the manufacturer; however, it is common practice to only test at full- and no-load conditions, unless analysis of the circuitry proves other conditions would be less favourable. The circuitry that controls the BACKFEED PROTECTION is intended to be single-fault-tolerant.

BACKFEED PROTECTION can accomplish this by disconnecting the AC MAINS SUPPLY wiring from the internal energy source, by disabling the inverter and removing the hazardous source(s) of energy, reducing the source to a safe level, or by placing a suitable mechanical barrier between the USER, SERVICE PERSONNEL, or electrician and the hazardous energy.

GGG.1.2 Hazardous energy is defined in the body of this Standard. The method of measurement is as follows:

a) For pluggable equipment, it is determined by opening all phases, neutral and ground.

b) For permanently connected devices, the neutral and ground are not removed during the BACKFEED tests.

GGG.1.3 Measurements are taken at the UPS input connections across the phases, from phase to neutral and phase and neutral to ground, using the body impedance model as the measurement device.

GGG.2 Air gap requirements for mechanical disconnect

An air gap is only required when the BACKFEED PROTECTION is mechanical in nature. The air gap is defined as the CLEARANCE distance in accordance with the RD. There are several elements to consider when determining the CLEARANCE requirement:

a) Under normal operation, the space between poles of phases must meet the requirements for BASIC INSULATION. Reference Tables 2M/RD and 2N/RD.

b) If the unit is operating on inverter, the source is considered to be a secondary supply, which is transient free. Reference Table 2M/RD (last column). For example, circuits less than 150 V rms require 0.7 mm for BASIC INSULATION, and circuits greater than 150 V rms but less than 300 V rms require 1.4 mm for BASIC INSULATION. For a UPS with floating outputs, opening all phases and the neutral using the required CLEARANCE for BASIC INSULATION is considered acceptable. If the output is grounded to the chassis, REINFORCED INSULATION or equivalent is required.

CLEARANCE of components meeting an applicable component standard may be further reduced, provided that they meet both the manufacturing quality control program that has at least the same level of assurance as the example given in Annex R.2/RD and the withstand voltage of Table G.2/RD. For example, 0.4 mm is an acceptable air gap for voltages not exceeding 300 V rms.

GGG.3 Fault testing

All BACKFEED PROTECTION control circuits are subject to failure analysis and testing.

GGG.4 Relays

Relays in the power path that are required to open for BACKFEED PROTECTION should be normally open when not energized.

If the relay does not meet the required CLEARANCES, the shorting of either pole/contact may be considered as a single fault to simulate the welding of the contacts. The failure of a single relay contact may be sensed and the inverter disabled to prevent feedback.

The relay must be horsepower-rated or pass a 50 cycle endurance test at 600% of the normal switching current.

GGG.5 Electronic protection

Electronic protection for BACKFEED PROTECTION is acceptable if the operation of the electronic protection device is sensed and the inverter is disabled if a fault is found. This is the same requirement as for a relay having less than the required air gap or CLEARANCE.

GGG.6 Mechanical protection

Mechanical protection for BACKFEED PROTECTION is acceptable if it prevents the USER from accessing HAZARDOUS VOLTAGES and cannot be readily defeated without the use of a TOOL. The voltage rating of the mechanical protection should be no less than the maximum out-of-phase voltage.

GGG.7 Control circuitry

The failure, open- or short-circuit, of any component of the BACKFEED PROTECTION circuitry may be analyzed to evaluate the effects on the proper operation of the BACKFEED PROTECTION. Testing may be done on all components where analysis of the results is arguable.

Components such as resistors and inductors are considered to fail open-circuit only. Capacitors may fail open or shorted. Solid-state devices typically fail short and then open.

Microprocessor controls are considered to be acceptable if the circuit operates safely with any single control line open or shorted to control logic ground. Failure of the microprocessor can also be simulated by opening the Vcc pin or shorting the Vcc pin to ground.

If the control circuitry is fully redundant, for example, N + 1, failure analysis of individual components is not required if the failure of one circuit results in a fail-safe mode of operation.

Annex HHH
(normative)

Ventilation of battery compartments

(see 4.3.8.101.2.4)

HHH.1 The requirements of HHH.2 to HHH.5 apply to units having VENTED BATTERIES.

HHH.2 The ENCLOSURE or compartment housing a battery shall be vented where gassing is possible during heavy discharge, overcharging, or similar type of usage. The means of venting shall provide airflow throughout the compartment in order to reduce the risk of buildup of pressure or accumulation of a gas mixture, such as hydrogen-air, that involves a risk of injury to persons.

HHH.3 Arcing parts, such as the contacts of switches, circuit breakers, and relays, shall not be located in the ENCLOSURE or compartment housing a VENTED BATTERY described in HHH.2, nor shall the ENCLOSURE or compartment vent into closed spaces where such parts are located. For purposes of this requirement, fuses and connectors are not considered to contain arcing parts. Battery or compartment monitoring sensors (such as temperature sensors and the like) may be located in the ENCLOSURE or compartment.

HHH.4 If the gas mixture is lighter than air (such as hydrogen-air), the requirement of HHH.2 may necessitate locating additional ventilation openings in the uppermost portions of the battery ENCLOSURE or compartment where such a gas mixture may accumulate.

HHH.5 With reference to HHH.4, the venting means shall prevent hydrogen concentrations in excess of 1% by volume. If the adequacy of the ventilation required in HHH.2 is not obvious, a determination shall be made by measurement of gas concentration in accordance with the battery compartment ventilation test in HHH.7. A battery at full charge, when most of the charging energy goes into gas, will generate approximately 1 ft^3 (28.3 L) of hydrogen gas per cell for each 63 ampere-hours of input. See HHH.6.

HHH.6 The ventilating means for an ENCLOSURE or a compartment housing a battery shall comply with the requirements of HHH.2 to HHH.5 under blocked fan and blocked filter conditions described in 5.3.101.

HHH.7 If a measurement is needed to determine if a battery compartment complies with HHH.5, the battery supply shall be subjected to the overcharge test in 4.3.8.101.2.5. During, and at the conclusion of the test, the maximum hydrogen gas concentration shall not be more than 2% by volume. Measurements shall be made by sampling the atmosphere inside the battery compartment at the periods of 2, 4, 6, and 7 h during the test. Samples of the atmosphere within the battery compartment shall be taken at the location where the greatest concentration of hydrogen gas is likely, using an aspirator bulb provided with the concentration measurement equipment, or other equivalent means.

HHH.7A The gas generation determination conducted as part of the Overcharge Thermal Runaway Test of UL 1973, the Standard for Batteries for Use in Stationary and Motive Auxiliary Power Application, can be utilized to determine suitable ventilation for vented batteries instead of running the test of HHH.7.

HHH.8 In the United States the following applies:

If the battery is located in a HAZARDOUS VOLTAGE, PRIMARY, or ELV CIRCUIT, the battery shall conform to the Standard for Batteries for Use in Stationary and Motive Auxiliary Power Application, UL 1973.

Annex III
(normative)

Standards for components

III.1 Component Standards

The CSA Group and UL Standards listed below are used for evaluation of components and features of products covered by this Standard. Components need only comply with the applicable component standard acceptable in the country where the product is to be used. These Standards shall be considered to refer to the latest edition and all amendments published to that edition.

CSA Group Standards

CAN/CSA-C22.2 No. 0.4-04 (R2009),
Bonding of Electrical Equipment

C22.2 No. 0.15-01 (R2012),
Adhesive Labels

CAN/CSA-C22.2 No. 0.17-00 (R2009),
Evaluation of Properties of Polymeric Materials

CAN/CSA-C22.2 No. 4-04 (R2009),
Enclosed and Dead-Front Switches

C22.2 No. 5-13,
Moulded-Case Circuit Breakers, Moulded-Case Switches and Circuit-Breaker Enclosures

C22.2 No. 8-M1986 (R2008),
Electromagnetic Interference (EMI) Filters

C22.2 No. 14-10,
Industrial Control Equipment

C22.2 No. 18.1-13,
Metallic Outlet Boxes

C22.2 No. 18.2-06 (R2011),
Nonmetallic Outlet Boxes

C22.2 No. 18.3-12,
Conduit, Tubing, and Cable Fittings

CAN/CSA-C22.2 No. 18.4-04 (R2009),
Hardware for the Support of Conduit, Tubing, and Cable

C22.2 No. 18.5-13,
Positioning Devices

C22.2 No. 21-95 (R2009),
Cord Sets and Power Supply Cords

C22.2 No. 24-93 (R2013),
Temperature-Indicating and Regulating Equipment

C22.2 No. 29-M1989 (R2009),
Panelboards and Enclosed Panelboards

C22.2 No. 39-13,
Fuseholder Assemblies

C22.2 No. 42-10,
General Use Receptacles, Attachment Plugs, and Similar Wiring Devices

C22.2 No. 43-08,
Lampholders

C22.2 No. 55-M1986 (R2012),
Special Use Switches

C22.2 No. 65-13,
Wire Connectors

C22.2 No. 66.1-06 (R2011),
Low Voltage Transformers Part 1: General requirements

C22.2 No. 66.2-06 (R2011),
Low Voltage Transformers Part 2: Special Purpose Transformers

C22.2 No. 66.3-06 (R2011),
Low Voltage Transformers Part 3: Class 2 and Class 3 Transformers

C22.2 No. 75-08,
Thermoplastic-Insulated Wire and Cables

C22.2 No. 77-95 (R2009),
Motors with Inherent Overheating Protection

CAN/CSA-C22.2 No. 94-M91 (R2011),
Special Purpose Enclosures

C22.2 No. 100-04 (R2009),
Motors and Generators

C22.2 No. 111-10,
General-Use Snap Switches

C22.2 No. 141-10,
Emergency Lighting Equipment

C22.2 No. 153-09,
Electrical Quick-Connect Terminals

C22.2 No. 158-10,
Terminal Blocks

C22.2 No. 178.1-12,
Transfer Switch Equipment

C22.2 No. 178.2-04 (R2009),
Requirements for Manually Operated Generator Transfer Panels

C22.2 No. 182.3-M1987 (R2009),
Special Use Attachment Plugs, Receptacles and Connectors

C22.2 No. 190-M1985 (R2009),
Capacitors for Power Factor Correction

C22.2 No. 197-M1983 (R2008),
PVC Insulating Tape

C22.2 No. 209-M1985 (R2008),
Thermal Cut-Offs

CAN/CSA-C22.2 No. 226-92 (R2011),
Protectors in Telecommunication Networks

C22.2 No. 235-04 (R2013),
Supplementary protectors

CAN/CSA-C22.2 No. 244-05 (R2010),
Switchboards

CAN/CSA-C22.2 No. 248.7-00 (R2010),
Low Voltage Fuses – Part 7: Class H Renewable Fuses

CAN/CSA-C22.2 No. 248.9-00 (R2010),
Low Voltage Fuses – Part 9: Class K Fuses

C22.2 No. 248.11-11,
Low Voltage Fuses – Part 11: Plug Fuses

C22.2 No. 248.12-11,
Low Voltage Fuses – Part 12: Class R Fuses

CAN/CSA-C22.2 No. 248.13-00 (R2010),
Low Voltage Fuses – Part 13: Semiconductor Fuses

CAN/CSA-C22.2 No. 248.14-00 (R2010),
Low Voltage Fuses – Part 14: Supplemental Fuses

CAN/CSA-C22.2 No. 248.15-00 (R2010),
Low Voltage Fuses – Part 15: Class T Fuses

CAN/CSA-C22.2 No. 60065:03 (R2012),
Audio, video and similar electronic apparatus – Safety requirements

CAN/CSA-C22.2 No. 61058-1-09,
Switches for Appliances – Part 1: General Requirements

CAN/CSA-E60730-1:13,
Automatic electrical controls for household and similar use – Part 1: General requirements

UL Standards

Air Filter Units –
UL 900

Analog Instruments, Electrical – Panel Board Types –
UL 1437

Attachment Plugs and Receptacles –
UL 498

Batteries for Use in Stationary and Motive Auxiliary Power Application –
UL 1973

Building Materials, Test for Surface Burning Characteristics of –
UL 723

Capacitors –
UL 810

Controls, Limit –
UL 353

Cord Sets and Power-Supply Cords –
UL 817

Switchboards –
UL 891

Enclosures for Electrical Equipment, Non-Environmental Considerations –
UL 50

Enclosures for Electrical Equipment, Environmental Considerations –
UL 50E

Electromagnetic Interference Filters –
UL 1283

Emergency Lighting and Power Equipment –
UL 924

Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors –
UL 486E

Fittings, Conduit, Tubing, and Cable –
UL 514B

Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains –
UL 60384-14

Flexible Cords and Cables –
UL 62

Fuseholders – Part 1: General Requirements –
UL 4248-1

Fuseholders – Part 4: Class CC –
UL 4248-4

Fuseholders – Part 5: Class G –
UL 4248-5

Fuseholders – Part 6: Class H –
UL 4248-6

Fuseholders – Part 8: Class J –
UL 4248-8

Fuseholders – Part 9: Class K –
UL 4248-9

Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse –
UL 4248-11

Fuseholders – Part 12: Class R –
UL 4248-12

Fuseholders – Part 15: Class T –
UL 4248-15

Industrial Control Equipment –
UL 508

Controllers, Programmable – Part 2: Equipment Requirements and Tests –
UL 61131-2

Switchgear and Controlgear, Low-Voltage – Part 1: General Rules –
UL 60947-1

Switchgear and Controlgear, Low-Voltage – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches –
UL 60947-5-2

Insulating Materials – General, Systems of –
UL 1446

Information Technology Equipment Safety – Part 1: General Requirements –
UL 60950-1

Lampholders –
UL 496

Low-Voltage Fuses – Part 1: General Requirements –
UL 248-1

Low-Voltage Fuses – Part 2: Class C Fuses –
UL 248-2

Low-Voltage Fuses – Part 3: Class CA and CB Fuses –
UL 248-3

Low-Voltage Fuses – Part 4: Class CC Fuses –
UL 248-4

Low-Voltage Fuses – Part 5: Class G Fuses –
UL 248-5

Low-Voltage Fuses – Part 6: Class H Non-Renewable Fuses –
UL 248-6

Low-Voltage Fuses – Part 7: Class H Renewable Fuses –
UL 248-7

Low-Voltage Fuses – Part 8: Class J Fuses –
UL 248-8

Low-Voltage Fuses – Part 9: Class K Fuses –
UL 248-9

Low-Voltage Fuses – Part 10: Class L Fuses –
UL 248-10

Low-Voltage Fuses – Part 11: Plug Fuses –
UL 248-11

Low-Voltage Fuses – Part 12: Class R Fuses –
UL 248-12

Low-Voltage Fuses – Part 13: Semiconductor Fuses –
UL 248-13

Low-Voltage Fuses – Part 14: Supplemental Fuses –
UL 248-14

Low-Voltage Fuses – Part 15: Class T Fuses –
UL 248-15

Low-Voltage Fuses – Part 16: Test Limiters –
UL 248-16

Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters –
UL 60947-4-1

Marking and Labeling Systems –
UL 969

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

Rotating Electrical Machines – General Requirements –
UL 1004-1

Optical Isolators –
UL 1577

Outlet Boxes, Flush-Device Boxes, and Covers, Nonmetallic –
UL 514C

Outlet Boxes, Metallic –
UL 514A

Panelboards –
UL 67

Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of –
UL 94

Polymeric Materials – Fabricated Parts –
UL 746D

Polymeric Materials – Long Term Property Evaluations –
UL 746B

Polymeric Materials – Short Term Property Evaluations –
UL 746A

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

Printed-Wiring Boards –
UL 796

Secondary Protectors for Communications Circuits –
UL 497A

Supplementary Protectors for Use in Electrical Equipment –
UL 1077

Snap Switches, General-Use –
UL 20

Valve Regulated or Vented Batteries with Aqueous Electrolytes –
UL 1989

Stationary Engine Generator Assemblies –
UL 2200

Switches for Appliances – Part 1: General Requirements –
UL 61058-1

Transfer Switch Equipment –
UL 1008

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

Temperature-Indicating and -Regulating Equipment –
UL 873

Controls for Household and Similar Use, Part 1: General Requirements, Automatic Electrical –
UL 60730-1

Terminal Blocks –
UL 1059

Terminals, Electrical Quick-Connect –
UL 310

Tests for Safety-Related Controls Employing Solid-State Devices –
UL 991

Tests for Sharpness of Edges on Equipment –
UL 1439

Thermal-Links – Requirements and Application Guide –
UL 60691

Thermally Protected Motors –
UL 1004-3

Transformers, Low Voltage – Part 1: General Requirements –
UL 5085-1

Transformers, Low Voltage – Part 3: Class 2 and Class 3 Transformers –
UL 5085-3

Transformers, Specialty –
UL 506

Surge Protective Devices –
UL 1449

Wire Connectors –
UL 486A-486B

Wires and Cables, Thermoplastic-Insulated –
UL 83

Annex JJJ
(normative)

French translations and markings

This annex shall be used in conjunction with Annex NAA/RD and identifies examples of additional markings required for Canada and the United States.

Excluding the words "WARNING" and "CAUTION", wording equivalent to that provided in this annex may be used.

French translations of required markings are considered informative. It is the responsibility of the manufacturer to provide bilingual markings, where applicable, in accordance with local jurisdictional requirements.

Table JJJ.1

Clause No.	Example of English text for marking	Example of French text for marking
1.7.1	a) number of phases unless intended for single phase only_____; b) RATED ACTIVE OUTPUT POWER_____ W or kW; c) RATED APPARENT OUTPUT POWER_____VA or kVA; d) rated output voltage_____V; e) rated output current_____A; f) rated output frequency_____Hz; g) short circuit withstand rating.	a) nombre de phases, sauf dans le cas d'un appareil pour circuit monophasé seulement ; b) PUISSANCE ACTIVE DE SORTIE NOMINALE, en W ou en kW ; c) PUISSANCE APPARENTE DE SORTIE NOMINALE, en VA ou en kVA ; d) tension de sortie nominale_____ V; e) courant de sortie nominal_____ A; f) fréquence de sortie nominale_____Hz; g) **tenue nominale au courant de court circuit.**
1.7.1.101	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. c) NOTICE: Only for use with manufacturer: _____, model: _____	a) AVIS : La sortie de cet appareil n'est pas purement sinusoïdale. Elle présente une distorsion harmonique de tension totale nominale de ___ pour cent, et la valeur nominale de la tension harmonique la plus élevée est de ___ pour cent. b) AVIS : Pour utilisation avec des charges ____. c) **AVIS : Pour utilisation uniquement avec le modèle : _____ fabriqué par : _____**
1.7.1.102	**SEE INSTALLATION INSTRUCTIONS BEFORE CONNECTING TO THE SUPPLY**	**VOIR LA NOTICE D'INSTALLATION AVANT DE BRANCHER À L'ALIMENTATION**
1.7.1.104	Date of manufacture: _____	Date de fabrication : _____
1.7.1.105	This UPS is for use with telephone equipment In accordance with Section 60 of the Canadian Electrical Code, Part I, and is subject to inspection by an inspector. This unit is intended for connection to pole-mounted or underground amplifiers.	Cette alimentation sans coupure est conçue pour du matériel de téléphonie, conformément à la section 60 du *Code canadien de l'électricité, Première partie* et peut être inspectée par un inspecteur. Ce dispositif est destiné à être raccordé à des amplificateurs montés sur poteau ou enfouis.
	In order to comply with the *Canadian Electrical Code, Part I*, this power supply must receive power from a disconnect marked suitable for use as service equipment.	Pour être conforme au *Code canadien de l'électricité, Première partie*, cette alimentation doit être alimentée par un dispositif de sectionnement portant un marquage indiquant qu'il peut être utilisé comme appareillage de branchement.
1.7.13.101	a) battery manufacturer name, catalogue number and number of batteries; b) nominal voltage of total battery string;	a) type ou référence au catalogue des batteries et nombre de batteries ; b) tension nominale de l'ensemble de la chaîne de batteries ;

Table JJJ.1 Continued on Next Page

Table JJJ.1 Continued

Clause No.	Example of English text for marking	Example of French text for marking
	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.	c) capacité nominale de l'ensemble de la chaîne de batteries ; d) étiquette de mise en garde signalant un danger chimique et de transfert d'énergie et renvoyant à des consignes de manutention et d'élimination pour la sécurité du PERSONNEL DE MAINTENANCE.
2.6.101	The output a.c. circuit is considered as a separately derived source	On considère que le circuit c. a. de sortie constitue une source d'alimentation indépendante
2.9.1.102	Intended for a CONTROLLED ENVIRONMENT	Destiné à un ENVIRONNEMENT CONTRÔLE
3.5.101	Not for telecommunication (telephone) network	Ne convient pas à des réseaux de télécommunications (téléphones)
EEE.1.4 c)	The output a.c. circuit is considered as a separately derived source. If local codes require grounding of this circuit, use terminal '' for bonding this circuit to the ENCLOSURE. Ground the ENCLOSURE to a suitable grounding electrode in accordance with local code requirements. Refer to the instruction manual.	On considère que le circuit c. a. de sortie constitue une source d'alimentation indépendante. Si les codes locaux exigent que ce circuit soit mis à la terre, utiliser la borne ___ pour assurer la continuité des masses entre ce circuit et l'ENVELOPPE. L' ENVELOPPE doit être mise à la terre au moyen d'une prise de terre appropriée, conformément au code local. Voir la notice.
EEE.1.5 b)	Grounding Electrode Terminal	Borne pour prise de terre
EEE.2.1	a) Use Copper Conductors Only b) Use Aluminum Conductors Only Use Aluminum or Copper-Clad Aluminum Conductors Only c) Use Copper or Aluminum Conductors Use Copper, Copper-Clad Aluminum, or Aluminum Conductors	a) Utiliser uniquement des conducteurs en cuivre b) Utiliser uniquement des conducteurs en aluminium Utiliser uniquement des conducteurs en aluminium ou en aluminium cuivré c) Utiliser des conducteurs en cuivre ou en aluminium Utiliser des conducteurs en cuivre, en aluminium cuivré ou en aluminium
MMM.2.4	Wrap line cables together and, if provided, tie cables together with nominal 3/8 in (9.5 mm) nylon rope or rope having a minimum tensile strength of 2000 lb (8896 N) at 6 in (152 mm) and 12 in (305 mm) from the line terminals with five wraps and, every additional 6 in with five wraps or every 1 in (25.4 mm) with one wrap	Envelopper les câbles d'alimentation réseau ensemble et, le cas échéant, les attacher au moyen d'une corde en nylon de 3/8 po (9,5 mm) ou présentant une résistance à la traction de 2000 lb (8896 N) à 6 po (152 mm) et à 12 po (305 mm) des bornes du réseau en effectuant cinq tours et en effectuant cinq tours pour chaque 6 po additionnels ou un tour pour chaque pouce (25,4 mm) additionnel
NNN.5.1	This UPS is rated for use on a circuit capable of delivering no more than ____ rms symmetrical amperes, ____ volts maximum	Cette alimentation sans coupure convient pour un circuit pouvant débiter au plus ___ A symétriques eff., et ____ V
NNN.5.2	When protected by Manufacturer ____ Type ____ ampere ____ maximum Class ____ fuse, this UPS is rated for use on a circuit capable of delivering no more than ____ rms symmetrical amperes, ____ volts maximum.	Si cette alimentation sans coupure est protégée par un fusible de type ____ A, et de classe ____ , fabriqué par _____, elle convient pour un circuit pouvant débiter au plus ____ A symétriques eff., et ____ V
NNN.5.2	When protected by Manufacturer ____ Type ____ circuit breaker rated no more than ____ amperes, this UPS is rated for use on a circuit capable of delivering no more than ____ rms symmetrical amperes, ____ volts maximum.	Si cette alimentation sans coupure est protégée par un disjoncteur de type ___, fabriqué par ____ , convenant à au plus ___ A, elle convient pour un circuit pouvant débiter au plus ____ A symétriques eff., et ____ V

Annex LLL
(informative)

Examples of US and Canadian regulatory requirements

This annex is used in conjunction with Annex NAE/RD and provides additional examples of and references for regulatory requirements that may apply to equipment. Applicability of these requirements is dependent on the construction of the equipment and its intended installation and use.

This annex is not intended to provide a complete list of all of the applicable requirements, only to serve as a reference for requirements that most commonly apply to this type of equipment.

For complete requirements, the *National Electrical Code*, ANSI/NFPA 70, the *Canadian Electrical Code, Part I*, CSA C22.1, or other referenced document must be consulted.

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

NOTE 1 Underlining to indicate text added to IEC 60950-1 is not used in this annex.

Table LLL.1

Clause No.	Topic/summary	NEC	CEC, Part I Rule or relevant CSA Group Standard
1.1.2	Marking of enclosure for other than general purpose enclosures		2-402
1.1.3	UPS units for use as legally required standby systems	701	46
1.7.1.103	Receptacles for industrial applications		26-700
1.7.2.104 (f)	Equipment with field wiring terminals shall be provided with instruction specifying the range of torque for tightening screw terminals	110.3 (B)	CAN/CSA-C22.2 No. 0.4 Table 3
2.7	Supplementary overcurrent protection shall not be used as a substitute for BRANCH CIRCUIT overcurrent devices	240.10	14-114
3.4 Annex FFF	Solid-state devices, restriction of use Solid-state devices shall not be used as isolating switches or as disconnecting means. Where supplementary disconnection is used with solid-state devices, suitable warning shall be provided		14-700 14-702 14-704

Annex MMM
(normative)

Test and construction requirements for UPS with fault current ratings higher than those specified in Table NNN.5

MMM.1 Short-circuit current

The UPS shall have one or more short-circuit rating values as specified in Table MMM.1, but the value shall not be less than the values based on an equipment rating as specified in Table MMM.2.

Table MMM.1
Available fault current ratings – rms symmetrical A

Amperes (A)		
5000	22 000	65 000
7500	25 000	85 000
10 000	30 000	100 000
14 000	35 000	125 000
18 000	42 000	150 000
20 000	50 000	200 000

Table MMM.2
Available short-circuit current

Equipment current rating, A[a]	Short-circuit current, A
100 or less	5 000
101 – 400	10 000
401 and higher	20 times rating but not less than 10 000

[a] May be higher at the option of the manufacturer. See Table MMM.1.

MMM.2 Maximum 100 000 ampere short-circuit current rating without short-circuit test

MMM.2.1 Scope

These requirements cover UPS switchboard sections and UPS sections that do not contain semiconductor switching components, and that have an rms symmetrical short-circuit current rating for which short-circuit tests may be waived. These requirements do not otherwise amend the requirements in this Standard.

MMM.2.2 Construction

MMM.2.2.1 General

MMM.2.2.1.1 A maximum rms symmetrical short-circuit current rating as shown in Table MMM.3 may be assigned to a through bus (which includes a splice bus), a tap, and a section bus, of a UPS rated as specified in Table MMM.3 without conducting short-circuit tests if all of the following conditions are met:

a) The construction is in accordance with MMM.2.2.1.2 – MMM.2.2.1.8

b) The performance is in accordance with MMM.2.3.1– MMM.2.3.3.

c) The UPS is marked in accordance with MMM.2.4.

MMM.2.2.1.2 For a maximum assigned rms symmetrical short-circuit current rating of 100 000 A, the UPS (consisting of one or more sections) shall contain a single integral main molded-case circuit breaker, low voltage a.c. power circuit breaker, or fused switch having a short-circuit rating not less than that of the UPS, or shall be marked for use with a remote device having a short-circuit current rating not less than that of the UPS. Supply bus bars ahead of the main overcurrent protective device shall be located in the same section or an adjacent section.

MMM.2.2.1.3 Copper or aluminum bus bars shall be nominally 1/4 in (6.4 mm) thick and have a width as described in Table MMM.3; holes in bus bars shall not be larger than 0.438 × 0.813 in (11.1 × 20.7 mm) with the larger dimension limited to use along the axis of the bus bar.

Larger holes may be provided as specified in MMM.2.2.1.4 for provision of current transformers.

MMM.2.2.1.4 With regard to Figure MMM.2, copper or aluminum bus bars shall be minimum 1/4 in (6.4 mm) thick and 2 to 7 in (50.8 to 178 mm) wide; holes in bus bars at SUPPORTS shall not be larger than 0.406 × 0.750 in (10.3 × 19.1 mm) and holes for bus bar type current transformers shall not be larger than 9/16 × 1 13/32 in (14.3 × 35.7 mm). A bus bar shall be prevented from rotating by means other than the mounting bolt specified in MMM.2.3.3.

Table MMM.3
UPS ratings and characteristics

Max rms sym. Short-circuit current	Min rating	Max rating	Max voltage rating (single or three-phase)	Min. bus bar width		Max. bus bar width[a]		Bus bars FF or EE[b]	No. of phases	Minimum distance between opposite polarity bus bars[c]				Maximum distance between supports or fraction thereof[d]		Ref. figures
										Closest point		Centre to centre				
A	A	A	V	in	mm	in	mm			in	mm	in	mm	in	mm	
100 000[e]	800	4 000[f]	480[f]	4	102	7	178	EE	3	1	25.4	5	127	21[g]	533	Figure MMM.2–Figure MMM.6
									1	2[g]	50.8	6[g]	152			
100 000[e]	800	4 000[f]	480[f]	4	102	7	178	FF	3	4	102	6	152	13[h]	330	Figure MMM.7
									1	5	127	7	178			
65 000	800	4 000[f]	480[f]	4	102	7	178	EE	3	1	25.4	5	127	21[g]	533	Figure MMM.2–Figure MMM.6
									1	2[g]	50.8	6[g]	152			
65 000[e]	800	4 000[f]	480[f]	4	102	7	178	FF	3	4	102	6	152	21[i]	533	Figure MMM.7
									1	5	127	7	178			
50 000	0	4 000[f]	480[f]	2	50.8	4	102	EE[j]	3	1-1/2	38.1	3-1/2	88.9	14	356	Figure MMM.2–Figure MMM.6
									1	2	50.8	6	152			
50 000	0	4 000[f]	480[f]	2	50.8	4	102	FF	3	4	102	6	152	21[i]	533	Figure MMM.7
									1	5	127	7	178			
42 000	0	1 500	480	2	50.8	4	102	EE[j]	1,3	5	127	9	229	21	533	Figure MMM.1

[a] Bus bars nominally 1/4 in (6.4-mm) thick aluminum or copper, one to four per phase. Refer to MMM.2.2.1.3 and MMM.2.2.1.4 for mounting and support hole size.

[b] Refer to MMM.2.2.1.7 (EE – bus bars arranged edge to edge; FF – bus bars arranged face to face).

[c] Refer to MMM.2.2.2.2 to MMM.2.2.2.5 and Figure MMM.8 and Figure MMM.9. Spacing between bus bars crossing at right angles may be as covered in MMM.2.2.2.3.

[d] Refer to MMM.2.2.1.4 to MMM.2.2.3.5 and Figure MMM.1 to Figure MMM.7, Figure MMM.13, and Figure MMM.14.

[e] Integral or remote main circuit breaker or fused switch required as described in MMM.2.2.1.2. Ratings are not applicable to a tap.

[f] The maximum voltage rating may be 600 V if the current rating does not exceed 2 000 A.

[g] The minimum distance may be 1 in (25.4 mm) for the closest point and 5 in (127 mm) centre to centre if the distance between supports is no more than 17 in (432 mm).

Table MMM.3 Continued on Next Page

Table MMM.3 Continued

Max rms sym. Short-circuit current	Min rating	Max rating	Max voltage rating (single or three-phase)	Min. bus bar width		Max. bus bar width[a]		Bus bars FF or EE[b]	No. of phases	Minimum distance between opposite polarity bus bars[c]				Maximum distance between supports or fraction thereof[d]		Ref. figures
										Closest point		Centre to centre				
A	A	A	V	in	mm	in	mm			in	mm	in	mm	in	mm	

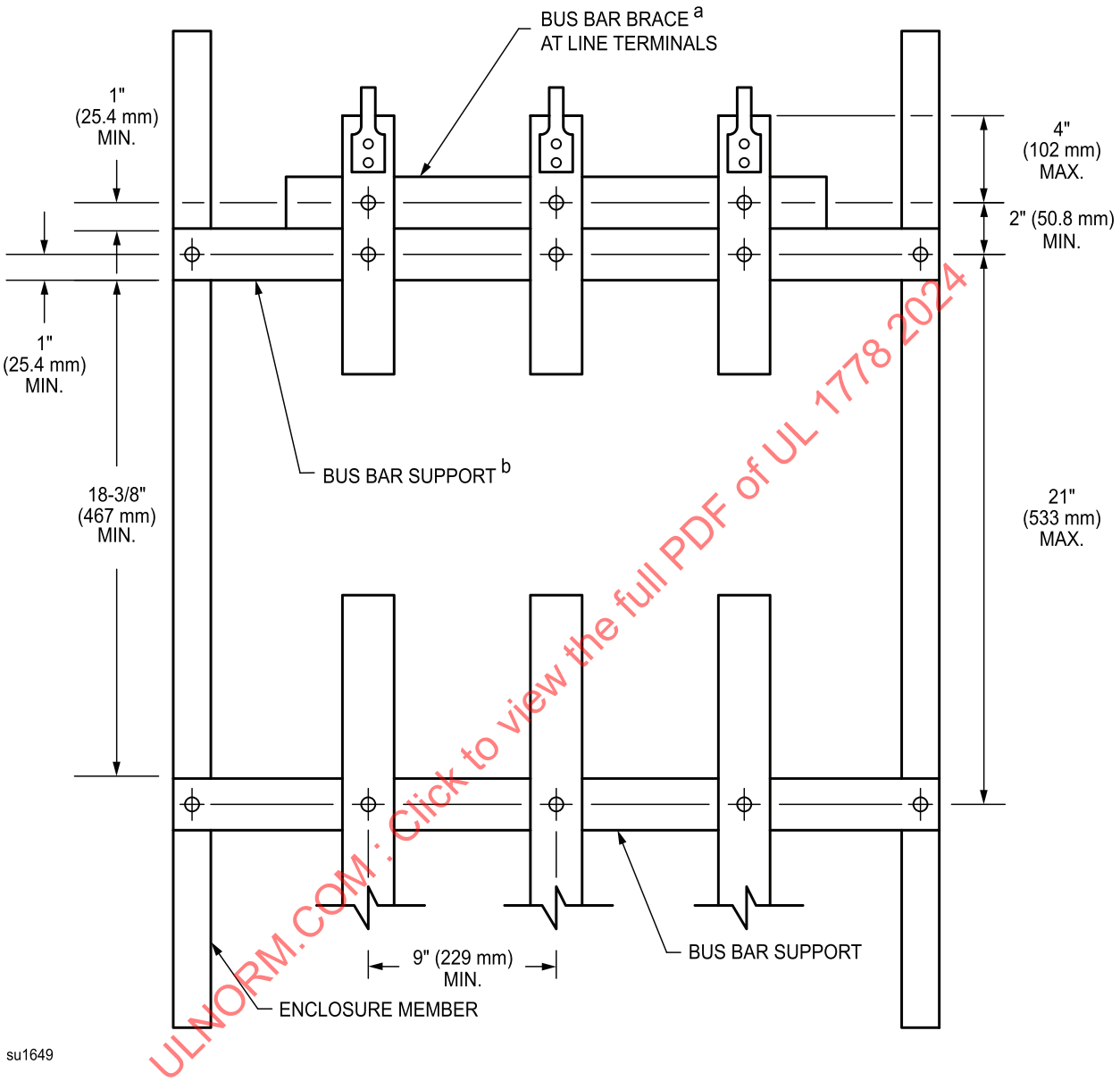
[h] Supports may be located a maximum of 48 in (1219 mm) apart if braces are located a maximum of 13 in (330 mm) apart. See Figure MMM.7.

[i] Supports may be located a maximum of 48 in (1219 mm) apart if braces are located a maximum of 21 in (533 mm) apart. See Figure MMM.7.

[j] Bus bars greater than 2 in (50.8 mm) in width may be L-shaped as indicated in MMM.2.2.1.5.

Figure MMM.1

Current transformer (CT) compartment



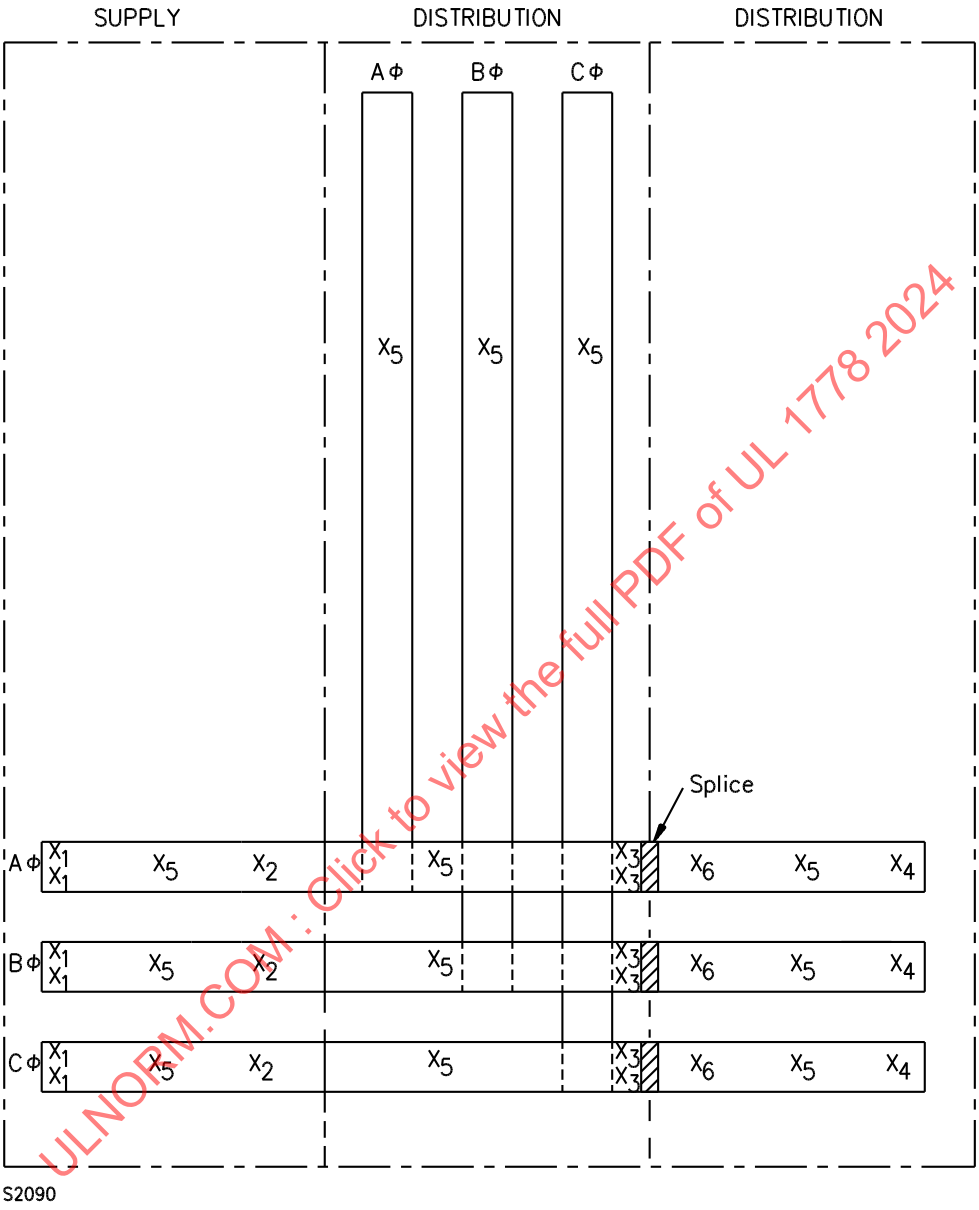
NOTE – Constructions shown in Figure MMM.2– Figure MMM.6 may also be used at connection to current transformers.

[a] See MMM.2.2.3.5.

[b] See MMM.2.2.3 and MMM.2.3.1 — MMM.2.3.3

Figure MMM.2

Location of SUPPORTS for edge-to-edge connection of bus bars for a UPS marked for use without a main or for use with a remote main



X – Bus SUPPORTS (bolts to nonmetallic channel, standoff insulator, or steel channel) as shown in Figure MMM.10 – Figure MMM.12.

X_1X_1 – Two at end of bus in supply section except that one SUPPORT may be used with a single bus bar 2 – 3 in (50.8 – 76.2 mm) wide with a short-circuit current rating of 50 000 A or less.

X_2 – At end of section. One SUPPORT when horizontal bus is continuous.

X_3X_3 – When splice plate is used, two supports for copper bus, one SUPPORT for aluminum bus, except that one SUPPORT may be used for a single copper bus bar 2 – 3 in (50.8 – 76.2 mm) wide with a short-circuit current rating of 50 000 A or less.

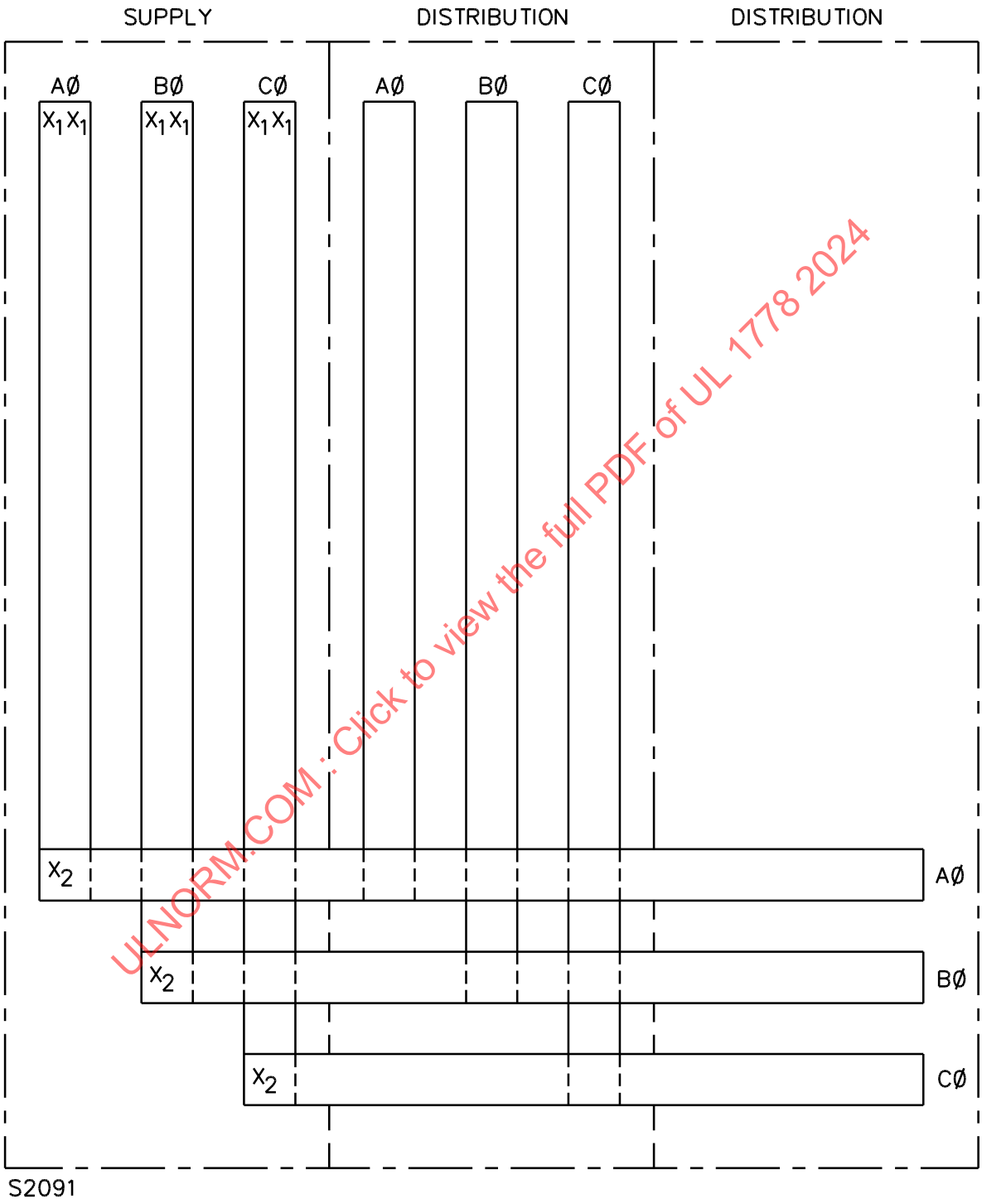
X_4 – One SUPPORT required at end of horizontal bus.

X_5 – One SUPPORT required at intervals as described in Table MMM.3. Connection of vertical bus to horizontal bus may serve as a SUPPORT for the vertical bus but not for the horizontal bus. See MMM.2.2.3 for spacings between bus bars at crossovers.

X_6 – At the load of splice bus, one SUPPORT required.

Figure MMM.3

Location of SUPPORTS for right-angle connection of edge-to-edge bus bars for a UPS without a main or marked for use with a remote main



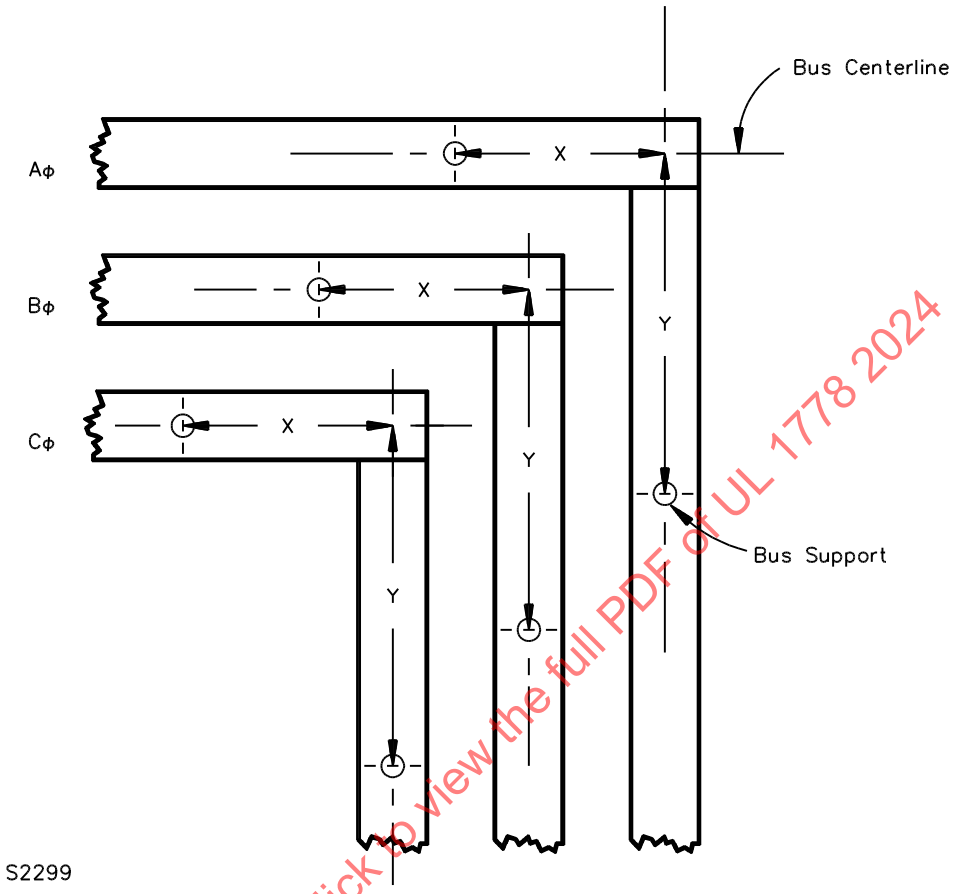
X_1X_1 – Two SUPPORTS required at line terminal end except one support may be used for single bus bar 2 – 3 in (50.8 – 76.2 mm) wide with a short-circuit current rating of 50 000 A or less.

X_2 – One SUPPORT required at connection of vertical to horizontal bus or as shown in Figure MMM.4.

NOTE – For all other SUPPORTS, see Figure MMM.2.

Figure MMM.4

Distance between SUPPORTS

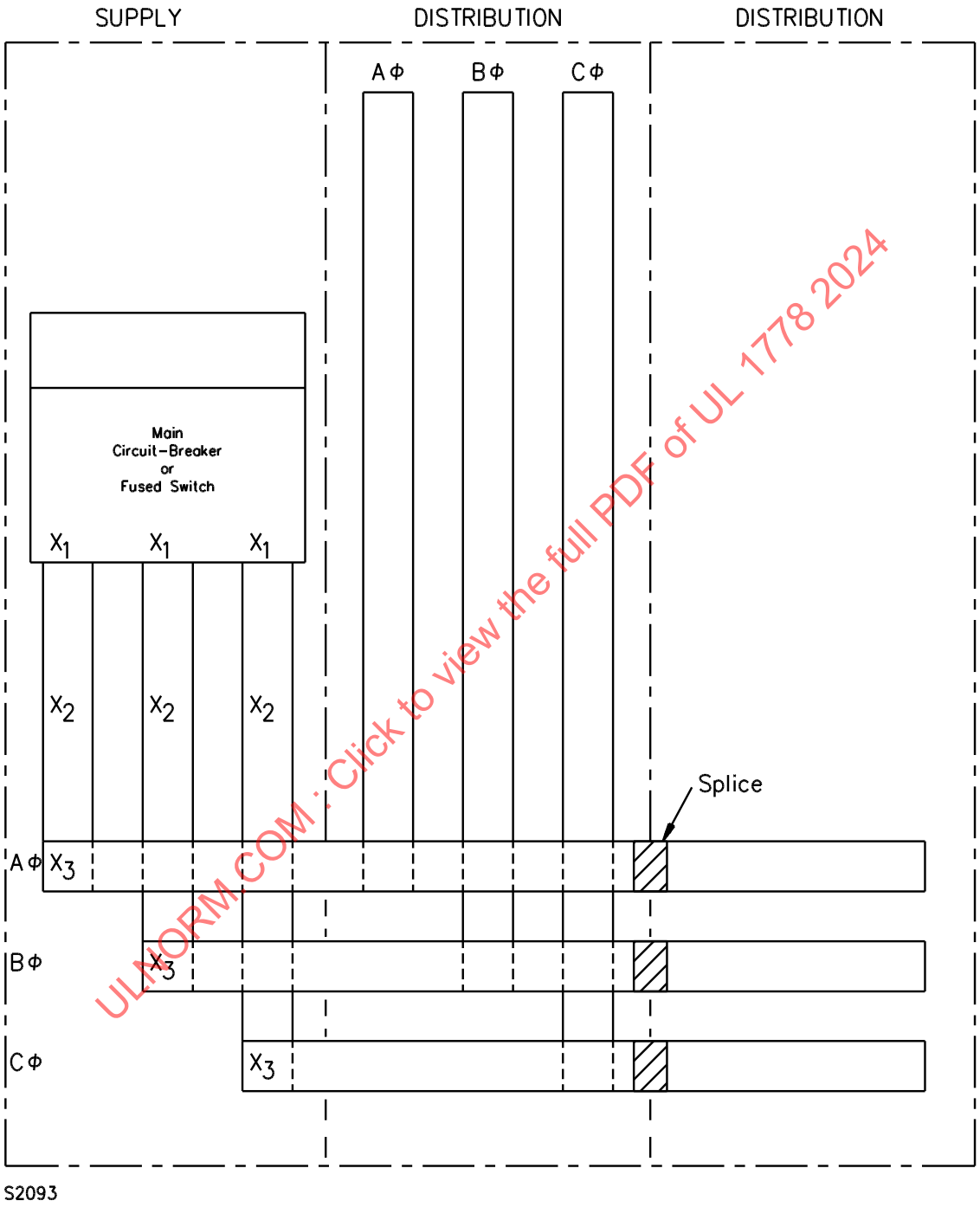


Distance X+Y equals maximum distance allowed between supports.

Distance X + Y is the maximum distance between SUPPORTS as shown in Table MMM.3.

Figure MMM.5

Location of SUPPORTS for edge-to-edge connection of bus bar with cables connected directly to main



X_1 – Connection to main serves as a SUPPORT.

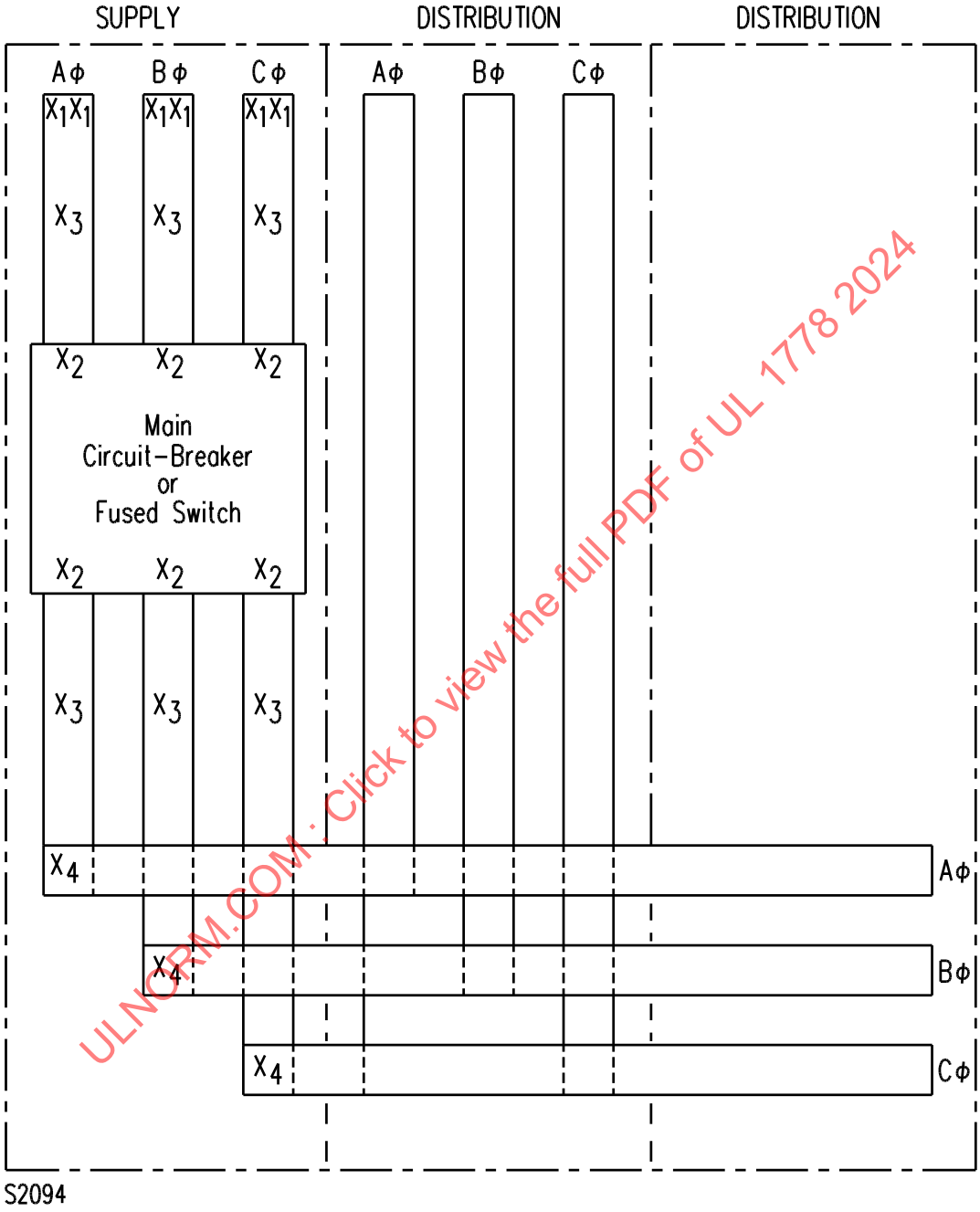
X_2 – One SUPPORT required at intervals as specified in Table MMM.3.

X_3 – SUPPORT at connection of vertical bus to horizontal or as shown in Figure MMM.4.

NOTE – For all other SUPPORTS, see Figure MMM.2.

Figure MMM.6

Location of SUPPORTS for right-angle connection of edge-to-edge bus bar with cables not connected directly to main



X_1X_1 – Two SUPPORTS required at line terminal end except only one SUPPORT may be used for a single bus bar 2 – 3 in (50.8 – 76.2 mm) wide with a short-circuit current rating of 50 000 A or less.

X_2 – Connection at main serves as SUPPORT.

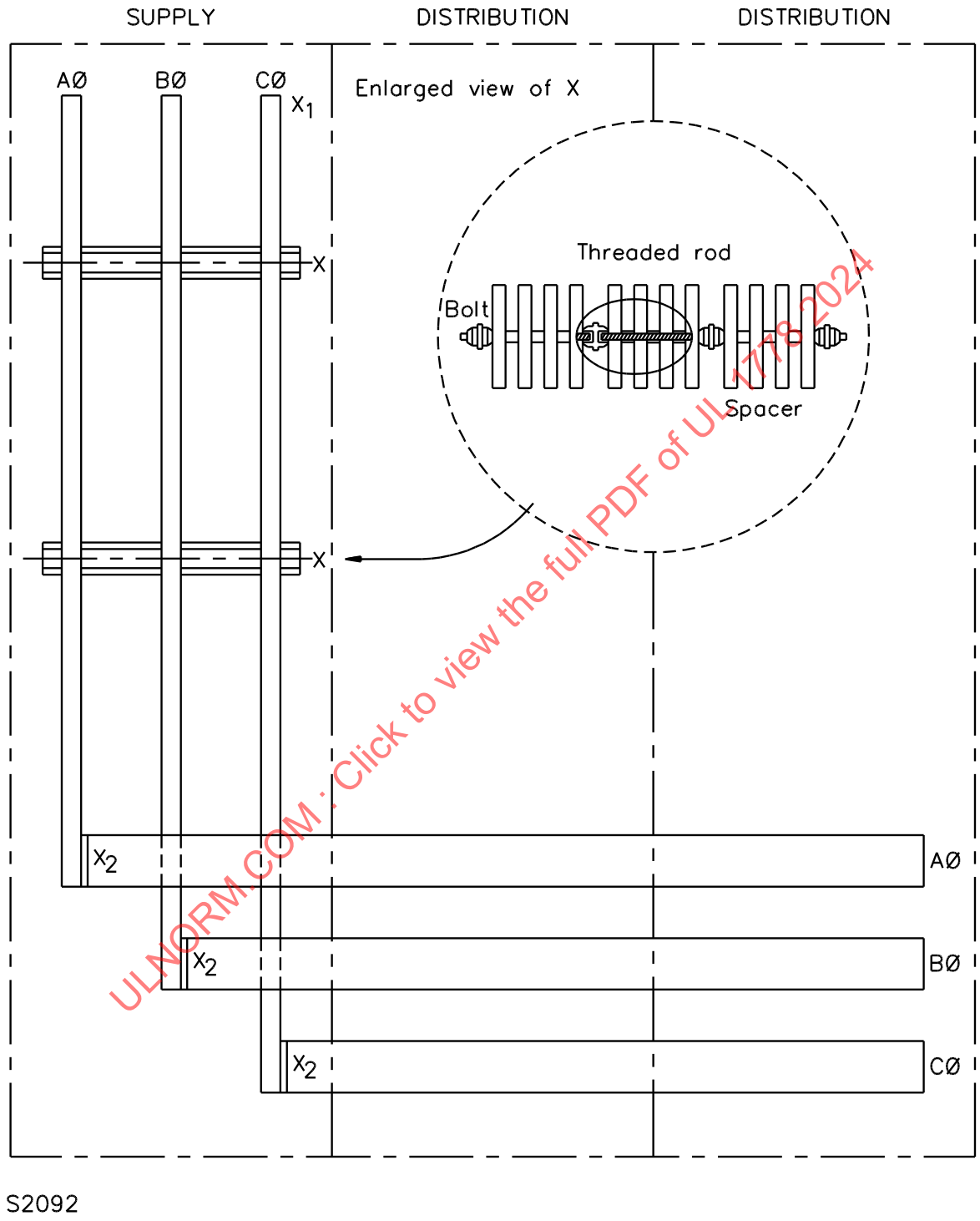
X_3 – One SUPPORT required at intervals as specified in Table MMM.3.

X_4 – One SUPPORT required at connection of vertical to horizontal bus or as shown in Figure MMM.4.

NOTE – For all other SUPPORTS, see Figure MMM.2.

Figure MMM.7

Location of SUPPORTS and BRACES for face-to-face connection of bus bars



X_1 – Line connection – SUPPORT provided by transformer or busway stub connected to enclosure.

X – Mechanical bracing between bus bars, SUPPORT located at intervals described in Table MMM.3 starting at X_1. Bracing not required to be secured to enclosure.

X_2 – One SUPPORT located not more than 48 in (1.2 m) from X_1. For SUPPORTS along horizontal bus, see Figure MMM.2 and Figure MMM.3. See MMM.2.2.3 for spacing between bus bars at cross over.

Figure MMM.8

Distances between edge-to-edge bus bars of opposite polarity

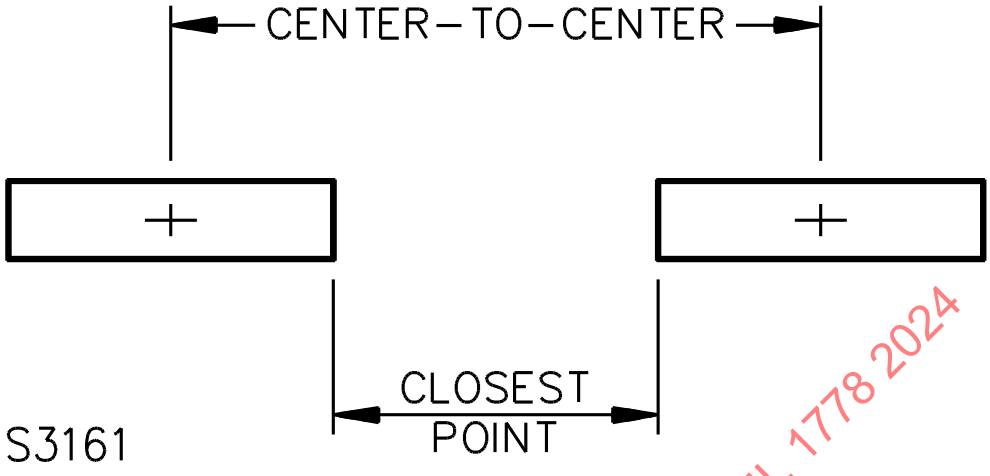


Figure MMM.9

Distances between face-to-face bus bars of opposite polarity

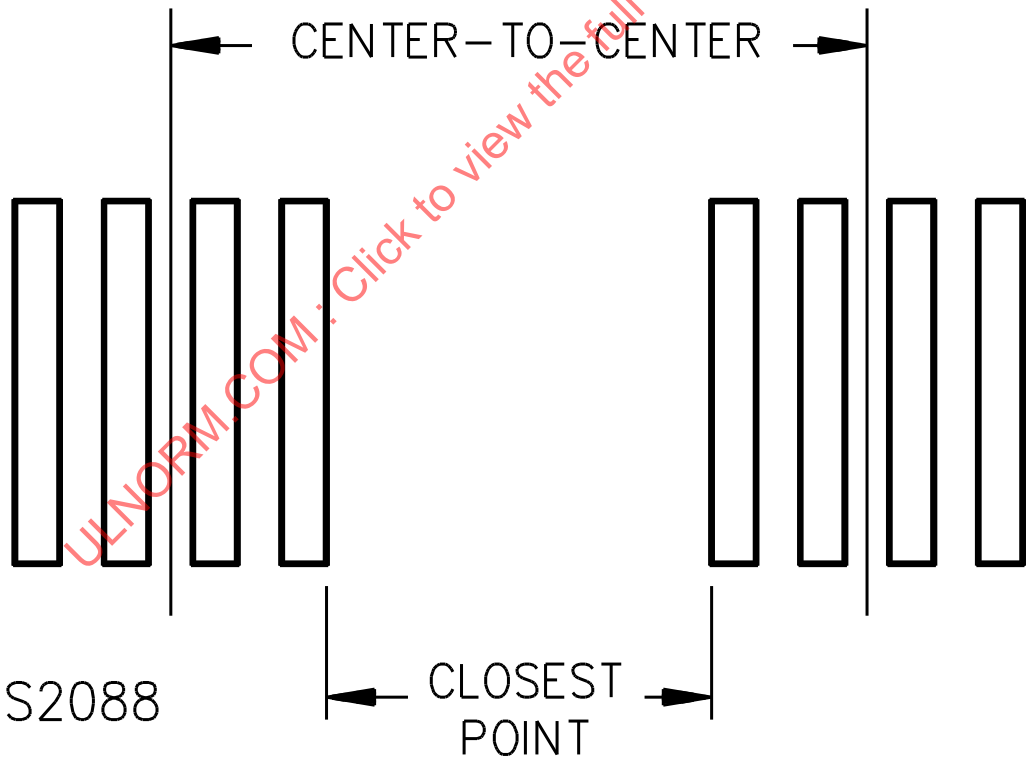


Figure MMM.10

Steel channel bus bar SUPPORT dimension

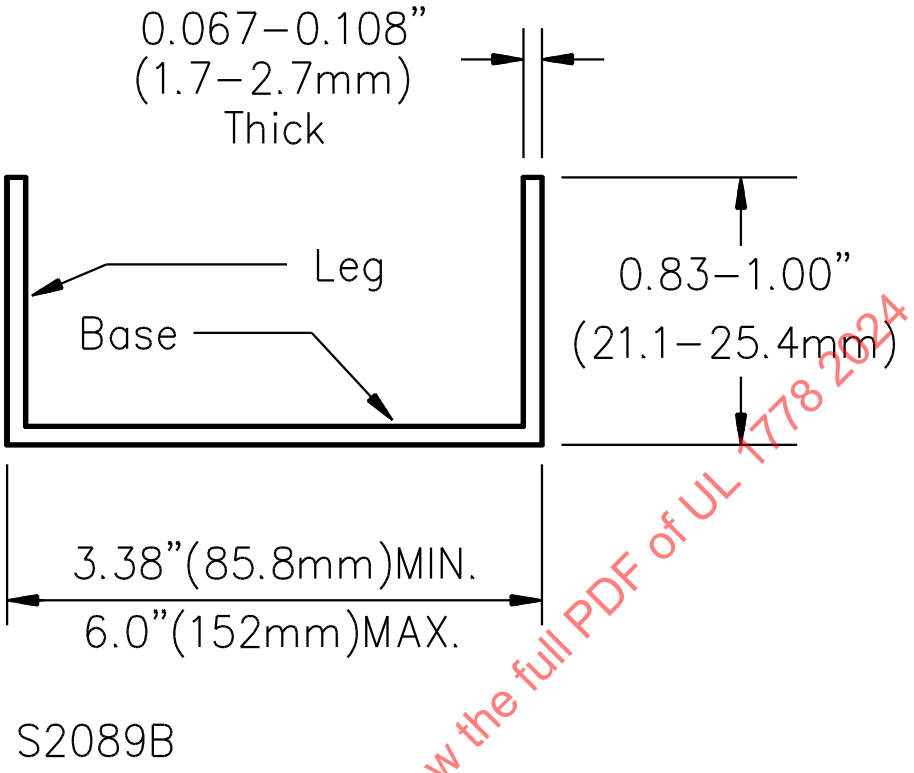


Figure MMM.11

Bus bar SUPPORT with standoff insulators mounted on leg of steel channel

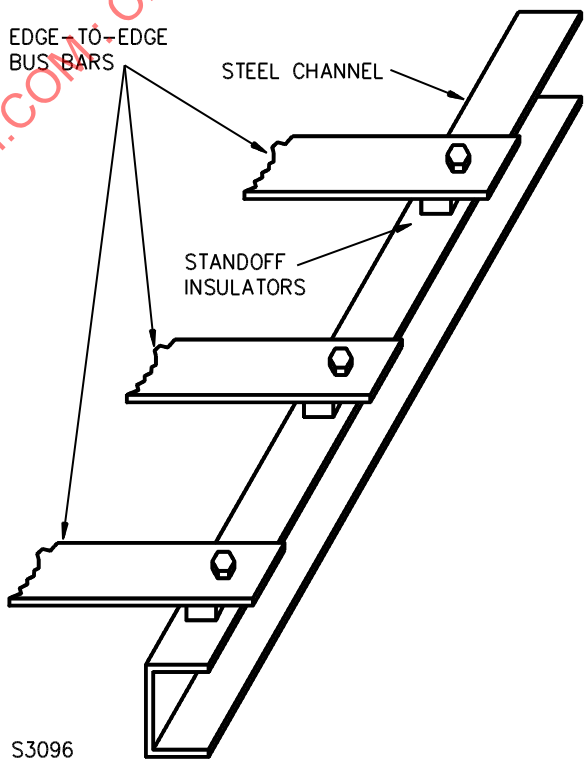
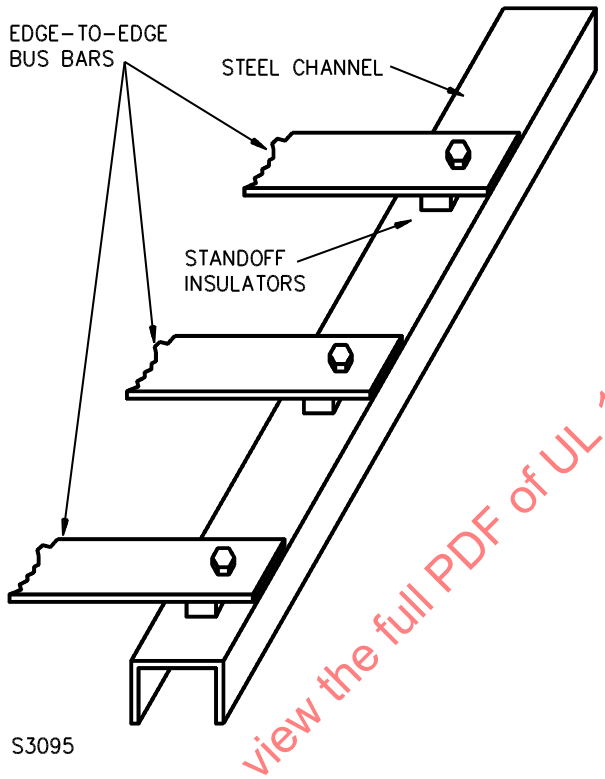


Figure MMM.12

Bus bar SUPPORT with standoff insulators mounted on base of steel channel



MMM.2.2.1.5 Bus bar configurations shall be flat and rectangular.

An L-shaped bus bar may be used if

a) it is considered to be a face-to-face configuration; or

b) the unsupported leg does not extend more than 2 in (50.8 mm) from the bus SUPPORT.

MMM.2.2.1.6 The number of bus bars shall not exceed four for each phase.

MMM.2.2.1.7 Phase bus bars, including neutral bus bars, shall be arranged edge-to-edge or face-to-face as described in Table MMM.3 and as shown in Figure MMM.1– Figure MMM.9.

A neutral bus bar need not comply with this requirement if the spacing between the adjacent surface of the neutral bus bar and the nearest phase bus bar is

a) at least 5-1/4 in (133 mm) or

b) 5 in (127 mm) if the short-circuit current rating of the UPS does not exceed 50 000 A.

MMM.2.2.1.8 Stacked bus bars shall not exceed a height of 1-3/4 in (44.5 mm) measured from the top of the standoff insulator or nonmetallic channel base to the top of the highest bus bar.

At a splice bus or a joint, the height of stacked bus bars shall not exceed 2 in (50.8 mm