UL 857

STANDARD FOR SAFETY

Busways

UL Standard for Safety for Busways, UL 857

Thirteenth Edition, Dated March 25, 2009

Summary of Topics

This revision of ANSI/UL 857 dated April 9, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL, CSA, and ANCE are committed to updating this harmonized standard jointly. However, the revision pages dated April 9, 2021 will not be jointly issued by UL, CSA, and ANCE as these revision pages only address UL ANSI approval dates.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated January 8, 2021.

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Association of Standardization and Certification
NMX-J-148-ANCE-2009
Third Edition

CSA Group
CSA C22.2 No. 27-09
Sixth Edition

Underwriters Laboratories Inc.
UL 857
Thirteenth Edition

Busways

March 25, 2009

(Title Page Reprinted: April 9, 2021)

Approved American National Standard

ANSI/UL 857-2011 (R2021)

Commitment for Amendments

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

ISBN 978-1-55436-530-2 © 2009 Canadian Standards Association

This Standard is subject to review within 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 Thirteenth Edition including revisions through April 9, 2021. The most recent designation of ANSI/UL 857 as a Reaffirmed American National Standard (ANS) occurred on April 9, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

The Department of Defense (DoD) has adopted UL 857 on April 20, 1993. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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Preface

This is the harmonized ANCE, CSA, and UL standard for Busways. It is the third edition of NMX-J-148-ANCE, the sixth edition of CSA C22.2 No. 27, and the thirteenth edition of UL 857. This edition of CSA C22.2 No. 27 supersedes the previous edition published in 2000. This harmonized standard has been jointly revised on December 9, 2011. For this purpose, CSA and UL are issuing revision pages dated December 9, 2011, and ANCE is issuing a new edition dated December 9, 2011.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc., (UL). The efforts and support of the CANENA Busway Technical Harmonization Committee are gratefully acknowledged.

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

The present Mexican Standard was developed by the CT CDI from the Comite de Normalizacion de la Asociacion de Normalizacion y Certificacion, A. C., CONANCE, with the collaboration of the busway manufacturers and users.

This standard was reviewed by the CSA Subcommittee on Busways, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

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

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard.

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

Interpretations

The interpretation by the standards development organization 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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Busways

1 Scope

1.1 Scope and object

1.1.1 This Standard applies to service-entrance, feeder, and branch-circuit busways and associated fittings rated at 600 V or less, 6 000 A or less, and intended for use in accordance with the Canadian Electrical Code, Part I (CE Code, Part I), the National Electrical Code (NEC), NFPA 70, and the Mexican Standard for Electrical Installations (Utility), NOM-001-SEDE, (see Annex B, Reference Item No. 1). These requirements do not apply to metal enclosed bus intended for connecting switchgear assemblies for use in prefabricated electric distribution systems.

1.1.2 For the purpose of these requirements, a busway is considered to be a grounded metal enclosure containing factory mounted conductors that are usually copper or aluminum bars, rods, or tubes.

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

1.1.4 Unless otherwise indicated, all voltage and current values mentioned in this Standard are root-mean-square (rms).

1.2 Reference publications

1.2.1 Products covered by this standard shall comply with the reference installation codes and standards 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 shall comply with the installation codes and standards for all countries where it is intended to be used. See Annex B for a list of reference publications.

1.2.2 For undated references to standards, such reference shall be considered to refer to the latest edition and all revisions to that edition up to the time when this standard was approved. For dated references to standards, such reference shall be considered to refer to the dated edition and all revisions published to that edition up to the time when this standard was approved.

1.2.3 In Canada, general requirements are as indicated in Reference Item No. 21, Annex B and Grounding and Bonding requirements are as indicated in Reference Item No. 22, Annex B.

1.3 Components

1.3.1 Except as indicated in Clause 1.3.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components generally used in the products covered by this Standard. A component shall comply with the ANCE, or the Canadian Standards Association, or the Underwriters Laboratories Inc. standards, as appropriate, for the country where the product is to be used.

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

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

b) Is superseded by a requirement in this standard.

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

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

1.4 Fittings

1.4.1 A trolley (busway fitting) shall comply with the clauses of this Standard listed in Annex D, Table D.1.

1.4.2 A fitting shall comply with the clauses listed in Annex D, Table D.2.

1.4.3 An outdoor fitting shall comply with the clauses listed in Annex D, Table D.2 and Table D.3.

1.5 Short-run busway

1.5.1 Short-run busway need only comply with those requirements specifically stating their application to short-run busway.

1.6 Insulating materials

1.6.1 Insulating material, other than wire insulation, tape, thermoplastic tubing, or continuous bus bar insulation, relied upon for over-surface spacing shall be resistant to arc-tracking under wet contaminated surface conditions and shall be:

a) A ceramic-type material or

b) A material having a Comparative Tracking Index (CTI) no less than 175 as determined in accordance with Reference Item No. 15, Annex B.

1.6.2 Insulating tape used in an outdoor ventilated busway shall be marked "Weather Resistant" under the conditions described in Reference Item No. 14, Annex B.

1.6.3 Requirements stated throughout this Standard for fittings apply to tap boxes, feed boxes, plug-in devices, and similar fittings; but do not apply to busway elbows, tees, and crosses.

2 Definitions

2.1 General

Reserved for future use.

2.2 Constructional units of assemblies

Reserved for future use.

2.3 External design of assemblies

2.3.1 Open-type assembly

Reserved for future use.

2.3.2 Dead-front assembly

Reserved for future use.

2.3.3 Enclosed assembly

Reserved for future use.

2.3.4 Busbar trunking system (busways)

2.3.4.1 Short-run busways

2.3.4.1.1 Short-run busways are unventilated busways intended:

a) Primarily to feed switchboards;

b) To have no intermediate taps (except for transformer stubs); and

c) For a maximum horizontal run of 9.14 m (30 ft) or a maximum vertical run of 3.05 m (10 ft).

2.3.4.1.2 Short-run busways include only straight lengths, elbows, fittings, and transformer taps (not necessarily end of run). A short-run busway is intended for horizontal runs, but one leg of any elbow may be installed in a vertical position.

2.3.4.2 Trolley busway

2.3.4.2.1 A trolley busway has provision for continuous contact with a trolley by means of a slot in the enclosure. Because the slot must accommodate a moveable trolley, the acceptable degree of exposure of uninsulated live parts in a trolley busway is necessarily larger than in a busway of another type.

2.3.4.3 Continuous plug-in busway

2.3.4.3.1 In Canada and Mexico, a continuous plug-in busway is rated at 400 A or less, has no exposed bus bars, and is intended for general use, including installation within the reach of persons. In the United States, a continuous plug-in busway is rated at 225 A or less.

2.3.4.4 Lighting plug-in busway

2.3.4.4.1 A lighting plug-in busway is rated at 50 A or less and is intended to provide:

a) Means for the support of luminaires [fluorescent, incandescent, or high-intensity discharge (HID)] and

b) Means by which the fixtures may be plugged into the power supply.

Note: In Canada the rating of the plug-in lighting busway is limited to values below 50 A by lighting branch circuit overcurrent protection requirements of the CEC, Part I.

2.4 Structural parts of assemblies

Reserved for future use.

2.5 Conditions of installation of assemblies

Reserved for future use.

2.6 Protective measures with regard to electric shock

Reserved for future use.

2.7 Gangways within an assembly

Reserved for future use.

2.8 Electronic functions

Reserved for future use.

2.9 Insulation co-ordination

Reserved for future use.

2.10 Short-circuit currents

Reserved for future use.

3 Classification of assemblies

Reserved for future use.

4 Electrical characteristics of assemblies

4.1 General

A busway or fitting shall be rated in amperes, volts, and in short-circuit current. A short-run busway shall be rated in accordance with Clause 7.5.2.2.1.

The ampere and voltage rating of an elbow, cross, or tee shall be identical with that of the busway with which it is intended for use.

A busway fitting incorporating a current-interrupting device shall be rated in accordance with the requirements for such an interrupting device.

A busway fitting that may be used for housing a circuit breaker of any of several different ratings may carry a voltage rating and a current rating equal to the maximum of such different ratings if the enclosure is marked in accordance with Clause 5.2.10.

4.2 Rated voltages

4.2.1 The voltage rating for a busway or fitting shall be 600 V or less.

4.3 Rated current (of a circuit of an assembly)

4.3.1 A busway may have a single- or a dual-current rating, exclusive of a second rating to indicate a reduced ampacity of a neutral. A single-current rating is a rating that applies to the busway when it is mounted in any position, unless the busway is marked in accordance with Clause 5.2.17.6. If a busway has a certain ampere rating when mounted in any position and, in addition, is rated for a higher ampere

rating when mounted in one particular position, both the lower and higher ampere values may be included as a dual-current rating, provided the busway is marked in accordance with Clause 5.2.10.

4.3.2 If a busway is for use on direct current only, the rating shall include such information.

4.3.3 If the ampacity of a neutral bus bar is less than that of the other bus bars, the rating shall include such information.

4.4 Rated short-time withstand current (I_{cw}) (of a circuit of an assembly)

Reserved for future use.

4.5 Rated peak withstand current (I_{pk}) (of a circuit of an assembly)

Reserved for future use.

4.6 Rated conditional short-circuit current (I_{cc}) (of a circuit of an assembly)

4.6.1 The short-circuit current rating of a busway or fitting shall be one or more of the values shown in Table 1.

Table 1
Short-circuit current ratings

RMS symmetrical or DC amperes		
5 000	25 000	75 000
7 500	30 000	85 000
10 000	35 000	100 000
14 000	42 000	125 000
18 000	50 000	150 000
22 000	65 000	200 000

4.7 Rated fused short-circuit current (I_{cf}) (of a circuit of an assembly)

Reserved for future use.

4.8 Rated diversity factor

Reserved for future use.

4.9 Rated frequency

Reserved for future use.

5 Information to be given regarding the assembly

5.1 General

A required marking shall be molded, die-stamped, paint-stenciled, stamped, or etched metal that is permanently secured or indelibly applied lettering on a label secured by adhesive or glue. Ordinary usage, including likely exposure to weather and other ambient conditions, handling, storage, and the like, of the

equipment shall be considered in the determination of the acceptability of the application. The need for exposure tests on forms of marking other than labels shall be individually investigated. After being subjected to the tests specified in Table 2, the sample shall rest, dry, or cool as applicable for the period of time specified for the test involved. Subsequently, the labels shall show no separation from the test surface except at the corners or edges. The total area of separation of the corners or edges shall not exceed 10 percent of the label area. The marking shall be legible.

For the purpose of the aging test conducted as part of the exposure conditions required in Reference Item No. 18, Annex B, rated surface temperatures shall be as specified in Table 3.

Other temperatures than those specified in Table 3 may be used for the purposes of the aging test if it can be demonstrated that the temperature will not be exceeded in service.

Table 2
Label test criteria

Enclosure type	Inside the enclosure	Outside the enclosure
Indoor	A	A
Outdoor	B	C

NOTES

1 Applies to nonmetallic labels and labels secured by adhesive.

2 The requirement and qualification tests from Reference Item 18, Annex B, are as follows:

a) Exposure conditions for labels intended only for indoor dry locations.

b) Exposure conditions for labels for use indoors where exposed to high humidity or occasional exposure to water.

c) Exposure conditions for labels intended for both indoor or outdoor use where exposed to high humidity or occasionally exposed to water.

Table 3
Rated surface temperatures

Temperature type	Indoor use, °C	Outdoor use, °C
High	60	80
Low	0	minus 35

A cautionary marking shall be located on a part:

a) That would require tools for removal or

b) That cannot be removed without impairing the operation of the product.

***Advisory Note**: In Canada, there are two official languages, English and French. Annex E provides French translations of the markings specified in this standard. Markings required by this standard will in some cases have to be provided in other languages to conform with the language requirements of the country where the product is to be used.*

5.2 Nameplates

5.2.1 Each length of a short-run busway and each fitting shall be marked with the manufacturer's name or trademark, the electrical ratings (rated voltage and current), and the number of poles, and may also be

marked for outdoor use. The short-circuit current rating markings shall be in accordance with Clauses 5.2.13 and 5.2.15.

5.2.2 Each length of busway and each fitting, elbow, or tee shall be legibly and permanently marked, where readily visible after installation, with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified;

b) The electrical ratings (rated voltage, current, and short circuit current); and

c) The number of poles (bus bars not at the same potential during normal use).

5.2.3 Each fitting, such as a switch or circuit breaker, shall be legibly and permanently marked, where readily visible after installation, with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified;

b) The catalog number, identification number, or the equivalent; and

c) The electrical ratings (rated voltage, current, and short-circuit current).

5.2.3.1 Fittings incorporating luminaires and evaluated for use on lighting busways and/or continuous plug-in busways shall additionally be marked to indicate the busway(s) with which the fitting is intended to be used.

5.2.4 The markings specified in Clauses 5.2.2 and 5.2.3 shall be on a nonremovable part and shall be readily visible after the busway system has been installed in the intended manner.

5.2.4.1 For fittings incorporating luminaries and evaluated for use on lighting busways and/or continuous plug-in busways, the markings specified in Clauses 5.2.2, 5.2.3, and 5.2.3.1 shall be visible during the installation of the fitting.

5.2.5 If a manufacturer produces or assembles busways and fittings at more than one factory, each finished length of busway and each finished fitting shall have a distinctive marking, which may be in code, by which it can be identified as the product of a particular factory.

5.2.6 A busway intended for use with a trolley shall be marked: "Trolley busway."

5.2.7 A lighting busway shall be marked with the words: "Lighting busway."

5.2.8 A continuous plug-in busway shall be marked with the words: "Continuous plug-in busway."

5.2.9 If a busway fitting has provision for one or more watthour meters, the current rating of the meter position shall be marked on the fitting. If the meter position is rated for continuous duty, the marking shall be: "____A Continuous (or equivalent)." If the meter position is rated for a maximum rating, the marking shall be: "____A (or equivalent) (____Amp Continuous (or equivalent))," in which case the maximum amperes shall be no more than 125 percent of the continuous-duty amperes.

5.2.10 A busway fitting containing a circuit breaker marked with a maximum rating as described in Electrical characteristics of assemblies, General, Clause 4.1, shall also be marked with instructions for determining the rating of the breaker actually installed therein, unless the breaker rating equals the maximum rating.

5.2.11 A busway having a dual-current rating, other than a dual rating resulting from a reduced neutral capacity as described in Clause 4.3.1, shall be marked, in association with the larger rating, with instructions concerning the position in which the busway must be mounted for such rating.

5.2.12 A busway shall be marked with the ampere rating of the overcurrent protective device to be used on the line side of the busway if the cross-sectional area of the ground bus or enclosure material is sized in accordance with Table 13.

5.2.13 A busway or fitting shall be marked with the following:

a) The phrase: "Short circuit current rating," and the short-circuit current rating in dc or rms symmetrical amperes as noted in Table 1. A busway fitting that has no external load circuit leaving the enclosure, such as a ground detector or the like, need not be marked with a short-circuit rating.

b) The maximum voltage rating for each short circuit current rating.

c) A phrase indicating that the short-circuit rating is limited to the lowest short-circuit rating of any busway or fitting installed (the phrase is not required if all such busways and fittings that are intended for installation have identical short-circuit current ratings).

d) In the case of a busway fitting containing a circuit breaker, a phrase indicating that a replacement shall be of the same manufacturer, type designation, short-circuit rating, and ampere rating, where applicable.

e) In the case of a busway fitting containing fuseholders rated over 10 000 A, a phrase: "Use Class (G, J, L, RK1, RK5, or T) fuses." The marking need not mention the class of fuse if the short-circuit rating of the busway is 10 000 rms symmetrical amperes or less.

f) Instructions for lashing, securing, or bracing of field-installed conductors in the case of a busway or fitting having provision for cable connections unless instructions for lashing, securing, or bracing field installed conductors are not necessary if the short-circuit test represented the worst case of unsupported conductors.

5.2.14 If the short-circuit current rating of a busway is dependent upon the use of a specific overcurrent device ahead of the busway, the busway shall be marked: "When protected by ____ ampere maximum Class ____ fuse or Type ____ circuit breaker rated not more than ____ amperes this busway is rated for use on a circuit capable of delivering not more than ____ RMS symmetrical amperes ____ volts maximum." The second blank space shall be filled with the fuse designation (G, J, L, RK1, RK5, or T). The third blank space shall be filled with the name of the circuit breaker manufacturer and the type designation. The value of amperes shall correspond to the symmetrical values given in Table 1.

5.2.15 If there is more than one short-circuit rating, all such ratings shall appear together. The markings shall be an integral part of the manufacturer's marking that contains the manufacturer's name or trademark and the electrical rating, unless it is an integral part of other appropriate marking of the busway or fitting.

5.2.16 Each length of busway and each fitting intended for outdoor use shall be plainly marked to indicate that fact and, if drain holes are provided, shall be marked: "Install with drain holes down," or with other wording to clearly indicate the mounting position necessary to provide adequate drainage.

5.2.17 Mounting or hanging information

5.2.17.1 The short-run busway marking specified in Clause 5.2.1 shall include the statement: "Total connected length not to exceed 9.14 m (30 ft)." The leg of a short-run elbow intended for installation in a vertical position shall be marked: "This leg may be installed as part of a straight vertical run not more than 3.05 m (10 ft) long." The marking shall include instructions to space mounting supports at intervals of no more than 1.52 m (5 ft).

5.2.17.2 Each length of busway intended for use in a vertical run shall be plainly marked to indicate that fact.

5.2.17.3 The intended mounting position of each length of busway shall be plainly marked on a busway that is not rated for both edgewise and flatwise mounting in a horizontal run.

5.2.17.4 The unsuitability for mounting in one or more of the positions shall be marked because of the inadequacy of enclosure strength, lack of ampacity, or other deficiency when mounted in that position.

5.2.17.5 Each length of either horizontal or vertical busway that is intended to be supported at intervals of more than 1.52 m (5 ft) shall be plainly marked to indicate the maximum support interval with which the busway can be used. If the support interval for vertical mounting exceeds the support interval for horizontal mounting, the marking shall clearly indicate that the higher support interval applies only when the busway is mounted vertically.

5.2.17.6 A busway having a single current rating shall be marked to indicate the intended mounting position, unless the busway has been investigated and determined acceptable for such rating when mounted in any position.

5.2.17.7 If a marking regarding the mounting or support of busway is required, that marking shall appear on or immediately adjacent to the nameplate that bears the marking required in Clause 5.2.17.6.

5.2.18 Service equipment information

5.2.18.1 A busway fitting that is intended for use as service equipment and that complies with Clause 7.1.1.31 shall be marked "Suitable for use as service equipment."

5.2.18.2 The marking shall be an integral part of the manufacturer's marking containing the manufacturer's name or trademark and the electrical rating, unless it is an integral part of another required marking of the fitting.

5.2.18.3 The marking shall be plainly visible after installation without requiring the opening of a door or cover, or the removal of a dead front or trim.

Other markings:

a) Shall not be located within 3.2 mm (1/8 in) of the marking described in Clause 5.2.18.1 and markings within 12.7 mm (1/2 in) of such marking shall be of less height or

b) Shall be in contrasting color or located in a distinctively separated area.

5.2.18.4 The characters in the markings shall be no less than 2.4 mm (3/32 in) high.

5.2.18.5 If a busway fitting is marked "Suitable only for use as service equipment," each service disconnecting means shall be marked "Service disconnect." The service disconnect marking identifying the service disconnecting switches or circuit breakers shall appear on or adjacent to the switch or circuit breaker handles.

5.2.18.6 If a busway fitting is marked "Suitable for use as service equipment," the service disconnect marking shall be provided in the form of pressure-sensitive markings in an envelope, or on a card, with instructions to apply near the disconnect handles if the equipment is used as service equipment.

5.2.19 Miscellaneous information

5.2.19.1 If a busway or fitting includes a transverse barrier or divider, as covered in Clause 7.1.1.8, there shall be a marking on the outside of the busway or fitting to indicate this fact.

5.2.19.2 A plug-in circuit breaker housing shipped separately from the circuit breaker or the neutral, as described in Clause 7.1.1.39, shall be marked:

a) To indicate the neutral, the circuit breaker, or both, for which it is intended. If the circuit breaker is omitted, the marking shall give the name of the manufacturer of the circuit breaker, the type or catalog designation of the breaker, and the number of poles.

b) With its maximum voltage and ampere rating and shall make reference to the rating of the circuit breaker that will be installed in it; for example, the fitting may be marked "See ampere rating on breaker handle." The marking, including the ampere rating of the breaker, may be located on the inside of a door or cover, provided that the door may be opened or the cover removed, regardless of the position of the breaker handle.

5.2.19.3 If, in accordance with Clause 7.1.1.39, a neutral assembly is shipped from the factory separately from the plug-in switch with which it is intended to be used:

a) The neutral assembly shall be marked with its own catalog number or the equivalent and with the name or trademark of the manufacturer and

b) The switch shall be marked with the catalog number or the equivalent for the neutral assembly and with an indication of the voltage ratings for which the neutral assembly must be used.

5.2.19.4 The on and off positions of the mechanism of a switching take-off device fitting shall be externally marked.

5.2.19.5 If a circuit breaker handle or a simple extension of that handle has an additional or intermediate position that it takes upon automatic tripping, that position and the resetting instructions for the breaker shall be described in the marking. Marking to indicate the tripped position shall not be required in the case of a separate, external operating handle, other than a simple handle extension, that is not part of the circuit breaker. Such a handle may remain in the on position.

5.2.19.6 A busway fitting containing a circuit breaker or a fused disconnect switch shall be marked "Line" and "Load" unless investigated for reverse line and load connection. The line and load markings may be located on a wiring diagram attached to the inside of the enclosure if the diagram indicates clearly the proper connections.

5.2.19.7 A nonswitched plug-in device that has not been found by test to comply with the requirements in Clauses 8.2.8.1 – 8.2.8.3 shall be marked "Do not remove under load."

5.2.20 Wire, wire connectors, and wire torque information

5.2.20.1 If a pressure terminal connector is not provided on the equipment as shipped, the equipment shall be marked stating which pressure terminal connector or component terminal assembly is rated for use with the equipment. The terminal assembly package shall carry an identifying marking, wire size, and the manufacturer's name or trademark.

5.2.20.2 Wire connectors of the type mentioned in the marking may be installed on the equipment at the factory with instructions, if necessary, to effect proper connection of the conductors.

5.2.20.3 If any terminal of a busway or fitting is marked to indicate that aluminum wire may be used at that terminal (such as being marked with the symbol "AL") and if such marking is visible under the conditions described in Clause 5.2.20.4, the busway or fitting shall be marked in accordance with Clause 5.2.20.4 and Clause 5.2.20.5 or 5.2.20.18, whichever applies.

5.2.20.4 The term "visible" refers to a marking that will be visible when a cover has been removed or is visible when a hinged cover of a component has been opened. A marking on a separately supplied connector or on a connector or part thereof that is likely to be removed or displaced during the wiring operation is considered to be visible.

5.2.20.5 If, because of wiring space or other factors, no terminal of a busway or fitting is acceptable for use with aluminum wire, the busway or fitting shall be marked "Use copper wire only."

5.2.20.6 If the wiring space and other factors are such that all terminals of a busway or fitting are acceptable for use with aluminum wire as well as with copper wire, the busway or fitting shall be marked "Use copper or aluminum wire."

5.2.20.7 If a field-installed overcurrent device is available, with markings to indicate that the terminals are acceptable for use with aluminum wires, the marking in Clause 5.2.20.6 shall be used only if:

a) The neutral terminals are rated for use with aluminum wire.

b) The marking includes a statement that the field-installed unit must carry the marking indicating acceptability for use with aluminum wire.

5.2.20.8 If the wiring space and other factors are such that some terminals of a busway or fitting are rated for use with aluminum wire as well as with copper wire, while the remainder of the terminals are rated for use with copper wire only, the busway or fitting shall be marked "Use copper wire only except at terminals ____" or equivalent. The marking shall positively identify the terminals that are rated for use with aluminum wire.

5.2.20.9 The word "terminal" as used in Clauses 5.2.20.3 and 5.2.20.5 – 5.2.20.8 signifies any terminal of a busway or fitting as well as a terminal of any component unit (circuit breaker, switch, or the like) that is installed or intended to be installed in the busway or fitting and to which wires are to be connected in the field.

5.2.20.10 Marking provided in accordance with Clauses 5.2.20.5 and 5.2.20.6 or Clause 5.2.20.8 shall be readily and clearly visible after installation with any cover or trim removed.

5.2.20.11 Only the words that are specified in Clauses 5.2.20.5 and 5.2.20.6 shall be used when these markings are provided, and any abbreviation used to designate copper and aluminum shall be "Cu-Al" or "Al-Cu."

5.2.20.12 The characters in the markings described in Clauses 5.2.20.5 – 5.2.20.8 shall be no less than 2.4 mm (3/32 in) high.

5.2.20.13 If a wire terminal is rated for securing more than one conductor in an opening and is intended for such use, a marking indicating the number of conductors shall be provided. The marking shall be on the wire connector, if visible, or in another visible location, such as next to the terminal or on a wiring diagram.

5.2.20.14 If a pressure terminal connector provided in the busway or fitting or in a terminal assembly described in Clause 7.8.3.2 (d) for a field-installed conductor requires the use of a particular tool for securing the conductor, any necessary instructions for using the tool shall be provided. The instructions

shall be included in a readily visible location, such as on the connector, on a wiring diagram, or a tag secured to the connector. The instructions may consist of a reference to the tool if assembly instructions are on the tool.

5.2.20.15 A busway or busway fitting shall be marked to indicate the specific tightening torque for each wire connector in the busway or fitting that is intended for field wiring. If different connectors are used for line, load, neutral, or ground, the specific torques to be applied to each connector shall be clearly indicated. The value of tightening torque for a field wiring terminal provided on a component such as a circuit breaker, switch, or the like need not be marked on the busway or fitting.

5.2.20.16 The torque to be marked for each connector shall be determined as specified in Clause 7.8.3.7. An example of a typical torque marking is shown in Annex C.

5.2.20.17 A busway or busway fitting having terminals for field wiring shall be marked in a location readily visible prior to being wired to indicate the required temperature rating of each field installed conductor.

5.2.20.18 A busway fitting provided with circuit breakers rated 110 A or less or having any circuits rated 110 A or less shall be marked to indicate use of 60°C sized conductors only for circuits rated 110 A or less, and 75°C sized conductors for circuits rated more than 110 A unless:

a) The marking may specify 75°C sized conductors for a circuit rated 110 A or less if:

1) The circuit breakers involved are marked 75°C or 60/75°C;

2) The circuit breakers are spaced at least 76.2 mm (3 in) apart from all other circuit breakers; and

3) The circuit breakers are to be installed in the field, in which case a marking shall specify that circuit breakers marked 75°C or 60/75°C only are to be used.

b) With regard to (a)(2), the circuit breakers need not be spaced 76.2 mm (3 in) apart if the test, described in Clause 8.2.1 is conducted with acceptable results.

With regard to (a)(3), and Clause 7.8.3.10 (a)(3), a 100-A circuit breaker marked for use with 75° C aluminum wire need not be spaced apart from other circuit breakers or be subjected to a temperature test.

5.2.20.19 A busway fitting that is marked to indicate that only 60° C field-installed conductors are to be used shall not reference a field-installed circuit breaker that has been investigated for 75° C conductors only.

5.3 Markings

Reserved for future use.

5.4 Instructions for installation, operation, and maintenance

5.4.1 A plug-in busway and, with regard to Clause 7.4.8, a plug-in fitting intended for use with a busway that:

a) Involves a possible short-circuit condition during the installation or removal of the plug-in fitting or

b) Does not establish grounding continuity 3.2 mm (1/8 in) before contacting a live part

shall be marked with the word "DANGER" and the following or equivalent wording: "Risk of electric shock or burn. Turn off power to busway before installing, removing, or working on this equipment." The wording shall be located on the front of the plug-in fitting so that it will be readily visible during any attempt to install or remove the fitting.

5.4.2 To provide for system performance testing as required, each ground fault relay or apparatus incorporating a ground fault relay or its functions intended for protection of a solidly grounded wye service rated more than 150 V to ground but not exceeding 600 V phase-to-phase shall be provided with information sheets describing system testing instructions, and with a test form. The form shall include a space for the date the test was performed and the results, and shall state that the form should be retained by those in charge of the building's electrical installation in order to be available to the authority having jurisdiction. The instruction shall include the following items and shall basically prescribe only that information necessary to perform the tests. The instructions shall be separate and apart from any more elaborate test detail that the manufacturer may wish to provide. The instructions shall specify that:

a) The interconnected system shall be evaluated in accordance with the busway manufacturer's detailed instructions, and that this evaluation shall be undertaken by qualified personnel.

b) The proper location of the sensors around the bus of the circuit to be protected shall be determined. This can be done visually, with knowledge of which bus is involved.

c) The grounding points of the system shall be verified to determine that ground paths do not exist that would bypass the sensors. The use of high-voltage testers and resistance bridges may be suggested.

d) The installed system shall be tested for correct response by the application of full scale current into the equipment to duplicate a ground fault condition, or by equivalent means such as by a simulated fault current generated by a coil around the sensors or a separate test winding in the sensors.

e) The results of the test shall be recorded on the test form provided with the instructions.

6 Service conditions

6.1 Normal service conditions

Reserved for future use.

6.2 Special service conditions

Reserved for future use.

6.3 Conditions during transport, storage, and erection

Reserved for future use.

7 Design and construction

7.1 Mechanical design

7.1.1 General

7.1.1.1 A busway and fitting shall employ only those materials that have been determined acceptable for the particular use. A busway system shall include all fittings necessary to make a complete installation.

7.1.1.2 A busway system shall be constructed so that the busways and fittings, when properly interconnected, will constitute a complete mechanical assembly that provides electrical continuity.

7.1.1.3 Fastenings between parts of an enclosure shall be spot welds, continuous welds, machine- or self-threading screws engaging no less than two full threads, rivets, or other means. Screw fastenings that engage threads in nonmetallic materials shall be such that the threads will not be stripped by hand-tightening with the intended tool.

7.1.1.4 Sheet metal screws may be used for fastenings of a busway proper (but shall not be used for the enclosure of a plug-in device) if they are not intended to be subject to removal and replacement.

7.1.1.5 A surface of steel employed in an enclosure shall be made corrosion-resistant by painting, enameling, galvanizing, plating, or equivalent means.

7.1.1.6 A steel part, other than the enclosure, a screw, or other fastening part, shall have corrosion resistance equivalent to that required for the enclosure. A screw and any other steel fastening part shall be plated.

7.1.1.7 A busway, other than a short run-busway, shall be provided with means for support (not necessarily integral with the busway) at intervals of no more than 3.05 m (10 ft) for a horizontal run and no more than 4.88 m (16 ft) for a vertical run. If the intended interval between supports is more than 1.52 m (5 ft), the busway shall be subjected to the test described in Clause 8.2.7.1 and the verification of crushing resistance, Clause 8.2.7.3.1. A vertical busway with supports no more than 3.05 m (10 ft) apart need not be subjected to the verification of bending resistance.

7.1.1.8 A transverse barrier or divider that restricts the free flow of air may be included in a busway section, but this acceptance shall not imply the barrier is a fire stop. The busway shall be marked in accordance with Clause 5.2.19.1.

7.1.1.9 A busway intended for outdoor use and constructed to prevent the passage of water between adjoining sections shall be subjected to the performance requirements specified in Clauses 8.2.6.1 and 8.2.6.2.

7.1.1.10 A construction shall be investigated for preventing the flow of water past the barrier and for resistance to a temperature of minus 10° C. In a ventilated outdoor busway, the barrier shall also be investigated for resistance to the weather.

7.1.1.11 A bus bar support shall be of strong, moisture-resistant, insulating material having a thermal index of at least 105°C. The thermal index may be 85°C if the temperature rise during a heating test is in accordance with Table 12.

7.1.1.12 Porcelain, cold-molded composition, and phenolic composition are among the acceptable materials for bus bar supports. Butyl rubber having a thermal index of 90°C may be used as a combination bus bar covering and support if it complies with the requirements for aging, dielectric voltage-withstand, and impact specified in Clauses 8.2.2, 8.2.7.2 and 8.2.9 and if it is no less than 1.2 mm (3/64 in) thick at every point where it supports the bus bar.

7.1.1.13 For other than a short-run busway, the distance between centers of adjacent supports along the length of the bus bar shall be 762 mm (30 in) or less.

7.1.1.14 An insulating covering for a bus bar shall have a thermal index no less than 95°C. The thermal index of an insulating covering on an unplated copper bus bar in an indoor-type lighting or continuous plug-in busway rated no more than 60 A may be 60°C. An insulating covering may have a thermal index of

85°C if the temperature rise during a heating test is in accordance with Table 12. See Annex B, Reference Item No. 16, for thermal index standards.

7.1.1.15 Varnished cloth is considered to have a thermal index of 85° C. A bus bar covering of thermoplastic splicing tape rated for general use at 80°C is considered to have a thermal index of 85°C if it complies with Clauses 8.2.9.2 and 8.2.9.3.1.

7.1.1.16 An insulating covering for a bus bar:

a) Shall be no less than 0.51 mm (0.020 in) thick;

b) May be less than 0.51 mm (0.020 in) thick but not less than 0.38 mm (0.015 in) thick if, upon investigation, the material:

1) Is determined to be acceptable for the application, considering such properties as ease of ignition, electrical resistance, dimensional stability, tensile strength, elongation, resistance to weathering, tear resistance, penetration, and abrasion; and

2) Withstands the application of a 5 000-V, 60-Hz test potential without breakdown. When conducting this test, the potential shall be brought up to the required value and held for one second. The potential shall be applied between the bus bar and metal foil wrapped around the covering, or

c) May be less than 0.38 mm (0.015 in) thick if the busway meets requirements (b)(1) and (b)(2) as stated above and is subjected to and successfully passes the mechanical and short-circuit tests in accordance with Clauses 8.2.3.1 and 8.2.7.

7.1.1.17 Thermoplastic tubing may be used as an insulating material for bus bars if all of the following conditions are met:

a) It is not subjected to compression, repeated flexure, or sharp bends.

b) All edges of the conductor covered with the tubing are rounded and free from sharp edges.

c) For chemically dilated tubing, a solvent recommended by the tubing manufacturer is used.

d) Its wall thickness (after assembly) is not less than 0.56 mm (0.022 in) for tubing 12.7 mm (1.2 in) or less in diameter, not less than 0.69 mm (0.027 in) for tubing 14.3 or 15.9 mm (9/16 or 5/8 in) in diameter, and not less than 0.71 mm (0.028 in) for larger tubing.

7.1.1.18 The acceptability of insulating materials used for bus bar covering, other than those specified in Clauses 7.1.1.12, 7.1.1.15, or 7.1.1.17, shall be determined in accordance with the requirements specified in Clause 7.1.2.3.1 and Table 9.

7.1.1.19 The enclosure of a ventilated busway shall have openings intended for ventilation or shall be formed from perforated sheet metal, expanded metal mesh, or the like.

7.1.1.20 In the case of an outdoor-use ventilated busway in which the ventilating openings constitute a major part of the area of the enclosure, consideration shall be given to the need for corrosion protection at the edges of the openings.

7.1.1.21 A bus bar covering in a ventilated busway shall provide protection against physical injury of the bus bar by a means equivalent to that provided by a wrap of varnished cambric tape.

7.1.1.22 A plug-in busway intended for the support of luminaires shall provide means for such support.

7.1.1.23 A busway or fitting intended for outdoor use shall be subjected to the tests described in Clause 8.2.6. The test shall be conducted in any mounting position indicated by markings.

7.1.1.24 The enclosure of any busway or fitting marked for outdoor use shall be provided with holes to drain accumulated water.

7.1.1.25 A gasket or vapor seal that is relied upon for the exclusion of moisture or the free flow of air shall be of a material rated for the purpose and shall be resistant to aging.

7.1.1.26 A gasket of rubber or rubber-like material that is considered to be resistant to aging shall comply with Clause 8.2.12.

7.1.1.27 A meter-socket base shall be mounted independently of the cover unless it is intended to be used with a current transformer.

7.1.1.28 A meter-socket base shall be mounted in an enclosure that completely houses all live parts, with an appropriate meter mounted in position.

7.1.1.29 A bare live part on a meter-socket base shall be recessed as follows:

a) No less than 12.7 mm (1/2 in) behind the plane of the outer edge of the meter mounting rim, or behind the plane of the meter mounting hole if a mounting rim is not provided and

b) Behind the plane of the cover, unless a barrier or the like is provided so that the cover may be removed without the likelihood of it contacting a bare live part.

7.1.1.30 If a busway fitting has provision for a watt-hour meter not intended for use with current transformers, the rating of the meter position shall be no less than the rating of the circuit in which it is used.

7.1.1.31 A busway fitting marked for service equipment use shall comply with Reference Item No. 17, Annex B, as follows:

a) The line and grounding electrode conductor terminals shall be of the pressure wire connector type rated for a minimum wire size of 8 AWG (8.4 mm^2). Line terminals may be omitted as specified in Clause 7.8.1.

b) Equipment intended for alternating-current service shall have a pressure terminal connector for connection of a grounded service conductor. A pressure terminal connector for a grounding electrode conductor shall also be provided at the same connection point. If provisions for load connections are made or intended, the connection point (neutral) shall be insulated from the enclosure unless the equipment is marked "Suitable only for use as service equipment."

c) If the connection point described in (b) is not insulated from the enclosure, there shall be a bond to the equipment enclosure. If the connection point is insulated from the enclosure, provision for installing a main bonding jumper, consisting of a separate screw, strap, or other means, shall be provided to bond the enclosure to the connection point. The construction shall be such that when the bonding means is not used, at least the minimum acceptable spacings will exist. Unless the intended use and method of installation of the bonding means are obvious, instructions for its installation shall be provided.

d) A fitting shall be constructed so that:

1) All ungrounded load conductors can be disconnected from the source of supply and

2) There is an overcurrent device (a fuse or circuit breaker) in series with each ungrounded service conductor.

e) Equipment marked for use as service equipment for 3-phase, 4-wire, wye-connected services rated in excess of 150 V to ground, but not exceeding 600 V phase-to-phase, shall be provided with ground fault protection, if rated 1 000 A or more, complying with Reference Item No. 17, Annex B.

f) Markings as specified in Clauses 5.2.18.1 – 5.2.18.4 shall be provided.

7.1.1.32 A busway fitting of the plug-in type shall not be marked for service equipment use if:

a) It is intended for use on the line side of the busway and

b) A live part would be exposed if the fitting could be disconnected from the busway with the switch or breaker in the on position.

7.1.1.33 Unless otherwise specified in this Standard, the enclosure of a busway fitting shall comply with the requirements in Reference Item No. 7, Annex B. The enclosure of a plug-in device not incorporating a switching mechanism may be of sheet steel having a thickness no less than 1.0 mm (0.042 in) if:

a) The device is rated at no more than 100 A;

b) The device is not intended for outdoor use;

c) Neither the length nor the width of the enclosure is more than 152 mm (6 in);

d) The area of the largest surface of the enclosure is no more than 155 cm^2 (24 in^2); and

e) The depth of the enclosure is no more than 76.2 mm (3 in).

7.1.1.34 A seam, joint, or splice at a corner or back edge of an enclosure of a fitting shall be closed and reinforced:

a) By a flange formed of the material from which the box is made;

b) By a separate flange; or

c) By other means, such as a continuous weld that provides a construction equivalent to an integral flanged construction.

7.1.1.35 The method of attachment of a plug-in device to the busway shall be such that:

a) After installation, there is no opening between the two enclosures larger than the size permitted in Clause 7.2.5 and

b) Positive metal-to-metal contact between the individual enclosures results unless the assembly complies with Clauses 8.2.4.3.1.1 and 8.2.4.3.3.1.

7.1.1.36 A busway plug-in device shall have provision for being secured to the busway in a manner that does not depend on friction alone.

7.1.1.37 A plug-in device not incorporating a switching mechanism shall require the use of a tool for removal from the busway and shall be marked in accordance with Clause 5.2.19.7 unless the plug-in device complies with the requirements in Clauses 8.2.8.1 – 8.2.8.3.

7.1.1.38 A fitting incorporating a disconnecting device (a switch or circuit breaker) with a separate, cover-mounted operating member shall be constructed so that the door, front, or cover cannot be secured in

place as intended with the handle or operating member indicating "Off" and the disconnecting contacts in the closed position.

7.1.1.39 All live parts shall be mounted in place when a plug-in device is shipped from the factory. However, a busway plug intended for housing one or more circuit breakers may be shipped separately from the circuit breaker, the neutral bus, or both. The neutral bus of an enclosed switch plug-in device may be shipped separately from the remainder of the device if all of the following conditions are met:

a) The parts involved are constructed so that the method of field installation of the separate parts is obvious and does not require installation of auxiliary parts to accomplish the mounting or provide the required spacings.

b) The construction is such that the installation of the circuit breaker or the neutral is unnecessary either:

1) To maintain spacings involving the means for connecting the plug-in unit to the bus bars (the stabs and mounting means), or to prevent such parts from turning or shifting; or

2) To maintain spacings involving connecting leads or bus bars inside the plug-in device, unless such leads or bus bars are appropriately insulated.

c) The fitting is marked in accordance with Clause 5.2.19.3.

d) Instructions for installing the separate parts are provided.

7.1.1.40 Individual conductors (bus bars, wires, and the like) of an alternating-current circuit carrying more than 50 A shall not be run through separate openings in a ferrous metal wall.

7.1.1.41 A short-run busway shall be constructed so that electrical and mechanical continuity of the complete enclosure will result when the busway system is installed. The enclosure shall be of substantial construction and shall completely enclose the bus bars; the bus bars at an end fitting need not be enclosed. Openings for ventilation shall not be provided.

7.1.1.42 A short-run busway shall be provided with a ground bus located within the enclosure that complies with the requirements specified in Clause 7.4.1 without including the cross-sectional area of the enclosure.

7.1.1.43 A short-run busway enclosure shall be constructed of galvanized sheet steel, painted sheet aluminum, or other sheet steel provided with corrosion protection as specified in Clause 7.1.1.54. The thickness shall be in accordance with Table 4.

Table 4
Thickness of sheet metal for short-run busway

Maximum inside width,		Minimum thickness of sheet metal			
		Zinc coated steel,		Aluminum,	
mm	(in)	mm	(in)	mm	(in)
152	6	1.42	0.056	1.91	0.075
457	18	1.78	0.070	2.41	0.095
762	30	2.46	0.097	3.09	0.122

7.1.1.44 Each longitudinal seam of a short-run busway enclosure shall be provided with fastenings spaced no more than 305 mm (12 in) apart, as measured along the length of the duct.

7.1.1.45 Four or more 6.4 mm (0.25 in) diameter drain holes shall be provided in each short-run busway section intended for outdoor use.

7.1.1.46 A short-run busway shall be provided with means for support at intervals of no more than 1.52 m (5 ft).

7.1.1.47 Short-run busway insulating supports for bus bars shall be spaced no more than 610 mm (24 in) apart, as measured between centers of adjacent supports along the length of the busway. An insulator shall be glazed porcelain, molded phenolic, sheet phenolic composition, or other insulating materials that have been investigated and determined to be rated for the purpose as described in Clauses 7.1.1.11 and 7.1.2.3.1.

7.1.1.48 An enclosure, an opening, a frame, a guard, a knob, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons during intended maintenance or use.

7.1.1.49 The enclosure shall contain all live parts and shall provide strength to maintain its shape when supporting a fitting intended for use with it. Every part shall be secured in place. A terminal to which an external connection will be made in a transformer tap or in a switchboard stub need not be enclosed.

7.1.1.50 An enclosure cover that prevents access to an overload protective device requiring renewal in its normal functioning shall be hinged, sliding, or otherwise attached to prevent its removal. To hold it closed, such a cover shall not depend solely upon screws or similar means requiring the use of a tool but shall be provided with a spring latch or catch. The requirement shall not apply to a plug-in device in which the enclosure is completed by the enclosure of the busway on which the device is mounted provided, the thickness of metal and the means of attaching the plug-in device are such that the resulting assembly is the equivalent of what would be required for the enclosure of the plug-in device itself.

7.1.1.51 Sheet metal employed for a busway enclosure shall have a thickness no less than that specified in Table 5 unless the busway complies with the requirements in Clauses 8.2.7.1.1.1, 8.2.7.2.1.1, and 8.2.7.3.1.1. Sheet metal employed for a fitting enclosure shall have a thickness in accordance with Clause 7.1.1.33. Sheet metal employed for a short-run busway shall have a thickness in accordance with Table 4.

A busway rated 100 A or less may employ an unventilated enclosure of sheet steel having a thickness of no less than 0.81 mm (0.032 in) and may employ a formed, unventilated enclosure of sheet steel no less than 0.66 mm (0.026 in) thick at any point if an insulating lining of vulcanized fiber, or the equivalent, no less 0.81 mm (0.032 in) thick is provided. The lining may serve as the sole separation between the bus bar and the enclosure.

Table 5
Thickness of sheet metal for busway other than short-run busway

Maximum inside width of widest surface,		Minimum thickness of sheet metal[a]			
		Steel,		Aluminum,	
mm	(in)	mm	(in)	mm	(in)
305[b]	12[b]	1.35	0.053	1.91	0.075
457	18	1.70	0.067	2.41	0.095
762	30	2.36	0.093	3.10	0.122
More than 762	More than 30	3.12	0.123	3.89	0.153

[a] The minimum thickness refers to the base material and does not include a coating thickness.

[b] The maximum width may be 457 mm (18 in) if the enclosure does not support the weight of the bus bar assembly.

7.1.1.52 The thickness of sheet metal to which a wiring system is to be connected shall be no less than 1.35 mm (0.053 in) for steel, and no less than 1.91 mm (0.075 in) for aluminum, excluding any coatings.

7.1.1.53 An enclosure consisting of metal other than sheet steel or aluminum shall comply with the requirements in Clauses 8.2.7.1.1.1, 8.2.7.2.1.1, and 8.2.7.3.1.1.

7.1.1.54 An outdoor busway sheet steel enclosure shall be made corrosion resistant by one of the following coatings:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in Table 1 of Reference Item No. 4, Annex B, with no less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in the reference. The weight of zinc coating may be determined by any method deemed acceptable; however, in case of question, the weight of the coating shall be established in accordance with the test method in Reference Item No. 5, Annex B.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.0155 mm (0.00061 in) on each surface with a minimum thickness of 0.0137 mm (0.00054 in). The thickness of the coating shall be established by the requirements in Clause 8.2.10.1.

c) A zinc coating conforming with (1) or (2) below and with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces after forming. If necessary, the acceptability of the paint may be determined by consideration of its composition or by corrosion tests. The paint may be omitted at the adjoining surfaces at joints between enclosure sections of a busway not having a ground bus.

1) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G60 or A60 in Table 1 of Reference Item No. 4, Annex B, with no less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in the reference. The weight of zinc coating may be determined by any method deemed acceptable; however, in case of question, the weight of coating shall be established in accordance with the test method of Reference Item No. 5, Annex B.

2) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.0104 mm (0.00041 in) on each surface with a minimum thickness 0.0086 mm (0.00034 in). The thickness of the coating shall be established by the requirements in Clause 8.2.10.1.

d) Other finishes, including paints, special metallic finishes and combinations of the two may be used if they comply with Reference Item No. 20, Annex B.

7.1.1.55 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at edges of holes after annealing shall be additionally painted in the affected area if the process damages the zinc coating.

7.1.1.56 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating shall be considered to be damaged. Simple sheared or cut edges and punched holes are not required to be additionally protected.

7.1.1.57 If the hot-dipped, mill-galvanized G90 coating on drawn, formed, extruded, or rolled sheet steel becomes damaged during handling or fabrication to the extent that the base metal is exposed, at least one coat of an organic finish of the epoxy or alkyd-resin type, or other outdoor paint, shall be applied after fabrication to the entire area where the damage to the coating occurred.

Exposed base metal of an uncoated cross-section surface at a cut edge or at a drilled opening is not required to be painted.

7.1.2 Clearances, creepage distances, and isolating distances

7.1.2.1 Clearances and creepage distances

7.1.2.1.1 Busway and fittings not incorporating a switching mechanism

7.1.2.1.1.1 The clearance and creepage distances in a busway and in a fitting not incorporating a switching mechanism shall be no less than those indicated in Table 6. Two busways shall be connected together in the intended manner to permit the distances to be measured at the joint.

The creepage distances in a ventilated busway incorporating any uninsulated live parts shall be no less than 150 percent of the values in Table 6.

Short-run busway clearance and creepage distance requirements shall be as specified in Clause 7.1.2.1.3.1.

Table 6
Clearances and creepage distances

Current rating, A	Location	Voltage between parts involved, V	Minimum distances			
			Clearances,		Creepage,	
			mm	(in)	mm	(in)
0 – 60	Between a live part and the enclosure	0 – 300	3.2	1/8	6.4	1/4
		301 – 600	12.7	1/2	12.7	1/2
0 – 60	Between a live part and a grounded metal part other than the enclosure	0 – 300	3.2	1/8	6.4	1/4
		301 – 600	9.5	3/8	12.7	1/2
0 – 60	Between live parts of opposite polarity	0 – 150	3.2	1/8	6.4	1/4
		151 – 300	6.4	1/4	9.5	3/8
		301 – 600	9.5	3/8	12.7	1/2
0 – 60	Between a live part and grounded metal in a take-off device	0 – 300	3.2	1/8	4.8	3/16
		301 – 600	9.5	3/8	12.7	1/2
61 – 100	Between a live part and the enclosure	0 – 600	12.7	1/2	12.7	1/2
61 – 100	Between live parts of opposite polarity and between a live part and a grounded or exposed metal part other than the enclosure	0 – 150	3.2	1/8	6.4	1/4
		151 – 300	6.4	1/4	9.5	3/8
		301 – 600	9.5	3/8	12.7	1/2
More than 100	Between a live part and a grounded metal part including the enclosure	0 – 300	12.7	1/2	12.7	1/2
		301 – 600	12.7	1/2	25.4	1
More than 100	Between live parts of opposite polarity	0 – 150	12.7	1/2	19.1	3/4
		151 – 300	19.1	3/4	31.8	1–1/4
		301 – 600	25.4	1	50.8	2

7.1.2.1.1.2 Table 6 is applicable to a take-off device on the basis of the current rating of the highest rated busway with which that device can be installed.

7.1.2.1.1.3 A part intended to be electrically connected to a grounded circuit conductor is considered to be a live part. However, the clearance and creepage distance between such a part and the enclosure need be no larger than that required for the lowest voltage rating category of the ampere-rating bracket in Table

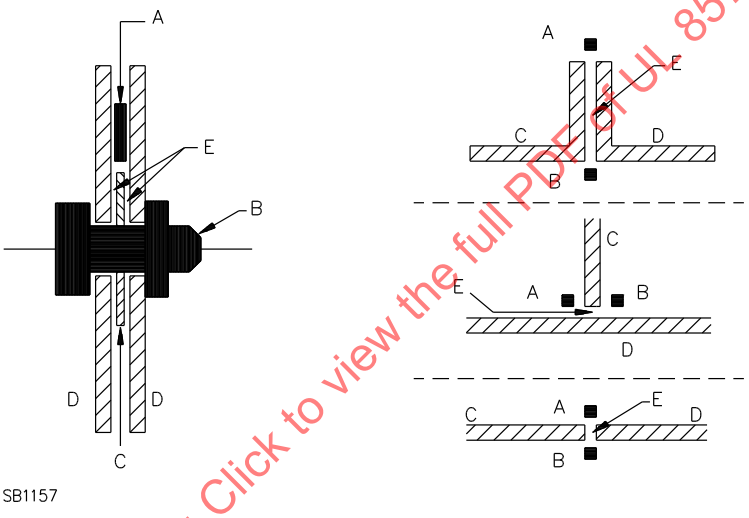
6 that includes the rating of the device involved. A part bonded to the enclosure is not considered a live part if the enclosure is marked in accordance with Clause 5.2.18.5.

7.1.2.1.1.4 If a bus bar covering employs a nonadhesive tape, clearance and creepage distances measured through the cracks between layers of tape shall be no less than those indicated in Table 6.

7.1.2.1.1.5 Clearance and creepage distances shall be measured through the cracks of a clamped joint if the joint has not passed the test specified in Clause 8.2.2.2. A clamped joint, as shown in Figure 1, is a joint between two pieces of insulating material that are under pressure. An adhesive, cement, or the like, used to effect a seal in lieu of a tightly mated joint shall be investigated under the requirements of Reference Item No. 16, Annex B.

Figure 1

Clamped joint



Parts A, B – Live parts of opposite polarity or a live part and grounded metal part with clearance and creepage distances through the crack between parts C and D less than required in Table 6.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent clearance distance.

Part E – The clamped joint.

7.1.2.1.1.6 In measuring a creepage distance, any slot, groove, or the like, 0.33 mm (0.013 in) wide or less in the contour of an insulating material shall be disregarded. Also, a clearance distance of 0.33 mm (0.013 in) or less between a live part and an insulating surface shall be disregarded and the part shall be considered in contact with the insulating material when measuring clearance and creepage distances.

7.1.2.1.1.7 A metallic part, such as a washer or the head of a screw, interposed between parts of opposite polarity or between a live part and grounded metal shall be considered a reduction of the clearance and creepage distances by an amount equal to the dimensions of the metal along the line of measurement.

7.1.2.1.1.8 Clearance and creepage distances shall be measured with all terminals wired with conductors of sizes appropriate for the current rating of the busway or fitting.

7.1.2.1.2 Fittings incorporating a switching mechanism

7.1.2.1.2.1 A clearance and/or creepage distance inside the overall enclosure of a fitting that incorporates a circuit breaker or switch shall be no less than the value indicated in Table 7.

Table 7
Clearance and creepage distances in switch and circuit breaker fittings

Voltage between parts involved, V	Minimum clearance and creepage distances between							
	Uninsulated live parts of opposite polarity				An uninsulated live part and a grounded metal part			
	Clearance,		Creepage,		Clearance,		Creepage,	
	mm	(in)	mm	(in)	mm	(in)	mm	(in)
0 – 130	12.7	1/2	19.1	3/4	12.7	1/2	12.7	1/2
131 – 300	19.1	3/4	31.8	1-1/4	12.7	1/2	12.7	1/2
301 – 600	25.4	1	50.8	2	12.7	1/2	25.4	1

7.1.2.1.2.2 Clearance and creepage distances shall be measured with the fitting and all its components mounted and installed in the intended manner. If the fitting involves a field-wiring terminal, the clearance and creepage distances shall be measured with wire of the proper ampacity installed.

7.1.2.1.2.3 In a fitting that incorporates a switch, the clearance and creepage distances between screwshells of plug fuseholders that are protected by surrounding walls of insulating material and between such screwshells and a metal cover plate may be less than those indicated in Table 7, but no less than 6.4 mm (1/4 in) in any case, if the depth of the receptacle as measured from the top of the wall to the plane of the center contact is no less than 19.1 mm (3/4 in).

7.1.2.1.2.4 In a fitting that incorporates a switch, the clearance distances given in Table 7 are not required to be maintained between switch blades and the enclosure cover when the switch is in the off position and the blades are deenergized, but such clearance distance shall be no less than 3.2 mm (1/8 in).

7.1.2.1.2.5 In a fitting that incorporates a switch, the clearance distance between a door or cover over a fuseholder and:

a) The center contact of an Edison-base plug fuseholder shall be no less than 39.7 mm (1-9/16 in).

b) The center contact of a Type S plug fuseholder shall be no less than 33.3 mm (1-5/16 in).

7.1.2.1.2.6 In a fitting that incorporates a switch, there shall be a clearance or creepage distance of no less than 3.2 mm (1/8 in) between line and load terminals of the same polarity.

7.1.2.1.3 Short-run busway

7.1.2.1.3.1 The clearance and creepage distances in a short-run busway shall be no less than those indicated in Table 8. Two sections shall be connected together in the intended manner to permit the distances to be measured at the joint.

Table 8
Clearance and creepage distances in short-run busways

Location	Minimum distances			
	Clearance,		Creepage,	
	mm	(in)	mm	(in)
Between a live part and a grounded metal part	25.4	1	25.4	1
Between live parts of opposite polarity	25.4	1	50.8	2

7.1.2.2 Isolation of withdrawable parts

Reserved for future use.

7.1.2.3 Dielectric properties

7.1.2.3.1 An insulating material other than those specified in Clause 7.1.1.12 shall have ratings as specified in Table 9, or an insulating material may be used based on the end-product tests specified in Reference Item No. 16, Annex B.

The specified values in Table 9 are derived from Reference Item No. 16, Annex B.

Table 9
Insulating material ratings

Test specified	Flammability rating of material[a]			
	V-0	V-1	V-2	HB
Comparative Tracking Index under moist conditions (CTI)[b] (volts)	≥ 175	≥ 175	≥ 175	≥ 175
High Current Arc Resistance to Ignition (HAI)[b] (mean number of arcs to cause ignition)	≥ 15	≥ 30	≥ 30	≥ 60
Hot Wire Ignition (HWI)[b] (mean ignition time in seconds)	≥ 7	≥ 15	≥ 30	≥ 30

NOTES:

1. The following additional parameters shall be considered for distortion under load and mold stress relief properties:

a) For the heat deflection temperature test[b], the minimum levels related to flammability classification shall be 10°C greater than use temperature, but not less than 90°C; or

b) For the vicat softening point test[b], the minimum levels related to flammability classification shall be 10°C greater than use temperature, but not less than 90°C; or

c) For the ball pressure temperature test[b], the minimum levels related to flammability classification shall be (40°C minus the ambient temperature) greater than the use temperature, but not less than 95°C.

2. A material having a comparative tracking index greater than 100 may be used if the voltage involved is 250 V or less.

[a] These flammability ratings are derived from Reference Item No. 9, Annex B.

[b] See Reference Item No. 15, Annex B, for this specified test.

7.1.3 Terminals for external conductors

7.1.3.1 There shall be ample space within an enclosure for the accommodation of field-installed conductors. The adequacy of wiring space shall be evaluated using the size and conductor material of a wire used at a terminal in accordance with Table 18 and Table 19. If a terminal is determined to be

acceptable for use with two or more combinations of conductors in multiple, each of which would be appropriate for that terminal, the combination necessitating the largest wiring space shall be used. If a terminal is provided for conductors in multiple, the size of each of the conductors shall be based on the use of multiple circuits. However, for ampacities of 110 A or less the size may be based on 60°C insulated conductors even if the marking specifies 60°C or 75°C wire.

7.1.3.2 The wire bending space provided in a busway or busway fitting shall be in accordance with Table 10 for the largest conductor entering or exiting the enclosure opposite the terminal. The wire bending space provided in a busway or busway fitting shall be in accordance with Table 11 if the conductor does not enter nor exit the enclosure through the wall opposite the terminal.

Table 10
Minimum wire bending distance at connectors

Wire size,		Wires per terminal (pole)[a]							
		1		2		3		4	
AWG or kcmil	(mm^2)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
14 – 10	2.1 – 5.3	Not specified		–	–	–	–	–	–
8	8.4	38.1	1-1/2	–	–	–	–	–	–
6	13.3	50.8	2	–	–	–	–	–	–
4	21.2	76.2	3	–	–	–	–	–	–
3	26.7	76.2	3	–	–	–	–	–	–
2	33.6	88.9	3-1/2	–	–	–	–	–	–
1	42.4	114	4-1/2	–	–	–	–	–	–
1/0	53.5	140	5-1/2	140	5-1/2	178	7	–	–
2/0	67.4	152	6	152	6	191	7-1/2	–	–
3/0	85	165 (12.7)	6-1/2 (1/2)	165 (12.7)	6-1/2 (1/2)	203	8	–	–
4/0	107	178 (25.4)	7 (1)	191 (38.1)	7-1/2 (1-1/2)	216 (12.7)	8-1/2 (1/2)	–	–
250	127	216 (50.8)	8-1/2 (2)	216 (50.8)	8-1/2 (2)	229 (25.4)	9 (1)	254	10
300	152	254 (76.2)	10 (3)	254 (50.8)	10 (2)	279 (25.4)	11 (1)	305	12
350	177	305 (76.2)	12 (3)	305 (76.2)	12 (3)	330 (76.2)	13 (3)	356 (50.8)	14 (2)
400	203	330 (76.2)	13 (3)	330 (76.2)	13 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)
500	253	356 (76.2)	14 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)	406 (76.2)	16 (3)
600	304	381 (76.2)	15 (3)	406 (76.2)	16 (3)	457 (76.2)	18 (3)	483 (76.2)	19 (3)
700	355	406 (76.2)	16 (3)	457 (76.2)	18 (3)	508 (76.2)	20 (3)	559 (76.2)	22 (3)
750	380	432 (76.2)	17 (3)	483 (76.2)	19 (3)	559 (76.2)	22 (3)	610 (76.2)	24 (3)
800	405	457	18	508	20	559	22	610	24
900	456	483	19	559	22	610	24	610	24
1 000	507	508	20	–	–	–	–	–	–
1 250	633	559	22	–	–	–	–	–	–

Table 10 Continued on Next Page

Table 10 Continued

Wire size,		Wires per terminal (pole)[a]							
		1		2		3		4	
AWG or kcmil	(mm^2)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
1 500	760	610	24	–	–	–	–	–	–
1 750	887	610	24	–	–	–	–	–	–
2 000	1 010	610	24	–	–	–	–	–	–

[a] Wire bending space may be reduced by the number in parentheses under the following conditions:

1) Only lay-in or removable wire connectors receiving one wire each are used (there may be more than one lay-in or removable wire connector per terminal) and

2) The removable wire connectors can be removed from their intended location without disturbing structural or electrical parts other than a cover, and can be reinstalled with the conductor in place.

Table 11
Wire bending space[a]

Size of wire,		Wire per terminal (pole)									
		1		2		3		4		5	
AWG or kcmil	(mm^2)	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
14 – 10	2.1 – 5.3	–	–	–	–	–	–	–	–	–	–
8 – 6	8.4 – 13.3	38.1	1-1/2	–	–	–	–	–	–	–	–
4 – 3	21.1 – 26.7	50.8	2	–	–	–	–	–	–	–	–
2	33.6	63.5	2-1/2	–	–	–	–	–	–	–	–
1	42.4	76.2	3	–	–	–	–	–	–	–	–
1/0 – 2/0	53.5 – 67.4	88.9	3-1/2	127	5	178	7	–	–	–	–
3/0 – 4/0	85.0 – 107	102	4	152	6	203	8	–	–	–	–
250	127	114	4-1/2	152	6	203	8	254	10	–	–
300 – 350	152 – 177	127	5	203	8	254	10	305	12	–	–
400 – 500	203 – 253	152	6	203	8	254	10	305	12	356	14
600 – 700	304 – 355	203	8	254	10	305	12	356	14	406	16
750 – 900	380 – 456	203	8	305	12	356	14	406	16	457	18
1 000 – 1 250	507 – 633	254	10	–	–	–	–	–	–	–	–
1 500 – 2 000	760 – 1 013	305	12	–	–	–	–	–	–	–	–

NOTE – The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned may be given further consideration.

[a] Alternatively, the values in Reference Item No. 23, Annex B may be used for a product intended for use only in Canada.

7.1.3.3 The distance mentioned in Clause 7.1.3.2 shall be measured in a straight line from the edge of the wire terminal closest to the wall, barrier, or obstruction in a direction perpendicular to the wall, barrier, or obstruction. The terminal shall be turned so that the axis of the wire opening in the connector is perpendicular to the wall of the enclosure without defeating any means provided to prevent its turning (such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or the like). A barrier, shoulder, or the like shall be disregarded when the measurement is being made if it does not reduce the radius to which the wire must otherwise be bent. The main connection for a neutral is considered to be a pole; neutral branch terminals are not counted in this determination.

7.2 Enclosure and degree of protection

7.2.1 No opening in the enclosure of a ventilated busway shall permit passage of a 16.3 mm (41/64 in) diameter rod.

7.2.2 An uninsulated live part in a ventilated busway shall be inaccessible to contact from outside the enclosure by a 6.7 mm (17/64 in) diameter rod.

7.2.3 The enclosure of an unventilated busway shall have no opening for ventilation and no opening with a minor dimension exceeding 1.6 mm (1/16 in) unless the opening for a plug-in device, the drain opening specified in Clause 7.1.1.24, and the opening between two enclosures specified in Clause 7.1.1.35 may have a larger minor dimension.

7.2.4 Other than the opening for the trolley, the enclosure of a trolley busway shall comply with Clause 7.2.3.

7.2.5 An opening for a plug-in device in other than a continuous plug-in busway or a lighting busway shall:

a) Be provided with a cover that is hinged, sliding, or otherwise secured against removal and with a latch or the equivalent to hold the cover in a closed position or

b) Have each uninsulated live part inside the enclosure recessed behind the plane of the opening by a distance no less than the smaller dimension of the opening, and

1) The opening is no larger than 9.5 mm by 15.9 mm (3/8 in by 5/8 in) or

2) If the opening has one dimension larger than 15.9 mm (5/8 in), it will not admit a 6.7 mm (17/64 in) diameter rod.

7.2.6 In a continuous plug-in busway or a lighting busway that is not also rated as a trolley busway, the size of the openings that accommodate plug-in devices, the insulation on the bus bars, or both, shall be such that adequate guarding against unintentional contact with a bare live part will be provided.

7.3 Temperature rise

7.3.1 Assemblies shall be constructed such that temperature rises do not exceed the limits of Table 12 as determined by the tests in Clause 8.2.1. The verification of temperature rise limits tests need not be performed on short-run busways complying with Clauses 7.8.2.2 – 7.8.2.6.

Table 12
Maximum temperature rises

	Materials and components	°C
1.	Unplated copper bus or any riveted joint[a]	30
2.	Any part that may be contacted by field wiring	50[b]
3.	Pressure terminal connectors for field-installed conductors	50
4.	Pressure terminal connectors used in circuits rated 110 A or less and marked for use with 75°C wire	65[c]
5.	Pressure terminals or wire connectors for internal wiring involving aluminum conductors unless the connector has been investigated for higher temperatures	50

Table 12 Continued on Next Page

Table 12 Continued

	Materials and components	°C
6.	Plated bus bar except as covered in item 2	55
7.	Wire insulation or insulating tubing	20[e]
8.	Electrical tape	40[d]
9.	Varnished cloth insulation	45[d]
10.	Fiber employed as electrical insulation	50[d]
11.	Phenolic or cold molded composition employed as electrical insulation or as a part whose failure would result in an undesired condition	110[d]
12.	Other insulation materials	see footnote e

[a] See Clause 7.8.1.4.

[b] A plated bus at the connection of field wiring using 75°C wire for circuits rated 110 A or less may have a 65°C rise.

[c] The temperature rise specified is applicable to a connector for copper wire. It is also applicable to a connector for aluminum wire or an aluminum-bodied connector provided the connector has a temperature rating or 90°C.

[d] This limitation does not apply to an insulated conductor or other material as described in Clause 7.1.1.11, 7.1.1.14, 7.1.1.15, 7.1.1.18 or 7.1.2.3.1, that has been investigated and rated for a higher temperature as specified in footnote e.

[e] In the United States, the temperature rise shall be 30°C less than the thermal index of the material for a lighting or continuous plug-in busway as covered in Clauses 2.3.4.3.1 and 2.3.4.4.1 and 40°C less than the thermal index of the material for other busways. In Canada and Mexico, the temperature rise shall be 30°C less than the thermal index of the material for a lighting or continuous plug-in busway rated 225 A or less as covered in Clauses 2.3.4.3.1 and 2.3.4.4.1 and 40°C less than the thermal index of the material for other busways.

7.3.2 The heating test on an elbow or tee may be represented by the heating test conducted on a similar straight length of busway. Among the items to be considered when comparing the similarities of the straight lengths to the elbows or tees are the current density in the bus bars, and the cross-sectional area and ventilation of the enclosures.

7.4 Protection against electric shock

7.4.1 A busway, busway fitting, or a plug-in or bolt-on unit shall be provided with one of the following means of grounding:

a) A ground bus, located within the enclosure, that is sized as specified in Table 14;

b) A ground bus located within the enclosure that is sized as specified in Table 13 if the busway, busway fittings, or plug-in or bolt-on units have been investigated in accordance with Clauses 8.2.3.1.1.10, 8.2.3.1.1.11, and 8.2.3.1.2 and are marked as specified in Clause 5.2.12 or 5.2.13; or

c) The sum of the cross-sectional areas of the enclosure metal and the ground bus is in compliance with Table 14 (or Table 13 and Clause 5.2.12); and the joints are tested as described in:

1) Clause 8.2.3.1.3.12 or

2) Clause 8.2.3.3, for a busway, busway fitting, or a plug-in or bolt-on unit having an rms symmetrical short-circuit current rating of 10 000 A or less.

Table 13
Size of ground bus or enclosure

Ampere rating of overcurrent protection on line side of busway or fitting, A	Minimum cross-sectional area of material[a]					
	Copper,		Aluminum,		Steel enclosure,	
	mm^2	(in^2)	mm^2	(in^2)	mm^2	(in^2)
15	1.94	0.003	3.23	0.005	14.19	0.022
20	3.23	0.005	5.16	0.008	22.58	0.035
60	5.16	0.008	8.39	0.013	38.71	0.060
100	8.39	0.013	13.55	0.021	58.06	0.090
200	13.55	0.021	21.29	0.033	90.32	0.140
300	21.29	0.033	33.55	0.052	141.94	0.220
400	26.45	0.041	42.58	0.066	180.64	0.280
500	33.55	0.052	53.55	0.083	225.81	0.350
600	42.58	0.066	67.74	0.105	290.32	0.450
800	53.55	0.083	85.16	0.132	361.29	0.560
1 000	67.74	0.105	107.10	0.166	458.06	0.710
1 200	85.16	0.132[b]	126.45	0.196[b]	580.64	0.900
1 600	107.10	0.166[b]	177.42	0.275[b]	729.03	1.130
2 000	126.45	0.196[b]	202.58	0.314[b]	858.06	1.330
2 500	177.42	0.275[b]	303.87	0.471[b]	1 206.45	1.870
3 000	202.58	0.314[b]	303.87	0.471[b]	1 380.64	2.140
4 000	253.55	0.393[b]	405.16	0.628[b]	1 722.58	2.670
5 000	354.84	0.550[b]	608.39	0.943[b]	2 412.90	3.740
6 000	405.16	0.628[b]	608.39	0.943[b]	2 754.83	4.270

NOTE – The table applies only if the busway or fitting is marked in accordance with Clause 5.2.12.

[a] If of the same metal, the cross-sectional areas of a ground bus and the enclosure may be added together.

[b] The cross-sectional area of a ground bus or enclosure fabricated of the same material as the main bus may be reduced to 12.5 percent of the combined areas of the main bus bars of one leg of a busway or fitting rated 1 200 A or more.

Table 14
Size of ground bus or enclosure

Minimum ampere rating of busway or fitting, A	Copper,		Aluminum,		Steel enclosure,	
	mm^2	(in^2)	mm^2	(in^2)	mm^2	(in^2)
90	8.39	0.013	13.55	0.021	58.06	0.09
150	13.55	0.021	21.29	0.033	90.32	0.14
200	21.29	0.033	33.55	0.052	141.94	0.22
225	33.55	0.052	53.55	0.083	225.81	0.35
500	53.55	0.083	85.16	0.132	361.29	0.56
800	67.74	0.105	107.10	0.166	451.61	0.70
1 000	85.16	0.132	126.45	0.196	580.64	0.90
1 200	114.19[a]	0.177[a]	146.45	0.227	774.19	1.20
1 600	152.26[a]	0.236[a]	189.68	0.294[a]	1 032.26	1.60
2 000	189.68[a]	0.294[a]	227.74	0.353[a]	1 290.32	2.00
2 500	227.74[a]	0.353[a]	332.26	0.515[a]	1 548.38	2.40
3 000	265.81[a]	0.412[a]	380.00	0.589[a]	1 806.45	2.80
4 000	380.00[a]	0.589[a]	522.58	0.810[a]	2 580.64	4.00

Table 14 Continued on Next Page

Table 14 Continued

Minimum ampere rating of busway or fitting, A	Copper,		Aluminum,		Steel enclosure,	
	mm^2	(in^2)	mm^2	(in^2)	mm^2	(in^2)
5 000	456.13[a]	0.707[a]	823.22	1.276[a]	3 096.77	4.80
6 000	570.32[a]	0.884[a]	1 013.55	1.571[a]	3 870.96	6.00

NOTE – If of the same metal, the cross-sectional areas of a ground bus and the enclosure may be added together.

[a] The cross-sectional area of a ground bus or enclosure fabricated of the same material as the main bus may be reduced to 12.5 percent of the combined area of the main bus bars of one leg of a busway rated 1 200 A or more.

7.4.2 A busway or fitting shall have provision in accordance with Clause 8.2.4.3.2.1 for grounding all metal parts that are exposed or that are likely to be touched by a person during operation or adjustment of the device and that can become energized, but are not intended to be energized.

7.4.3 In a busway and in a fitting other than a plug-in fitting, an insulating lining or barrier of fiber or similar material employed where a clearance or creepage distance would otherwise be less than the required value shall be no less than 0.71 mm (0.028 in) thick. An insulating covering on a bus bar employed in place of the minimum clearance distance shall comply with requirements for insulating coverings specified in Clause 7.1.1.16.

7.4.4 An insulating lining or barrier used as the sole separation in a busway:

a) Between a live part and a grounded metal part or

b) Between uninsulated live parts of opposite polarity

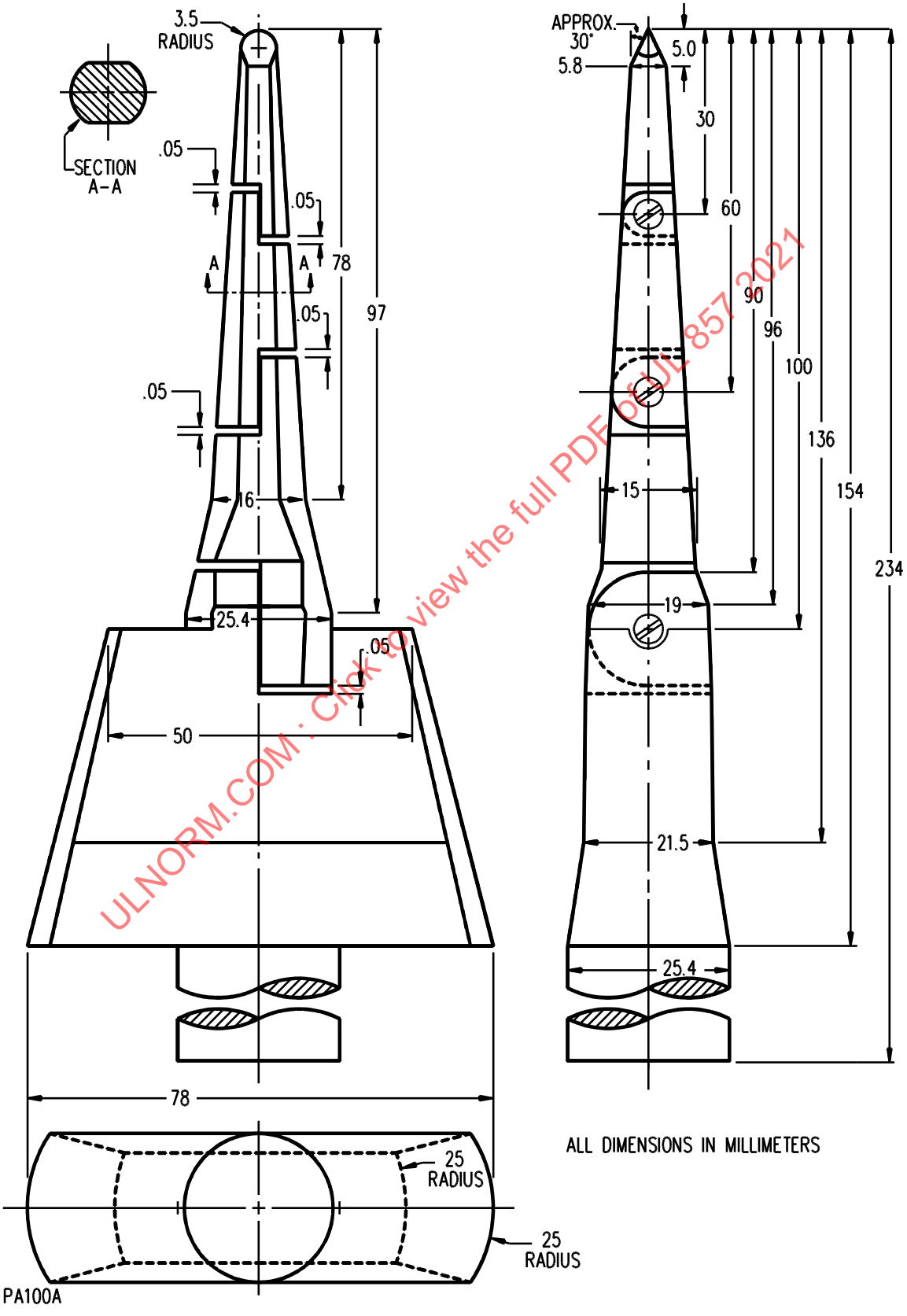
shall be of material that has been investigated and rated for the support of uninsulated live parts; a busway rated 100 A or less may employ an insulating lining of vulcanized fiber, or the equivalent, no less than 0.8 mm (1/32 in) thick.

7.4.5 For a continuous plug-in busway, an uninsulated live part shall be located or shielded so it is not accessible to unintentional contact by persons during intended use.

7.4.6 An uninsulated live part shall be considered inaccessible if a probe as illustrated in Figure 2 cannot be made to touch any part that involves the risk of electric shock to earth ground or to another uninsulated live part when the system is completely installed as intended. No force shall be used when placing the probe in the opening.

Figure 2

Articulate probe with web stop



7.4.7 The probe may be articulated into any configuration and may be rotated or angled to any position before, during, or after insertion into the opening. The penetration may be to any depth allowed by the opening size, including minimum depth combined with maximum articulation.

7.4.8 A plug-in busway and plug-in fitting intended for use with a busway shall be:

a) Constructed to reduce the risk of insertion or removal of the contact members of the intended plug-in fitting in such a way as to result in a short-circuit condition, such as a live part contacting a grounded metal part or

b) Marked as specified in Clause 5.4.1.

7.4.9 Insulating material in an opening of a busway intended to receive a plug-in fitting, or on contact members of the plug-in fitting, shall be fastened in place.

7.4.10 The grounding means between the enclosure or grounded metal part of a plug-in unit and the busway enclosure shall be constructed such that the grounding continuity specified in Clause 8.2.4.3.1.1 will be:

a) Established 3.2 mm (1/8 in) before contact-making current-carrying parts of the plug-in unit come together and

b) Maintained until contact-breaking current-carrying parts of the plug-in unit become separated by at least 3.2 mm (1/8 in).

The 3.2 mm (1/8 in) distance need not be maintained if the plug-in unit is marked as specified in Clause 5.4.1.

7.4.11 The requirements in Clauses 7.4.12 – 7.4.14 apply to all plug-in fittings, whether or not switching mechanisms are incorporated therein.

7.4.12 An insulating barrier or liner used as the sole separation between an uninsulated live part and a grounded metal part (including the enclosure), or between uninsulated live parts of opposite polarity, shall be of material that is rated for the mounting of uninsulated live parts, and shall be no less than 0.71 mm (0.028 in) thick. Fiber no less than 0.71 mm (0.028 in) thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.

7.4.13 When a combination of clearance distance and an insulating barrier or liner is used in place of the required clearance distance, the barrier or liner shall be no less than 0.71 mm (0.028 in) thick. If the barrier or liner is of fiber, the clearance distance shall be no less than 0.8 mm (1/32 in), and if the barrier or liner is of other material that is not rated for the support of an uninsulated live part, the clearance distance to be provided shall be acceptable for the particular application.

A barrier or liner that is used in addition to no less than one-half the required clearance distance shall be no less than 0.33 mm (0.013 in) thick, provided the barrier or liner:

a) Is of material rated for the mounting of an uninsulated live part;

b) Has the strength necessary to withstand exposure to mechanical damage;

c) Is held in place; and

d) Is located so that it will not be affected adversely by operation of the equipment in service.

7.4.14 Insulating material having a thickness less than that indicated in Clauses 7.4.12 and 7.4.13 may be used if, upon investigation, it is determined to be acceptable for the particular application.

7.4.15 A 15- or 20-A attachment plug receptacle shall be of the grounding type and shall have the grounding contact electrically connected to the enclosure of the fitting by a conductor sized in accordance with Table 15.

Table 15
Size of bonding conductor

Maximum rating or setting of automatic overcurrent device in circuit ahead of equipment, A	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3

[a] Or equivalent cross-sectional area.

7.5 Short-circuit protection and short-circuit withstand strength

7.5.1 General

Reserved for future use.

7.5.2 Information concerning the short-circuit withstand strength

7.5.2.1 Fittings

7.5.2.1.1 A fuseholder for a plug fuse that protects a receptacle as mentioned in Clause 7.4.15 shall be Type C, Type S, or shall be the Edison-base type with a factory-installed, nonremovable Type S adapter.

7.5.2.1.2 A fuseholder or a current-interrupting device in a busway fitting shall have a short-circuit current rating no less than the short-circuit current rating of the busway fitting if the busway-fitting, short-circuit current rating exceeds 5 000 A.

7.5.2.2 Short-run busway

7.5.2.2.1 A short-run busway shall be rated at 2 000 A or less and shall have a short-circuit current rating of 10 000 ac (rms symmetrical) or dc amperes; however, a higher short-circuit current rating from Table 16 may be assigned if the busway is designed in accordance with Clauses 7.5.2.2.2 and 7.5.2.2.3.

7.5.2.2.2 A short-circuit current rating as shown in Table 16 may be assigned to a short-run busway without tests if:

a) Each insulating support is of a type that has been determined to provide acceptable mechanical strength by means of a short-circuit test involving equivalent forces;

b) The spacing between supports is no more than specified in Table 16, as measured between centers of adjacent supports along the length of the busway; and

c) A ground bus in accordance with Table 14 is provided.

Table 16
Short circuit current ratings and forces

Quantity and width of bus bar; all bus bars are 6.4 mm (1/4 in) thick)		RMS symmetrical short- circuit current rating A[a]								Maximum force on insulator[b]			
		25 000		50 000		75 000		100 000		Cantilever,[c,d] N·m (lbs-in)		Compression or tension,[c,d] N/support (lbs/support)	
		Maximum center line spacing between supports, mm (in)											
Qty	Width mm (in)	Cu	Al	Cu	Al	Cu	Al	Cu	Al	Cu	Al	Cu	Al
1, 2, or 3	22.2 (7/8)	305 (12)	254 (10)	178 (7)	146 (5.75)	–	–	–	–	40.3 (357)	27.2 (241)	1 815 (408)	1 490 (335)
1, 2, or 3	38.1 (1-1/2)	343 (13.5)	279 (11)	196 (7.75)	165 (6.5)	146 (5.75)	121 (4.75)	127 (5)	102 (4)	54.8 (485)	35.1 (311)	3 456 (777)	2 767 (622)
1, 2, or 3	50.8 (2)	381 (15)	305 (12)	216 (8.5)	178 (7)	152 (6)	127 (5)	133 (5.25)	108 (4.25)	77.9 (689)	51.1 (452)	4 671 (1 050)	3 781 (850)
1, 2, or 3	76.2 (3)	432 (17)	356 (14)	356 (14)	203 (8)	191 (7.5)	152 (6)	140 (5.5)	114 (4.5)	102 (903)	68.3 (604)	5 840 (1 313)	4 777 (1 074)
1, 2, or 3	102 (4)	508 (20)	432 (17)	305 (12)	241 (9.5)	216 (8.5)	178 (7)	165 (6.5)	133 (5.25)	142 (1 260)	93 (823)	6 904 (1 552)	5 574 (1 253)
1, 2, or 3	127 (5)	610 (24)	508 (20)	343 (13.5)	279 (11)	241 (9.5)	196 (7.75)	191 (7.5)	152 (6)	190 (1 679)	121 (1 075)	7 967 (1 791)	6 370 (1 432)
2 or 3	76.2 (3)	–	610 (24)	508 (20)	457 (18)	457 (18)	406 (16)	356 (14)	305 (12)	692 (6 125)	509 (4 500)	15 569 (3 500)	13 345 (3 000)
2 or 3	102 (4)	–	610 (24)	559 (22)	508 (20)	483 (19)	432 (17)	381 (15)	330 (13)	795 (7 031)	597 (5 281)	16 681 (3 750)	14 457 (3 250)
2 or 3	127 (5)	–	610 (24)	610 (24)	559 (22)	508 (20)	457 (18)	406 (16)	356 (14)	904 (8 000)	692 (6 125)	17 793 (4 000)	15 569 (3 500)
2 or 3	152 (6)	–	610 (24)	–	610 (24)		508 (20)	–	406 (16)	–	904 (8 000)	–	17 793 (4 000)
3	76.2 (3)	–	610 (24)	–	610 (24)	–	508 (20)	–	406 (16)	–	964 (8 533)	–	18 980 (4 267)
3	102 (4)	–	610 (24)	–	610 (24)	–	508 (20)	–	457 (18)	–	1 220 (10 800)	–	21 351 (4 800)
3	127 (5)	–	610 (24)	–	610 (24)	–	508 (20)	–	457 (18)	–	1 220 (10 800)	–	21 351 (4 800)

[a] These values are for a 102 mm (4 in) center-to-center spacing between adjacent bus bars. For a 76 mm (3 in) center-to-center spacing, multiply these values by 0.8.

[b] See Clause 7.5.2.2.2(a).

[c] For a 76 mm (3 in) center-to-center bus spacing, multiply these values by 1.07.

[d] Except for 6.4 mm (1/4 in) by 22.2 mm (7/8 in) bus, these values are for available short-circuit current of 100 kA. For 75 kA, 50 kA, or 25 kA, multiply these values by 0.81, 0.6, or 0.3, respectively.

7.5.2.2.3 Table 16 is based on a minimum 102 mm (4 in) spacing between center lines of phase bus bars or groups of bus bars if bus bars are in multiple. Table 16 is also based on a minimum 102 mm spacing between the center lines of phase bus bars, neutral bus bars, or both, and a ground bus bar or the side of the enclosure parallel to the bus bars. If bus bars are in multiple, 6.4 mm (1/4 in) minimum spacing shall be assumed between adjacent bus bars of the same phase. Bus bars may be wider or thicker than shown in Table 16.

7.6 Switching devices and components installed in assemblies

Reserved for future use.

7.7 Internal separation of assemblies by barriers or partitions

Reserved for future use.

7.8 Electrical connections inside an assembly: bars and insulated conductors

7.8.1 General

7.8.1.1 A wire within an enclosure, compartment, raceway, or the like shall be located or protected to prevent contact with any sharp edge, burr, fin, or the like that can damage the conductor insulation.

7.8.1.2 An aluminum conductor, insulated or uninsulated, used for internal wiring between current-carrying parts, shall be terminated at each end by a method that has been determined acceptable for the combination of metals involved at the connection point.

7.8.1.3 A current-carrying part shall be copper, aluminum, or copper alloy rated for the purpose.

7.8.1.4 A copper bus bar rated 600 A or less need not be plated if it is tested in accordance with the requirements in Clause 8.2.1, and limited to a temperature rise of 30°C as specified in Table 12. All other bus bars shall be plated with silver, tin, or nickel at all joints and connections.

7.8.1.5 Iron or steel, plated or unplated, shall not be used for a current-carrying part. Plated steel screws and nuts may be used to bolt bus bars together and to secure soldering lugs or pressure wire connectors.

7.8.1.6 If bus bars are held together by screws, a threaded part shall have no fewer than two full clean cut threads no finer than the requirements of Reference Item No. 2, Annex B, for coarse threads. If the screw does not pass entirely through the threaded part, it shall engage full, clean cut threads for a distance no less than the diameter of the screw.

7.8.1.7 At a riveted connection of current-carrying parts involving aluminum, each rivet shall have a spring washer at one end and either a spring washer or a flat washer at the other end. Other constructions may be used if they have been investigated and determined to be acceptable.

7.8.1.8 The flat washer specified in Clauses 7.8.1.7 and 7.8.1.9 shall:

a) Be plated steel;

b) Have a thickness of at least 1/6 that of the diameter of the rivet or bolt; and

c) Have an outer diameter at least 150 percent of the diameter of the rivet or bolt and no less than the outer diameter of the spring washer.

7.8.1.9 A bolted connection of current-carrying parts shall employ one of the following:

a) A spring washer shall be used at one end of a bolt securing current-carrying parts together. Unless the bolt is tapped into a current-carrying part, a spring washer, a flat washer, or both, shall be used at the other end of the bolt.

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

c) A flat washer 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.

d) Other constructions may be used if they have been investigated and determined to be acceptable.

7.8.1.10 A spring washer as mentioned in Clauses 7.8.1.7 and 7.8.1.9 shall:

a) Be a dished washer of stainless or hardened and tempered steel;

b) Have an outer diameter no less than 150 percent of the bolt diameter;

c) Have a thickness no less than 1/8 of the bolt diameter; and

d) Have a dish no less than 3-1/2 percent of the bolt diameter.

7.8.1.11 A live part shall be fastened to its support or base and shall be prevented from turning or shifting by means other than friction. Bus bars need not be so fastened and wire connectors may turn under the conditions specified in Clause 7.8.3.10.

7.8.1.12 A bus bar joint in which the clamping force depends upon the busway enclosure shall not be impaired by external mechanical loading of the busway.

7.8.1.13 The assembly shall be subjected to a test in accordance with Clauses 8.2.1.2.1 and 8.2.1.3.1 before and after being subjected to the test in accordance with Clause 8.2.7.1.1.1. At the conclusion of the second test:

a) The temperature at any bus bar connection in the joint shall be no more than 2.0°C higher than the corresponding values at the conclusion of the initial test and

b) The average of the temperatures at all of the connections shall be no more than 1.0°C higher than the corresponding values at the conclusion of the initial test.

7.8.1.14 In a busway containing two or more bus bars per phase, a tap or feed device shall make contact with each bus bar of a phase, or the multiple bus bars shall be effectively paralleled within 3.05 m (10 ft) of each tap, feed, or load point.

7.8.1.15 All necessary bolts, nuts, and washers shall be provided for connecting busway sections. The length of the bolts shall be such that clearance and creepage distances in accordance with Table 6 will be maintained.

7.8.2 Dimensions and rating of bus bars and insulated conductors

7.8.2.1 Regarding Table 17, for other than a short-run busway, part of the bus material may be removed for slots or holes (whether used or not) provided the remaining material at any cross-section along the length of the bus bar has at least 70 percent of the required ampacity and the remaining metal in any 152 mm (6 in) length of bus is at least 93 percent of the metal of a bus having the required ampacity. For example, a 25.4 mm (1 in) wide bus could have 7.1 mm (9/32 in) holes on 25.4 mm (1 in) centers, or a 102 mm (4 in) wide bus could have 10.3 mm (13/32 in) wide slots 81.3 mm (3.2 in) long every 152 mm (6 in).

Table 17
Ratings and sizes of bus bars

Ampere rating in AC or DC	Minimum dimensions[a,b]					
			Aluminum			
	97 percent minimum conductivity,		61 percent minimum conductivity,		55 percent minimum conductivity,	
	mm	(in)	mm	(in)	mm	(in)
225	3.2 by 22.2	1/8 by 7/8	6.4 by 22.2	1/4 by 7/8	6.4 by 22.2	1/4 by 7/8
400	6.4 by 38.1	1/4 by 1-1/2	6.4 by 50.8	1/4 by 2	6.4 by 50.8	1/4 by 2
600	6.4 by 50.8	1/4 by 2	6.4 by 76.2	1/4 by 3	7.1 by 76.2	9/32 by 3
800	6.4 by 76.2	1/4 by 3	6.4 by 102	1/4 by 4	7.1 by 102	9/32 by 4
1 000	6.4 by 102	1/4 by 4	6.4 by 152 or two 6.4 by 76.2	1/4 by 6 or two 1/4 by 3	7.1 by 152 or two 7.1 by 76. 2	9/32 by 6 or two 9/32 by 3

[a] A minus tolerance of 5 percent in the cross-sectional area is allowed for rounding and shaping of a bus bar.

[b] A bus bar having other dimensions may be considered to comply with this requirement if it has a cross-sectional area no less than that determined by multiplying the dimensions specified in the table and if it has rigidity no less than that of a bar having such dimensions.

7.8.2.2 A bus bar in a short-run busway shall be of aluminum with a conductivity of at least 55 percent IACS (International Annealed Copper Standard) or copper. Each bus bar shall be plated with silver, tin, or nickel at each bolted joint or connection.

7.8.2.3 Each bus bar joint between short-run busway sections and between a short-run busway and a fitting intended to be connected in the field shall be bolted, and plug-in connections shall not be used. A bus bar joint within prefabricated sections shall be bolted or welded in a manner that will provide electrical continuity and mechanical strength.

7.8.2.4 In short-run busway, a connection at current-carrying parts shall be evaluated for compliance with Clauses 7.8.1.6 – 7.8.1.10.

7.8.2.5 The current density at a short-run busway bolted joint shall be 31 A/cm^2 (200 A/in^2) or less.

7.8.2.6 A bus bar in a short-run busway rated at 1 000 A or less shall have a cross-section no smaller than that indicated in Table 17 based on the current rating of the busway and the material of the bus bar. The current density in a bus bar in a short-run busway rated at more than 1 000 A shall be:

a) 124 A/cm^2 (800 A/in^2) or less if the bar is of copper.

b) 93 A/cm^2 (600 A/in^2) or less if the bar is of aluminum.

7.8.2.7 A busway, other than short-run busway, rated 1 000 A or less and employing plated and bolted joints shall have bus bars sized as specified in Table 17; however, bus bars of different size may be deemed acceptable based on the test specified in Clause 7.3.1. In a 3-phase, 4-wire busway and in a single-phase, 3-wire busway, the neutral may be smaller in cross-section than the other bus bars if its ampacity, as determined in accordance with Table 17, is marked on the nameplate.

7.8.2.8 A busway, other than short-run busway, rated over 1 000 A shall be tested in accordance with the test described in Clause 8.2.1. A copper bus bar intended to carry more than 1 000 A of direct current at a current density of no more than 1.55 A/mm^2 (1 000 A/in^2) is acceptable without temperature-rise verification.

7.8.2.9 The current density at a bolted contact between bus bars shall be no more than 0.31 A/mm^2 (200 A/in^2) if the device is to be acceptable without verification of the temperature-rise limits.

7.8.2.10 In determining the area of contact surfaces of a bolted or riveted connection, no subtractions shall be made for the areas of the holes used for clamping bolts or rivets.

7.8.2.11 In a 3-phase, 4-wire or a single-phase, 3-wire transformer tap fitting, the cross-sectional area of the neutral bus bar shall be no less than that of the other bus bars unless it is intended that all leads from transformers to the neutral bus bar be connected to a single bus bar terminal.

7.8.3 Wiring

7.8.3.1 A pressure wire connector shall be provided for the connection of each wire intended to be installed in the field and shall be the same type as specified in Clause 8.2.3.

7.8.3.2 Pressure terminal connectors for field connection (line or load) are not required to be provided if the following conditions are met:

a) Component terminal assemblies are available from the equipment manufacturer or one or more pressure terminal connectors are specified for field installation on the equipment.

b) A fastening device such as a stud, nut, bolt, spring or flat washer (or both), and the like, as required for an effective installation, is either provided as a part of the component terminal assembly or is mounted on or separately packaged with the equipment.

c) The installation of the terminal assembly does not involve the loosening or disassembly of parts other than a cover or other part giving access to the terminal location. The means for securing the terminal connector is readily accessible for tightening before and after installation of conductors.

d) If the pressure terminal connector provided in a component terminal assembly requires the use of a particular tool for securing the conductor, any necessary instructions are included in the component assembly package or with the equipment.

e) Installation of the pressure terminal connectors in the intended manner results in a product meeting the requirements of the Standard.

f) The equipment is marked in accordance with Clause 5.2.20.1.

7.8.3.3 Wire binding screws or studs and nuts may be used for securing a 10 AWG (5.3 mm^2) or smaller conductor.

7.8.3.4 Alternative wire connectors (crimp for mechanical, crimp for crimp, or mechanical for mechanical) may be used in a busway or fitting without conducting a short-circuit test if the short-circuit current rating of the busway is less than 100 000 A and if the short-circuit current rating divided by the number of conductors per phase results in a current of 50 000 A per conductor or less.

7.8.3.5 Alternative wire connectors (crimp for mechanical, crimp for crimp, or mechanical for mechanical) may be used in a busway or fitting which is supplied with overcurrent protective device without conducting a short-circuit test, provided the following conditions are met:

a) The number of conductors per leg is equal to or greater than the number of conductors tested.

b) The average pullout force C, in accordance with Reference Item No. 12, Annex B, of three samples of the alternative wire connector is equal to or greater than the average pullout force of three samples of the wire connectors used in the short-circuit test.

7.8.3.6 A pressure wire connector provided with or specified for use with a busway or busway fitting shall comply with the requirements of Reference Item No. 12, Annex B.

7.8.3.7 The tightening torque for a field-wiring terminal shall be as specified by the busway or busway fitting manufacturer. The busway or fitting shall be marked with the required tightening torque value in a location readily visible prior to being wired. The specified tightening torque shall be either no more than 100 percent nor less than 90 percent of the value employed in the static heating test, or may be less than 90 percent if the connector is investigated with the marked tightening torque value in accordance with the requirements in Reference Item No. 12, Annex B, for the wire size corresponding to the ampere rating of the busway. A field wiring terminal shall be tested in accordance with Clause 8.2.11.

7.8.3.8 The pressure wire connector shall be fastened to the bus bar and shall not overhang the insulating support unless the construction is such as to prevent any reduction of spacings below the required minimum values.

7.8.3.9 The connector shall accommodate a conductor or conductors having an ampacity equal to or more than the current rating of the busway or fitting as shown in Table 18. For a transformer tap, the connectors may accommodate a conductor having an ampacity as shown in Table 19.

Table 18
Ampacity of insulated conductors

Wire size,		60°C[a]		75°C[a]	
AWG or kcmil	(mm^2)	Copper	Aluminum	Copper	Aluminum
14	2.1	(15) 20[b]	–	(15) 20[b]	–
12	3.3	(20) 25[b]	(15) 20[b]	(20) 25[b]	(15) 20[b]
10	5.3	30	25	(30) 35[b]	(25) 30[b]
8	8.4	40	30	50[c]	40[c]
6	13.3	55	40	65[c]	50[c]
4	21.2	70	55	85[c]	65[c]
3	26.7	85	65	100[c]	75[c]
2	33.6	95	75	115	90
1	42.4	110	85	130	100
1/0[d]	53.5[d]	see footnote e	see footnote e	150	120
2/0[d]	67.4[d]	see footnote e	see footnote e	175	135
3/0[d]	85.0[d]	see footnote e	see footnote e	200	155
4/0[d]	107[d]	see footnote e	see footnote e	230	180
250[d]	127[d]	see footnote e	see footnote e	255	205
300[d]	152[d]	see footnote e	see footnote e	285	230
350[d]	177[d]	see footnote e	see footnote e	310	250
400[d]	203[d]	see footnote e	see footnote e	335	270
500[d]	253[d]	see footnote e	see footnote e	380	310
600[d]	304[d]	see footnote e	see footnote e	420	340
700[d]	355[d]	see footnote e	see footnote e	460	375
750[d]	380[d]	see footnote e	see footnote e	475	385
800[d]	405[d]	see footnote e	see footnote e	490	395
900[d]	456[d]	see footnote e	see footnote e	520	425
1 000	506	see footnote e	see footnote e	545	445

Table 18 Continued on Next Page

Table 18 Continued

Wire size, AWG or kcmil	Wire size, (mm^2)	60°C[a] Copper	60°C[a] Aluminum	75°C[a] Copper	75°C[a] Aluminum
1 250	633	see footnote e	see footnote e	590	485
1 500	760	see footnote e	see footnote e	625	520
1 750	887	see footnote e	see footnote e	650	545
2 000	1 013	see footnote e	see footnote e	665	560

NOTES.

1 For internal wiring, larger ampacities may be used on the basis of a temperature test.

2 These values of ampacity apply only where a maximum of 3 current carrying conductors will be field-installed in a single conduit. If 4 or more conductors other than a grounding conductor or a neutral that carries the unbalanced current will be installed in a conduit, the ampacity of each of these conductors is reduced as shown below. These reduced values do not apply to internal wiring of a busway fitting.

a) 4 – 6 conductors = 80 percent of values in the table.

b) 7 – 24 conductors = 70 percent of values in the table.

c) 25 – 42 conductors = 60 percent of values in the table.

d) 43 or more conductors = 50 percent of values in the table.

[a] The values 60°C and 75°C indicate the wire temperature rating.

[b] The values shown in parentheses shall be used for wires connected to an overcurrent protective device.

[c] The ampacity of these sizes shall be considered to be the same as for 60° wire when connected to a molded-case circuit breaker unless the breaker is marked 75°C.

[d] For a multiple conductor connector at a terminal, the ampacity value shall be multiplied by the number of conductors that the terminal will accommodate 1/0 AWG and larger.

[e] For wire sizes 1/0 AWG and larger, it is assumed that wire at least a 75°C temperature rating will be used.

Table 19
Ampacity of insulated conductors in free air

Wire size, AWG or kcmil	Wire size, (mm^2)	60°C[a] Copper	60°C[a] Aluminum	75°C[a] Copper	75°C[a] Aluminum
14	2.1	(20) 25[b]	–	(20) 30[b]	–
12	3.3	(25) 30[b]	(20) 25[b]	(25) 35[b]	(20) 30[b]
10	5.3	40	(30) 35[b]	(40) 50[b]	(30) 40[b]
8	8.4	60	45	70[c]	55[c]
6	13.3	80	60	95[c]	75[c]
4	21.2	105	80	125[c]	100[c]
3	26.7	120	95	145[c]	115[c]
2	33.6	140	110	170[c]	135[c]
1	42.4	165	130	195[c]	155[c]
1/0	53.5	see footnote d	see footnote d	230	180
2/0	67.4	see footnote d	see footnote d	265	210
3/0	85.0	see footnote d	see footnote d	310	240
4/0	107	see footnote d	see footnote d	360	280
250	127	see footnote d	see footnote d	405	315
300	152	see footnote d	see footnote d	445	350

Table 19 Continued on Next Page

Table 19 Continued

Wire size,		60°C[a]		75°C[a]	
AWG or kcmil	(mm^2)	Copper	Aluminum	Copper	Aluminum
350	177	see footnote d	see footnote d	505	395
400	203	see footnote d	see footnote d	545	425
500	253	see footnote d	see footnote d	620	485
600	304	see footnote d	see footnote d	690	540
700	355	see footnote d	see footnote d	755	595
750	380	see footnote d	see footnote d	785	620
800	405	see footnote d	see footnote d	815	645
900	456	see footnote d	see footnote d	870	700
1 000	506	see footnote d	see footnote d	935	750
1 250	633	see footnote d	see footnote d	1 065	855
1 500	760	see footnote d	see footnote d	1 175	950
1 750	887	see footnote d	see footnote d	1 280	1 050
2 000	1 013	see footnote d	see footnote d	1 385	1 150

NOTE – Table 18 applicable only with respect to Clause 7.8.3.9.

[a] The rating indicates the wire temperature rating.

[b] The values shown in parentheses shall be used for wires connected to an overcurrent protective device.

[c] The ampacity of these sizes shall be considered to be the same as for 60°C wire when connected to molded case circuit breakers unless the breaker is marked 75°C.

[d] For wire sizes 1/0 AWG and larger, it is assumed that wire with at least a 75°C temperature rating will be used.

7.8.3.10 The size and type of a field-installed conductor shall be determined as follows:

a) For currents as indicated in Table 18 and Table 19:

1) Wire rated at 75°C shall be used for 1/0 AWG (53.5 mm^2) and larger sizes.

2) Wire rated at 60°C shall be used for the 1 AWG (42.4 mm^2) size; however, wire rated at 75°C may be used when the busway fitting provided with circuit breakers rated 110 A or less is tested and marked in accordance with Clause 5.2.20.18.

3) Wire rated at 60°C shall be used for 2 AWG (33.6 mm^2) and smaller sizes, however, sizes 2 AWG (33.6 mm^2) wire rated at 75°C may be used if the busway fitting is provided with a 100 A circuit breaker marked for use with 75°C aluminum wire. When so marked, the circuit breakers need not be spaced apart from other circuit breakers or be subjected to the test described in Clause 8.2.1.

b) Aluminum wire shall be used at any terminal identified on a wiring diagram or the like as described in Clauses 5.2.20.3 – 5.2.20.11 as being rated for use with such wire, whether or not that terminal is also identified as being rated for use with copper wire.

7.8.3.11 A bolted connection between a wire connector and a bus bar shall be evaluated for compliance with Clauses 7.8.1.6 – 7.8.1.10.

7.8.3.12 A wire connector shall be prevented from being turned to such a position that spacings would be reduced to values less than those required. When minimum or larger spacings exist after the wire connectors are turned from their normal position 30 degrees toward each other or toward other live or grounded metal parts, no means to prevent turning need be provided.

7.8.3.13 A wire-binding screw or stud of a wiring terminal shall be no smaller than No. 10 (M5) with no more than 32 threads per inch (0.80 pitch). The terminal shall be provided with an upturned lug, a cupped

washer, or the equivalent, capable of retaining a 14 AWG (2.1 mm^2) solid conductor even though the screw or nut might become loose; however, a No. 8 (M4) machine screw having more than 32 threads per inch (0.70 pitch) may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

7.8.3.14 A wire-binding screw terminal design is one in which the conductor is intended to encircle the terminal screw for at least three-quarters of its circumference, but without overlapping of the conductor.

7.8.3.15 A wire-binding screw shall thread into metal.

7.8.3.16 A terminal plate tapped for a wire-binding screw shall be of metal no less than 0.76 mm (0.030 in) thick. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

7.8.3.17 If a pressure-wire connector is used as a terminating device for aluminum, it shall be investigated and determined acceptable for use with aluminum under the conditions involved (for example, temperature, heat cycling, or the like).

7.8.3.18 A drop cord connected to a plug-in unit shall be Type S, SE, SO, ST, or STO flexible cord, or bus drop cable having an ampacity, as shown in Table 20, no less than the current rating of the plug-in unit.

Table 20
Cord ampacity

Copper conductor size,		Ampacity, A	
AWG	(mm^2)	1-Phase	3-Phase
18	0.82	10	7
16	1.30	13	10
14	2.10	18	15
12	3.30	25	20
10	5.30	30	25
8	8.40	40	35
6	13.30	55	45
4	21.20	70	60
2	33.60	95	80

7.8.3.19 A drop cord connected to a fitting shall be provided with strain relief and bushings.

7.8.3.20 If a knot in a flexible cord serves as a strain relief, a surface that the knot can touch shall be free from projections, sharp edges, burrs, fins, or the like that can cause abrasion of the cord insulation.

7.8.3.21 At a point where a flexible cord passes or is intended to pass through an opening in a wall, barrier, or enclosing case, there shall be a secured bushing or the equivalent, and it shall have a smoothly rounded surface against which the cord can bear.

7.8.3.22 A busway fitting having a drop cord or flexible cord or containing a receptacle shall also contain overcurrent protection ahead of the cord or receptacle. The ampere rating of the overcurrent protection shall not exceed the ampere rating of the cord or receptacle.

7.8.3.23 A fitting constructed or marked so that it will not be installed in a busway rated over 20 A need not contain overcurrent protection.

7.8.3.24 A fitting constructed or marked so that it will not be installed on a busway having an ampere rating higher than the cord ampacity or the receptacle ampere rating need not contain overcurrent protection.

7.8.3.25 A fitting need not contain overcurrent protection if it is marked for use only on the load side of overcurrent protection not exceeding the receptacle ampere rating.

7.8.3.26 Overcurrent protection may be omitted from the fitting if the line of fittings intended for use with the busway includes a fitting with a receptacle of the same rating and is provided with proper overcurrent protection.

7.9 Requirements for electronic equipment supply circuits

Reserved for future use.

7.10 Electromagnetic compatibility

Reserved for future use.

7.11 Description of the types of electrical connections or functional units

Reserved for future use.

8 Test specifications

8.1 General

Reserved for future use.

8.2 Type tests

8.2.1 Verification of temperature-rise limits

8.2.1.1 General

8.2.1.2 Arrangement of the bus bar trunking system

8.2.1.2.1 For the temperature rise test, three 3.05 m (10 ft) lengths of busway shall be bolted together in a straight run in the intended manner and supported horizontally 508 mm (20 in) or more from the floor. The opening at each end of the run shall be blocked to prevent the passage of air. The sample shall be tested in still air. The sample shall be placed in a position representing the service conditions most likely to produce maximum operating temperatures or in accordance with the marked instructions in Clause 5.2.10, 5.2.17.3, or 5.2.17.6. If an elbow or tee requires testing, it shall be assembled between two 3.05 m (10 ft) lengths of busway.

8.2.1.3 Temperature rise limits (stabilization method)

8.2.1.3.1 The busway shall be tested at any convenient voltage, with rated current flowing, and the supply circuit shall have the number of phases corresponding to the busway rating. A 60-Hz power supply shall be used unless another frequency is indicated in the busway marking. If a line of busways is involved, heating tests shall be made on the 3-phase, 3-pole products. Such tests shall be generally considered as representing 3-phase, 4-wire and single-phase, 2-wire or 3-wire busways, provided that the ampacity of the neutral, if any, complies with Clause 7.8.2.7. The phase currents in polyphase supply connections to

the busway shall be balanced. If there are two or more bus bars per phase, the current shall be allowed to distribute itself in the various bus bars according to the characteristics of the busway.

8.2.1.3.2 Conductors of rated size shall be used in connecting the ends of the bus bars to the source of supply and for short circuiting the bars at the other ends. These conductors shall be such that no appreciable amount of heat is contributed to or withdrawn from the busway under test. Heat flow through the connections to external conductors shall be determined by comparing temperature observations made by means of thermocouples placed on the external conductors and the ends, the center, and intermediate points throughout the run of busway under test. A temperature shall be considered to be constant when three successive readings taken at 15-minute intervals indicate no change. Normally this requires 8 to 10 hours of operation.

8.2.1.4 Temperature rise limits (heat cycling method)

8.2.1.4.1 General

8.2.1.4.1.1 A busway shall be subjected to a heat cycling test if it employs:

a) Spring-loaded bus bar joints or

b) Aluminum bus bars that are not provided with spring washers or the like at bolted connections between bus bars.

For the heat cycling test, the rated busway current shall vary in cycles in the manner described in Clauses 8.2.1.4.2.2 and 8.2.1.4.2.3. Results shall comply with the limitations on increase in temperature rise specified in Clause 8.2.1.4.2.3.

8.2.1.4.1.2 Two 3.05 m (10 ft) lengths of the busway shall be connected together. The joints between the bus bars shall be conditioned by being assembled and disassembled 5 times prior to final assembly for the test.

8.2.1.4.1.3 A spring-loaded joint shall be considered to be one in which the clamping force is developed by the deflection of a spring member in the assembly of the joint. For the purpose of this requirement, a dished washer shall not be considered to exert spring loading.

8.2.1.4.1.4 When a busway employing aluminum bus bars and intended for use with a plug-in fitting is tested with such a fitting in the manner described in Clauses 8.2.1.4.2.1 – 8.2.1.4.2.3, and with rated current flowing, the change in temperature rise shall be no more than indicated in Clause 8.2.1.4.2.3.

8.2.1.4.2 Test arrangement

8.2.1.4.2.1 This test is to determine the suitability of the plating of aluminum bus bars. If plating of the same characteristics is employed on a line of busways of the same design but of different current ratings, a test on one combination of busway and plug-in fitting shall be considered to be representative of the line. For the test, the largest size (ampere rating) of plug-in device shall be mounted on the smallest size (ampere rating) busway that will accommodate it. Before any current is allowed to flow, the bus bars shall be conditioned by 25 cycles of insertion and removal of the plug-in device in the intended manner.

8.2.1.4.2.2 The temperature rises on the contacts of the fitting and on the bus bars adjacent to the contacts shall be determined while the equipment is carrying the specified current continuously. After temperatures have become constant under these conditions, the current shall be stopped and the equipment shall be allowed to cool to room temperature.

8.2.1.4.2.3 The equipment shall then be subjected to two successive sets of cycling of the current. Each set shall consist of 42 complete cycles. During each cycle the current shall be on for 2 hours and off for 2 hours; or if, during the initial heating mentioned in Clause 8.2.1.4.2.2, average temperatures on the fitting contacts and the bus bars at the end of 2 hours are more than 5° C lower than the average final temperatures during continuous operation, the current shall remain on for 3 hours in each cycle. Stable maximum temperatures shall be observed again after the 42nd cycle and also after the 84th cycle. The final temperatures shall not be more than 5° C higher than those observed initially, nor shall the final temperatures be more than 5°C higher than those observed at the conclusion of the 42nd cycle.

8.2.1.5 Measurement of temperatures

Reserved for future use.

8.2.1.6 Ambient air temperature

Reserved for future use.

8.2.1.7 Results to be obtained

8.2.1.7.1 The connection between a plug-in device and the busway shall be able to continuously carry the current indicated in Clause 8.2.1.7.2 without showing a temperature rise of more than 30° C or be tested in accordance with Clauses 8.2.1.4.2.2 and 8.2.1.4.2.3 without showing a temperature rise of more than 55°C.

8.2.1.7.2 For the test mentioned in Clause 8.2.1.4.2.3:

a) A plug-in device incorporating fuseholders shall be tested at its rated current with dummy fuses in the fuseholders.

b) A circuit breaker plug-in device shall be tested while carrying 80 percent of its rated current.

During the test, no current shall flow through the busway (other than that of the device on test). No preliminary conditioning cycles of assembly and disassembly shall be required. A plug-in device shall be tested when installed on a busway for which it is intended, and that has an ampere rating of twice the ampere rating of the plug-in device (or as close to that as possible).

8.2.1.7.3 The temperature rise on an enclosed switch, circuit breaker, or other component of a plug-in device shall comply with the requirements for such component.

8.2.1.7.4 When performing a heating test on the trolley of a trolley busway, the following shall be considered:

a) The type of moving contact;

b) The materials involved; and

c) Any other features that would be affected by the temperatures attained.

8.2.2 Verification of dielectric voltage withstand

8.2.2.1 General

8.2.2.1.1 A busway and its fittings shall withstand for 1 minute without breakdown the application of a 60-Hz essentially sinusoidal potential of 1 000 V plus twice maximum rated voltage:

a) Between live parts and the enclosure and

b) Between live parts of opposite polarity.

8.2.2.1.2 Test arrangement

The test shall be made with a 500 V-A or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential shall be increased from zero to the required test value for 1 minute. The increase in the applied potential shall be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by the voltmeter. The dielectric voltage-withstand test of a trolley busway shall follow the endurance test without any cleaning of the sample.

8.2.2.2 Clamped joint test

A clamped joint between two insulators shall be tested using two samples:

a) The clamped joint on the first sample shall be opened up to produce a space 3.2 mm (1/8 in) wide. This may be accomplished by loosening the clamping means or by drilling a 3.2 mm (1/8 in) diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60-Hz dielectric breakdown voltage through this hole shall then be determined by applying a gradually increasing voltage (500 V per second) until breakdown occurs.

b) The second sample, with the clamped joint intact, shall be subjected to a gradually increasing 60-Hz voltage until 110 percent of the breakdown voltage of (a) has been reached. If the breakdown voltage of (a) is less than 4 600 Vrms, the voltage to be applied to the second sample shall be further increased to 5 000 V rms and held for 1 second. There shall be no electrical breakdown of the second sample.

8.2.2.3 Reduced insulation thickness test

An insulating covering, as specified in Clause 7.1.1.16, shall be subjected to the application of a 5 000-V, 60-Hz potential applied between the bus bar and a metal foil wrapped around the insulating covering. In conducting this test, the potential shall be brought to the required value and held for 1 second. There shall be no electrical breakdown.

8.2.3 Verification of short-circuit withstand strength

8.2.3.1 Short-circuit withstand strength test at rated voltage

8.2.3.1.1 General

8.2.3.1.1.1 If a busway fitting includes a meter socket, the fitting shall be subjected to a short-circuit test in accordance with the applicable requirements in Reference Item No. 8, Annex B.

8.2.3.1.1.2 Except as indicated below, a busway fitting containing a switch shall be subjected to the following tests as covered in the applicable sections of the requirements in Reference Item No. 10 or 19, Annex B

a) The Close-Open Test;

b) The Dielectric Voltage-Withstand Test;

c) The Short Circuit-Withstand Test;

d) The Low Level Dielectric Voltage-Withstand Test;

e) The Closing Test; and

f) The Low Level Dielectric Voltage-Withstand Repeated Test.

8.2.3.1.1.3 The tests described in Clause 8.2.3.1.1.2 need not be performed if the switch was previously evaluated for the short-circuit current rating involved and all three of the following conditions are met:

a) The enclosure of the busway fitting has equal or greater volume than the enclosure used in the investigation of the switch;

b) The distance from an arcing part to the nearest live part or grounded metal surface in the busway fitting is no less than that distance in the test enclosure; and

c) The hinges and latch or screws in the fitting construction are equal to or stronger than those in the tested enclosure.

8.2.3.1.1.4 If a busway fitting contains a circuit breaker, the circuit breaker shall be a type that has been tested and rated for the short-circuit current and voltage marked on the busway fitting (including a series combination rating described in Clause 8.2.3.1.1.7 and the marking described in Clause 5.2.14). The tests on a busway fitting containing a circuit breaker shall be conducted in accordance with Reference Item No. 13, Annex B. If the circuit breaker is located in a panelboard in the busway fitting, the test shall be conducted in accordance with Reference Item No. 8, Annex B. The fitting employing the circuit breaker is to be subjected to the following tests:

a) The Maximum Current Test (single- and three-phase ground path);

b) The Maximum Voltage-Withstand Test; and

c) The Dielectric Voltage-Withstand Test.

8.2.3.1.1.5 The tests described in Clause 8.2.3.1.1.4 need not be performed if all three of the following conditions were met during the evaluation of the circuit breaker:

a) The enclosure of the busway fitting has equal or greater volume than the test enclosure used in the investigation of the circuit breaker;

b) The distance from an arcing part to the nearest live part or grounded metal surface in the busway fitting is equal to or greater than that distance in the test enclosure; and

c) The hinges and latch or screws in the busway fitting construction are equal to or stronger than those in the test enclosure.

8.2.3.1.1.6 The tests specified in Clauses 8.2.3.1.3.11 – 8.2.3.1.3.14 shall be conducted on a busway and fitting even if a switch or circuit breaker in the fitting complies with the conditions specified in Clauses 8.2.3.1.1.2 and 8.2.3.1.1.4.

8.2.3.1.1.7 If the short-circuit current rating of the busway fitting exceeds the interrupting rating of a circuit breaker within the fitting, the fitting and circuit breaker shall be tested in accordance with the requirements for series-connected molded-case circuit breakers in Reference Item No. 13, Annex B, and be marked in accordance with Clauses 5.2.13(b) and 5.2.14.

8.2.3.1.1.8 If the short-circuit current rating of the fitting exceeds the short-circuit current rating of any circuit breaker that can be added in the field, the fitting shall be marked in accordance with Clause 5.2.13(c).

8.2.3.1.1.9 A typical configuration of a busway system shall be tested to determine compliance with the requirements specified in Clause 8.2.3.1.4.1. A busway system with a 5 000-A, short-circuit current rating or a busway system rated over 100 A with a 7 500- or 10 000-A, short-circuit current rating need not be tested.

8.2.3.1.1.10 If the busway is marked for use on the load side of fuses as described in Clause 5.2.14, a short-circuit test is not required if the same bus and support system has been previously tested with acceptable results, and the peak-let-through currents (I_p) recorded in the previous test is greater than the let-through characteristics of the fuse as shown in Table 21.

Table 21
Peak-let-through currents (I_p) and clearing I^2t for fuses

Fuse rating, A	Between threshold and 50 kA		100 kA		200 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
Class CC and G fuses						
15	3[a]	2[a]	3	2	4[a]	3[a]
20	3[b]	2[a]	4	3	5[a]	3[a]
30[a]	6[b]	7[a]	7.5[a]	7[a]	12[a]	7[a]
30[b]	–	–	6[b]	5[b]	–	–
60[b]	–	–	10[b]	25[b]	–	–
300-V Class T fuses						
30	5	3.5	7	3.5	9	3.5
60	7	15	9	15	12	15
100	9	40	12	40	15	40
200	13	150	16	150	20	150
400	22	550	28	550	35	550
600	29	1 000	37	1 000	46	1 000
800	37	1 500	50	1 500	65	1 500
1 200	50	3 500	65	3 500	80	4 000
Class J and 600-V Class T fuses						
30	6	7	7.5	7	12	7
60	8	30	10	30	16	30
100	12	60	14	80	20	80
200	16	200	20	300	30	300
400	25	1 000	30	1 100	45	1 100
600	35	2 500	45	2 500	70	2 500
800[c]	50[c]	4 000[c]	55[c]	4 000[c]	75[c]	4 000[c]
Class L fuses						
800	80	10 000	80	10 000	80	10 000
1 200	80	12 000	80	12 000	120	15 000
1 600	100	22 000	100	22 000	150	30 000
2 000	110	35 000	120	35 000	165	40 000
2 500	–	–	165	75 000	180	75 000
Class L fuses						
3 000	–	–	175	100 000	200	100 000
4 000	–	–	220	150 000	250	150 000
5 000	–	–	–	350 000	300	350 000

Table 21 Continued on Next Page

Table 21 Continued

Fuse rating, A	Between threshold and 50 kA		100 kA		200 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
Class L fuses						
6 000	–	–	–	350 000	350	500 000
Class R fuses[d]						
30	11	50	11	50	14	50
60	20	200	21	200	26	200
100	22	500	25	500	32	500
200	32	1 600	40	1 600	50	2 000
400	50	5 000	60	5 000	75	6 000
600	65	10 000	80	10 000	100	12 000

NOTE – Measurement instrumentation for test circuits delivering more than 10 000 A shall be in accordance with Reference Item No. 13, Annex B.

[a] Value applies only to Class CC fuses.

[b] Value applies only to Class G fuses.

[c] Value applies only to Class T fuses.

[d] Value applies only to Class RK5 fuses.

8.2.3.1.1.11 An alternative bus support need not be subjected to a short-circuit test if it has the same shape and equal or greater mechanical strength than the support that was subjected to a short-circuit test.

8.2.3.1.2 Test arrangement

8.2.3.1.2.1 The following guidelines shall be used for sample selection:

a) A line of busway and fittings need only be tested at maximum and minimum ampere ratings if the general constructions are similar and if the following are all the same:

1) Short-circuit rating;

2) Bus bars per phase;

3) Method of bus bar support;

4) Center-to-center phase spacing; and

5) Spacing between supports.

Busways and fittings at intermediate ratings shall also to be tested if calculations based on their construction and short-circuit current rating indicate the likelihood of greater force on a support or greater deflection of a bus than would occur in the test at either the maximum or minimum rating.

b) In a line of busways and fittings with different short-circuit current ratings, the samples selected for testing to represent the line shall represent:

1) The weakest bus support and the weakest bus structure including the ground bus or a reduced size neutral bus;

2) The differences in joints between busway sections; and

3) The differences in field wiring terminals.

c) Among the factors to be considered in selecting samples as specified in (b) are:

1) The stiffness of the bus bars as related to bus cross-section, material, and distance between supports along the bus;

2) The force on the bus as related to distance between buses of opposite polarity, distance between supports along the bus, short-circuit current rating, and impedance of the busway; and

3) The force on bus supports as related to length of bus between supports, distance between bus of opposite polarity, short-circuit current rating, and impedance of the busway.

If the thermal performance of the busway depends on intimate contact between the bars and the housing, samples shall represent the construction most likely to result in loss of contact due to bowing of the bus bar or of the housing. The combination of these factors will usually require that more than one test be conducted.

d) Tests on a busway with multiple bus bars per phase may be considered representative of a similar busway with fewer bars per phase if:

1) The assigned short-circuit current rating of the busway with fewer bus bars per phase is no greater than the tested busway rating reduced by the ratio of the number of bus bars in the two constructions;

2) The bus bars are of the same size and material as in the tested construction;

3) The spacing between supports is no greater than the tested construction;

4) The center-to-center, phase-to-phase spacing is no less than the tested construction; and

5) The type of bus support and overall general construction is the same as in the tested busway.

8.2.3.1.2.2 The following configurations shall be tested:

a) Samples containing an end cable tap box installed on the line end of the busway shall have a combined length not exceeding 7.62 m (25 ft). Samples containing an end cable tap box installed on the load end of the busway shall have a combined length not exceeding 6.4 m (21 ft) and the length of a cable connected to the end tap box shall not exceed 1.22 m (4 ft). Each type of fitting and a straight length typical of the longest single length of busway shall be tested. Each test sample shall include at least one joint.

b) A busway plug-in fitting, trolley, service entrance busway fitting, or a bolt-on take-off device shall be tested on any convenient length of the highest current rated busway for which it is intended and shall be installed at the first available position closest to the point of power supply with any contacts closed.

A smaller rated busway may be used if the difference in impedance is compensated by using larger or shorter leads or by having more than required available short-circuit current. The length of the busway used to connect the fitting may be of any convenient length.

8.2.3.1.3 Current source characteristics

8.2.3.1.3.1 The characteristics of the current source shall be as follows:

a) The open circuit voltage shall be no less than the busway voltage rating for the short-circuit rating involved. All ac test potentials shall be obtained from a 48- to 60-Hz source of supply.

b) The short-circuit capability of the source of potential, together with any limiting impedance, shall be such as to permit the required test current (rated dc or average symmetrical rms short-circuit amperes) to flow through a short-circuit applied at the test station terminals.

c) The power factor of the rated voltage test current source shall not be in excess of the values shown in Table 22. The power factor of the test current source shall be calculated from readings of single phase maximum instantaneous peak amperes, 3-phase total asymmetrical rms amperes, symmetrical rms amperes, and reference to Table 23. The M ratios shall be determined as follows:

$$M_A\ (for\ 3\text{-}phase\ tests) = \frac{Asymmetrical\ \ rms\ \ amperes\ \ (average\ \ of\ \ 3\ phases)}{Symmetrical\ \ rms\ \ amperes\ \ (average\ \ of\ \ 3\ phases)}$$

$$M_P(for\ \ single\ phase\ tests) = \frac{Maximum\ \ instantaneous\ peak\ \ amperes\ (during\ first\ \ cycle)}{Symmetrical\ \ rms\ \ amperes}$$

Table 22
Test circuit parameters

Rated short-circuit RMS symmetrical current, A		Maximum power factor
More than	No more than	
0	10 000	0.5
10 000	20 000	0.3
20 000	200 000	0.2

Table 23
Short-circuit parameters

Short-circuit power factor percent	Short-circuit X/R ratio	Ratio to symmetrical RMS amperes	
		Maximum 1-phase instantaneous peak amperes, M_p	Average 3-phase asymmetrical RMS amperes at 1/2 cycle, M_A
0	4.0000	2.828	1.39400
1	99.9950	2.785	1.37400
2	49.9900	2.743	1.35400
3	33.3180	2.702	1.33600
4	24.9800	2.663	1.31800
5	19.9750	2.625	1.30200
6	16.6370	2.589	1.28600
7	14.2510	2.554	1.27100
8	12.4600	2.520	1.25600
9	11.0660	2.486	1.24200
10	9.9499	2.455	1.22900
11	9.0357	2.423	1.21600
12	8.2731	2.394	1.20400
13	7.6270	2.364	1.19300
14	7.0725	2.336	1.18200
15	6.5912	2.309	1.17200

Table 23 Continued on Next Page

Table 23 Continued

Short-circuit power factor percent	Short-circuit X/R ratio	Ratio to symmetrical RMS amperes	
		Maximum 1-phase instantaneous peak amperes, M_p	Average 3-phase asymmetrical RMS amperes at 1/2 cycle, M_A
16	6.1695	2.262	1.16200
17	5.7967	2.256	1.15200
18	5.4648	2.231	1.14400
19	5.1673	2.207	1.13500
20	4.8990	2.183	1.12700
21	4.6557	2.160	1.11900
22	4.4341	2.138	1.11200
23	4.2313	2.116	1.10500
24	4.0449	2.095	1.09900
25	3.8730	2.074	1.09200
26	3.7139	2.054	1.08700
27	3.5661	2.034	1.08100
28	3.4286	2.015	1.07600
29	3.3001	1.996	1.07100
30	3.1798	1.978	1.06600
31	3.0699	1.960	1.06200
32	2.9607	1.943	1.05700
33	2.8605	1.926	1.05300
34	2.7660	1.910	1.05000
35	2.6764	1.894	1.04600
36	2.5915	1.878	1.04300
37	2.5109	1.863	1.04000
38	2.4342	1.848	1.03700
39	2.3611	1.833	1.03400
40	2.2913	1.819	1.03100
41	2.2246	1.805	1.02900
42	2.1608	1.791	1.02700
43	2.0996	1.778	1.02500
44	2.0409	1.765	1.02300
45	1.9845	1.753	1.02100
46	1.9303	1.740	1.01900
47	1.8780	1.728	1.01700
48	1.8276	1.716	1.01600
49	1.7790	1.705	1.01400
50	1.7321	1.693	1.01300
55	1.5185	1.641	1.00800
60	1.3333	1.594	1.00400
65	1.1691	1.553	1.00200
70	1.0200	1.517	1.00100
75	0.8819	1.486	1.00040
80	0.7500	1.460	1.00012
85	0.6197	1.439	1.00000
90	0.4843	1.424	1.00000
95	0.3287	1.416	1.00000
100	0.0000	1.414	1.00000

8.2.3.1.3.2 The magnitude of the rms symmetrical short-circuit current available at the test station terminals with the terminals short-circuited with the shortest practical length of bus bar shall be determined as specified in the applicable requirements in Reference Item No. 13, Annex B. The power factor may be determined as noted in Clause 8.2.3.1.3.1(c) or in accordance with Reference Item No. 13, Annex B. The recovery voltage shall comply with the applicable requirements for molded-case circuit breakers if the calibrated circuit is used in tests involving an overcurrent device.

8.2.3.1.3.3 All short-circuit tests shall be conducted with the busway mounted in any convenient position. The busway enclosure shall be supported in a manner that provides no more additional bracing or support than would be provided by a hanger intended to be used with the busway.

8.2.3.1.3.4 The method of making line connections to a separate main device shall be as shown in Figure 3. The combined length of each cable (line and load) shall not exceed 2.44 m (8 ft).

When an end cable tap box is tested at the line end of the busway, it shall be supplied by means of cable no more than 1.22 m (4 ft) in length having an ampacity as shown in Table 18 based on 75°C insulation, nearest to but no less than the rating of the busway. The tap box line terminals shall be wired and tightened to the torque specified in the busway marking.

If an end cable tap box is not tested at the line end of the busway, the line connections to the busway may be bus bars no more than 1.22 m (4 ft) in length of equal or greater ampacity as those used in the busway.

Cable (or bus bars) that exceeds the length specified above may also be used, provided the additional length is included in the test circuit calibration.

Separate short-circuit tests shall be conducted with copper cable and with compact aluminum cable, unless:

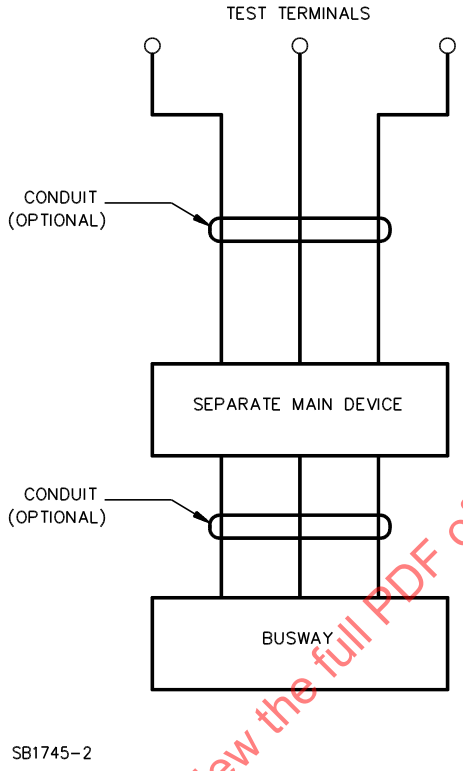
a) The test sample may be tested with copper cable if the busway is restricted to use with copper cable in accordance with Clause 5.2|20.5.

b) The test sample may be tested with aluminum or copper cable if the short-circuit current rating divided by the number of cables per phase results in a current of 50 000 A per cable or less.

c) If the short-circuit current rating is greater than 50 000 A per conductor, the test sample may be tested with either compact aluminum or copper cable if the type of cable used for the short-circuit test has a lower pullout force than the untested cable material.

Figure 3

Connection method



For a busway rated over 100 A, the lead to the enclosure or ground bus for the test specified in Clauses 8.2.3.1.3.11 and 8.2.3.1.3.13 may be sized as specified in Table 24.

Table 24
Minimum ground bus or enclosure test lead, copper

Busway ampere rating		Maximum short circuit rating, kA[a]	Test lead size,	
More than	No more than		AWG or kcmil[a]	(mm^2)
100	400	35	1/0	53.5
400	500	35	1/0	53.5
500	600	50	2/0	67.4
600	800	50	2/0	67.4
800	1 000	65	3/0	85.0
1 000	1 200	85	250	127
1 200	1 600	100	300	152
1 600	2 000	150	400	203
2 000	2 500	200	500	253
2 500	3 000	200	600	304
3 000	4 000	200	750	380
4 000	5 000	200	900	456
5 000	6 000	200	1 250	633

[a] If the short-circuit rating of the busway exceeds the value specified in the second column, the minimum test lead size shall be that specified in the third column for the corresponding increased short-circuit rating as shown in column two.

8.2.3.1.3.5 The cable shall not be braced inside a cable tap box unless the construction includes instructions for such bracing, as the construction in some cases will not provide provision for bracing of cables. The cable may be braced as it leaves the enclosure. The cable may exit from the enclosure through conduit not exceeding 305 mm (12 in) in length.

8.2.3.1.3.6 The sample shall be shorted at the load end as follows:

a) For a busway of continuous length without load connection facilities, the short shall be applied at the load end of the test sample by bus bars of minimum length and of ampacity equal to or greater than the busway conductors. The parallel bars in each phase shall be connected together at both feed and load ends as required in actual service.

b) For a fitting having provision for connection of cable, the load terminals shall be short circuited by 1.22 m (4 ft) of cable per leg and the busway shall be a maximum of 6.4 m (21 ft) in length. The cable shall be copper having an ampacity in accordance with Table 18 based on 75°C nearest to but no less than the rating of the fitting. The cable may exit from the fitting through conduit not exceeding 305 mm (12 in) in length. The terminals shall be wired and tightened in the same manner as described for the tap box line terminals in Clause 8.2.3.1.3.4.

c) A plug-in fitting shall be tested with the short applied only on the load side of the fitting. A second test shall be conducted with the short applied only on the load end of the busway. A separate sample of the plug-in fitting may be used for each test. If the fitting is intended for use with busways of different ampere or short circuit current ratings, the test with the short on the load side of the fitting need only be done with a representative busway. It will in some cases be necessary to test with several different busways for the test where the short is at the end of the busway.

8.2.3.1.3.7 If a busway is marked for use only on the load side of a fuse as described in Clause 5.2.14, or if the test sample includes a busway fitting containing a fuseholder, a fuse of the intended class, voltage, and current rating shall be installed in the fuseholder if the test current will be below the point (threshold value of the fuse) at which the fuse is considered to be current limiting. If the test is for a 7 500- or 10 000-A rms symmetrical short-circuit current rating and the fuseholder is intended for a plug or Class H fuse, a nonrenewable time delay fuse shall be used. If the test is for a short-circuit current rating over 10 000 rms symmetrical amperes and if the test current will be above the threshold value of the intended fuse, a test fuse shall be used that has such characteristics that, when tested on a single-phase circuit, it will permit peak let-through current and clearing I^2t no less than the corresponding values specified in the requirements for the class of fuse (CC, G, J, L, RK5, or T) and the current and voltage rating of the fuse intended for use with the device being tested as shown in Table 21. To obtain the required values of these characteristics, it will in some cases be necessary to employ a fuse having different dimensions than that of the fuse specified for use with the device, in which case an external fuseholder shall be used.

8.2.3.1.3.8 If an external fuseholder is employed it shall be inserted:

a) Between the fuse clip on the line side and the fuse clip on the load side;

b) On the load side of the test sample ahead of the shorting point; or

c) On the line side of the busway.

If external fuses are located as described in (b) or (c), a copper bus or tube (dummy fuse) shall be installed in each fuseholder of the busway fitting. Under all conditions, the leads, if any, for connecting the external fuseholder shall be included in the calibration when testing at rated voltage, unless the combined length of all leads and the supply cable does not exceed 1.22 m (4 ft).

8.2.3.1.3.9 A copper bus bar or tube (dummy fuse) shall have a cross-section no less than that of the blade or ferrule of the fuse that the fuseholder is intended to accommodate. Each bar or tube may be

individually reinforced to enable it to withstand the short-circuit forces. The bar or tube shall be secured in place in the same manner as the fuse in normal service.

8.2.3.1.3.10 For other than the test covered in Clause 8.2.3.1.3.13, the enclosure shall be connected to a 30-A, nonrenewable, nondelay-type cartridge fuse to the line lead of the pole least likely to arc to the enclosure. The connection shall be made to the load side of the limiting impedance by a 10 AWG (5.3 mm^2) copper wire, 1.22 – 1.83 m (4 – 6 ft) long. The enclosure shall otherwise to be insulated from the test station ground.

8.2.3.1.3.11 The number of phases for the test circuit shall be one of the following:

a) A 3-phase busway shall be tested on a 3-phase circuit.

b) A single-phase busway shall be tested on single-phase circuit.

c) A dc-rated busway shall be tested on a dc source or on an ac source; the peak value of the steady state (symmetrical wave) current shall be equal to the required dc withstand current.

8.2.3.1.3.12 Each configuration shall also to be subjected to a single-phase (or dc) short-circuit test between the ground bus (or enclosure if a ground bus is not provided) and the phase bus nearest the ground bus (or nearest the enclosure if no ground bus is provided). The test shall be conducted in accordance with 8.2.3.1.3.13.

8.2.3.1.3.13 If the test station output is 3-phase, 3-wire, the ground bus and the nearest phase bus shall be connected to a single-phase test circuit. If the test station output is 3-phase, 4-wire, the busway ground bus shall be connected to the test station neutral and the nearest phase bus to one phase of the test station. In either case, the open circuit line to ground bus voltage of the test circuit shall be no less than the maximum rated line-to-line voltage of the busway, divided by 1.732; and the available short circuit current at the test terminals shall be no less than the rated short-circuit current of the busway.

8.2.3.1.3.14 A single-phase test shall be conducted using the neutral and nearest phase bus bar for a 3-phase, 4-wire busway employing a neutral bus bar that is:

a) Smaller than a phase bus bar;

b) Spaced closer to a phase bus bar than the phase bus bars are to each other; or

c) Braced differently from the phase bus bar bracing.

The method shall be as described in Clause 8.2.3.1.3.13 using the neutral bus bar instead of the ground bus bar.

8.2.3.1.3.15 The test voltage shall be obtained at the input connections to the bus bars by reading the open-circuit, line-to-line, or line-to-neutral voltage immediately before the test. The test voltage shall not to be less than rated voltage. The test voltage shall not exceed the rated voltage plus 5 percent without the concurrence of all concerned.

8.2.3.1.3.16 Controlled closing shall be used in all tests as specified in Table 25 except for a 3-phase test involving an overcurrent device.

Table 25
Closing angle

Number of phases	Bus bar relationships	Bus most likely to cause failures	Closing angle electrical degrees[a]
1	All	All	0 ±10
3	Edge-to-edge	A phase	-14 ±10
3	Edge-to-edge	C phase	+14 ±10
3	Face-to-face	A phase	-6 ±10
3	Face-to-face	C phase	+6 ±10
3	All	B phase	+14 ±10

[a] Values refer to the zero point of the supply voltage on a phase to neutral basis in the case of a 3-phase circuit. Minus values represent current turned on before the voltage zero point, and plus values represent current turned on after the voltage zero point.

8.2.3.1.3.17 The duration of the short-circuit test current for a fitting having no overcurrent device and for a busway not marked for use with an overcurrent device in accordance with Clause 5.2.20.13 shall be no less than 3 cycles (on a 60-Hz basis). A fitting containing an overcurrent device shall be subjected to a short-circuit test until the overcurrent device functions.

A busway marked in accordance with Clause 5.2.14 may be tested with the specified circuit breakers or fuses as specified in Clauses 8.2.3.1.3.7 and 8.2.3.1.3.8 in the circuit.

8.2.3.1.4 Results to be obtained

8.2.3.1.4.1 After a busway or fitting has been subjected to short-circuit tests, the busway or fitting shall be in substantially the same mechanical condition as it was before the test. It shall also comply with Clauses 8.2.3.1.4.3, 8.2.3.1.4.4, and all of the following:

a) The fuse connected to the enclosure shall not open.

b) The enclosure or a part of the enclosure, such as a filler plate, door, and the like, shall not be damaged or displaced to the extent that a live part is accessible.

c) A closed door of a busway fitting enclosure shall not be blown open.

d) There shall be no arcing damage or loss of contact at a joint between enclosures.

e) The busway or fitting shall comply with the dielectric voltage-withstand test described in Clauses 8.2.2.1.1 and 8.2.2.1.2. The ac test voltage is based on the rated busway voltage. A dc test voltage equal to 1.414 times the specified ac test voltage may be used.

f) A bus bar or strap shall not be permanently distorted or displaced to an extent that affects the normal functioning of the busway or fitting, or reduces an electrical spacing to less than 75 percent of the values specified in Table 6.

g) A bus bar insulator or support or bus bar or cable restraint shall not be broken. A bus bar or cable support, restraint, or insulator may be cracked or chipped if the resulting spacings are no less than 75 percent of the values specified in Table 6.

h) There shall be no arcing damage between live parts of opposite polarity.

i) No conductor shall pull out of a terminal connector, and there shall be no damage to the conductor.

8.2.3.1.4.2 The use of a plug-in or a bolted take-off device shall be evaluated by the applicable requirements of:

a) Reference Item No. 10, Annex B;

b) Reference Item No. 11, Annex B;

c) Reference Item No. 13, Annex B;

d) Reference Item No. 17, Annex B; or

e) Reference Item No. 19, Annex B.

Welding of a bus-plug contact to a bus bar during the test shall not be to the extent that the weld cannot be broken by normal means; however, pitting of a bus-plug contact during the test of the device itself may occur if it does not initiate phase-to-phase, phase-to-neutral, or phase-to-ground arcing in the busway. However, welding or pitting of aluminum parts can affect the plating at contacts and will in some cases require investigation by a heating test.

8.2.3.1.4.3 Each tested plug-in device shall be plugged into typical openings of the other section or length where there were no devices during the tests. In addition, a plug-in device tested with the short-circuit applied at the load end of the busway shall be plugged into an opening of an untested length of busway. Any abnormal difficulty encountered in inserting a device shall be considered a noncompliance of the requirements for:

a) The busway, if distortion of the bars is the cause of the trouble or

b) The device, if the cause of the trouble is in the device.

8.2.3.1.4.4 If the thermal performance depends on intimate contact between the bars and the housing, there shall not be a substantial loss of contact. If this cannot be determined by visual examination, the temperature test shall be repeated. The temperature rise shall not be more than 60°C.

8.2.3.2 Short-circuit withstand strength test at reduced voltage

8.2.3.2.1 General

8.2.3.2.1.1 This clause provides requirements for an alternative short-circuit test method to the rated voltage method described in Clause 8.2.3.1. This method may be used if the test sample does not include a circuit breaker.

8.2.3.2.1.2 The requirements covering the following items shall be as specified in Clause 8.2.3.1:

a) Sample selection;

b) Sample preparation;

c) Load connection;

d) Fuses;

e) Time; and

f) Evaluation.

The requirements covering closing, power factor, and test circuit calibration are not specified so long as the measured test current is no less than that specified in Clause 8.2.3.2.1.5.

8.2.3.2.1.3 The method of line connection shall be as specified in Clause 8.2.3.1.3.4 except the line leads may be longer than 1.22 m (4 ft).

8.2.3.2.1.4 The open circuit voltage shall be at least 100 V.

8.2.3.2.1.5 The maximum single-phase current, instantaneous peak current, and the 3-phase average rms asymmetrical total current measured during the test shall be that value which would have resulted if tested at rated voltage.

8.2.3.2.2 Test arrangements

8.2.3.2.2.1 The determination of the busway characteristics shall be made as follows:

a) The electrical characteristics of a busway shall be calculated from measurements of current and power input and voltage drop across any convenient length of busway, but no less than 6.1 m (20 ft), including at least one joint fitting. The electrical characteristics shall be used in calculating the current required when a short-circuit test not involving a ground bus or enclosure is conducted at other than rated voltage. The test set-up shall be as shown in Figure 4 and modified where necessary to record values for a single-phase or direct current rated busway.

b) The test current may be derived from any convenient source of potential. The value of current used shall be that of the normal current rating of the busway. For a 3-phase test circuit, the rms symmetrical current shall be the average of the currents in the 3 phases. However, the rms symmetrical current in any one phase shall be no less than 90 percent of the value of the rated current.

c) The value of voltage drop shall be measured by observing the input voltage between pairs of input terminals to the sample with rated current flowing in all bus bars with the load or output terminals shorted together by the shortest practical length of bus of the same ampacity as used in the busway. The test and readings shall be conducted with the sample heated to constant temperature. The voltage drop value used in calculations shall be the average of the observed values for a polyphase- rated busway and the actual observed value for a single-phase or direct-current rated busway. The voltage drop shall be measured at the input end of the busway with the short-circuit applied between the elements at the load end.

d) The power input for a 3-phase test shall be obtained from the sum of observed wattmeter readings. For a single-phase test, the power input shall be determined with the potential coil of the wattmeter connected between the line bus bars.

e) The following calculations shall be made:

$$Z_3 = \frac{V}{IL\sqrt{3}} \quad (3\text{-}phase) \qquad Z_1 = \frac{V}{IL} \quad (single\text{-}phase)$$

$$R_3 = \frac{P}{3I^2L} \quad (3\text{-}phase) \qquad R_1 = \frac{P}{I^2L} \quad (single\text{-}phase)$$

$$X_3 = \sqrt{(Z_3)^2 - (R_3)^2} \quad (3\text{-}phase) \qquad X_1 = \sqrt{(Z_1)^2 - (R_1)^2} \quad (single\text{-}phase)$$

where:

Z_3 and Z_1 are the 3-phase and single-phase impedances, respectively, ohms per unit length;

V is the measured voltage drop, in volts;

I is the test current, in amperes;

L is the length of the sample, in meters (feet);

R_3 and R_1 are the 3-phase and single-phase ac resistances, respectively, in ohms per unit length on a line-to-neutral basis;

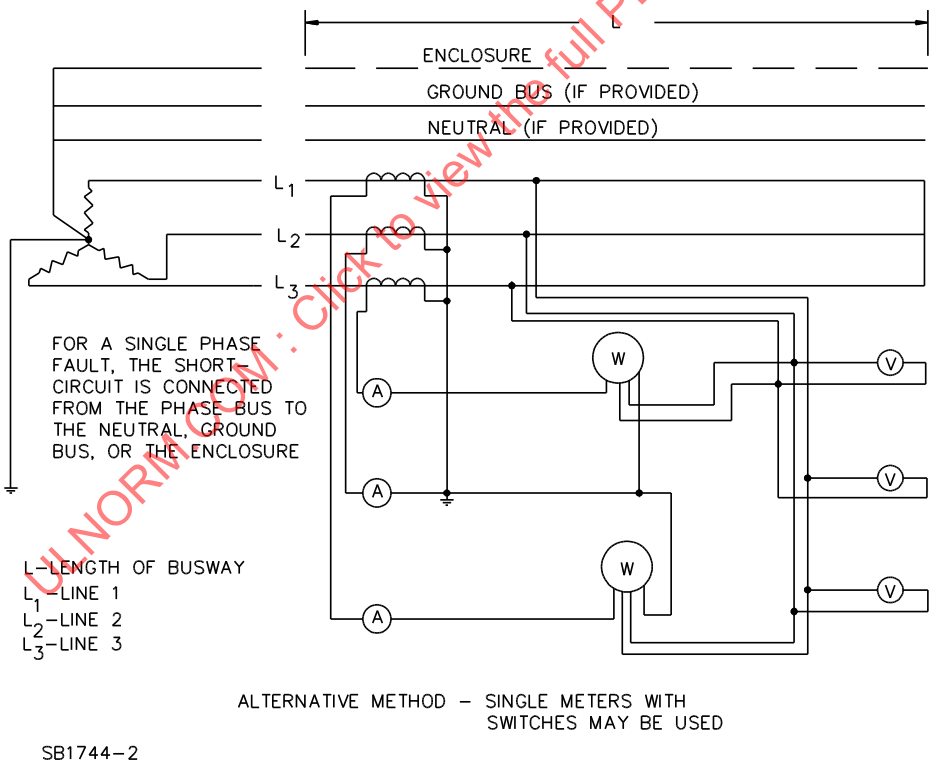
P is the measured power input, in watts; and

X_3 and X_1 are the 3-phase and single-phase reactance, respectively, in ohms per unit length on a line-to-neutral basis.

f) For the test in which the current flows through the enclosure or ground bus, the values of R and X in ohms per unit length shall be determined for the phase and ground bus by subtracting the R and X values of the source from the total R and X values obtained during a short-circuit test with the busway in the circuit and the through current at no less than 5 000 A. This method may also be used to determine the R and X values for the other short-circuit tests that do not involve the enclosure or ground bus.

Figure 4

Test circuit



8.2.3.2.2.2 The determination of the test circuit parameters for a short-circuit test shall be made as follows:

a) The power factor and the magnitude of the actual test current required to pass through the bus bars of the test sample shall be so adjusted that the following are equal to or higher than the calculated value for a test made at rated voltage:

1) For a single-phase test, the maximum single-phase peak instantaneous amperes or

2) For a 3-phase test, the average rms asymmetrical amperes.

b) The magnitude of the test current shall be determined from an oscillogram in accordance with the following:

For an alternating current test, single-phase peak instantaneous amperes or 3-phase rms asymmetrical total current shall be determined with the buses short-circuited at the load end, so that the test current flows through these buses. The rms asymmetrical total current shall include the direct current component, if any. It shall be measured at an instant 1/2 cycle after the short-circuit occurs and shall be calculated in accordance with Reference Item No. 3, Annex B.

c) The magnitude of the test current that would pass through the bus bars of the test sample, when tested at rated voltage, shall be calculated by the following formulas:

1) For a 3-phase busway:

$$I_{T3} = \frac{V_3}{\sqrt{\left(A\frac{V_3}{I_{R3}} + 29\sqrt{3}\ R_3\right)^2 + \left(\frac{BV_3}{I_{R3}} + 29\sqrt{3}\ X_3\right)^2}}$$

where:

I_{T3} is the required test current in symmetrical amperes that would flow at a rated voltage test;

V_3 is the voltage rating of the busway (line-to-line);

A and B are sine and cosine multiplying factors from Table 26;

I_{R3} is the rated 3-phase short-circuit current in symmetrical amperes at voltage V_3;

R_3 is the alternating current resistance of the buses in ohms per unit length on a line-to-neutral basis; and

X_3 is the reactance of the buses in ohms per unit length on a line-to-neutral basis.

and:

Maximum required average rms total current = $M_A\ I_{T3}$

where:

M_A is the ratio from Table 23 of average 3-phase rms total asymmetrical amperes at 1/2 cycle to symmetrical rms amperes based on the value:

$$\frac{X_{T3}}{R_{T3}} = \frac{BV_3 + 29\sqrt{3}\ X_3\ I_{R3}}{AV_3 + 29\sqrt{3}\ R_3\ I_{R3}}$$

where:

X_{T3} is the total reactance of the test current source and the busway when tested on a source of rated voltage; and

R_{T3} is the total alternating current resistance of the test current source and the busway when tested on a source of rated voltage.

2) For a single-phase busway:

$$I_{T1} = \frac{V_1}{\sqrt{\left(A\frac{V_1}{I_{R1}} + 29\,R_1\right)^2 + \left(\frac{BV_1}{I_{R1}} + 29\,X_1\right)^2}}$$

where:

I_{T1} is the required test current in symmetrical amperes that would flow at a rated voltage test

V_1 is the voltage rating of the busway (line-to-line);

A and B are the sine and cosine multiplying factors from Table 26;

I_{R1} is the rated single-phase short circuit current in symmetrical amperes at voltage V_1;

R_1 is the alternating current resistance of the buses in ohms per unit length for the single-phase connection; and

X_1 is the reactance of the buses in ohms per unit length for the single-phase connection.

and:

Maximum required peak instantaneous amperes = $M_A\,I_{T1}$

where:

M_A is the ratio from Table 23 of maximum single-phase instantaneous peak amperes during the first cycle after short circuit occurs to symmetrical rms amperes based on the value of:

$$\frac{X_{T1}}{R_{T1}} = \frac{BV_1 + 29\sqrt{3}\,X_1\,I_{R1}}{AV_1 + 29\sqrt{3}\,R_1\,I_{R1}}$$

where:

X_{T1} is the total reactance of the test current source and the busway when tested on a source of rated voltage; and

R_{T1} is the total alternating current resistance of the test current source and the busway when tested on a source of rated voltage.

Table 26
Sine and cosine factors

Rated symmetrical short-circuit current, A		Multiplying factors	
More than	No more than	A	B
0	10 000	0.500	0.866
10 000	20 000	0.300	0.954
20 000	200 000	0.200	0.980

8.2.3.3 Enclosure joint short-time fault current test

8.2.3.3.1 For a busway, busway fitting, or a plug-in or bolt-on unit that is not required to be subjected to the tests described in Clauses 8.2.3.1 or 8.2.3.2, the joint between busway sections or between a section and a fitting or a plug-in or bolt-on unit shall carry the required current for the time specified in Table 27, unless:

a) The busway, busway fitting, or a plug-in or bolt-on unit has a ground bus located within the enclosure that complies with Table 13 or Table 14 without including the cross-sectional area of the enclosure or

b) The ground bus and enclosure are subjected to a short-circuit test as specified in Clause 8.2.3.1.3.12.

Table 27
Short-time fault current levels

Maximum rating of busway or fitting, A[a]	Equivalent copper ground bus size,[b] AWG	(mm^2)	Time, sec.	Current, A	Equivalent copper ground bus size,[c] AWG	(mm^2)	Time, sec.	Current, A
60	8	8.4	4	1 180	10	5.3	4	750
90	8	8.4	4	1 180	8	8.4	4	1 180
100	6	13.3	6	1 530	8	8.4	4	1 180
150	6	13.3	6	1 530	6	13.3	6	1 530
200	4	21.2	6	2 450	6	13.3	6	1 530
300	2	33.6	6	3 900	4	21.2	6	2 450
400	1/0	53.5	9	5 050	3	26.7	6	3 100
500	1/0	53.5	9	5 050	2	33.6	6	3 900
600	2/0	67.4	9	6 400	1	42.4	6	4 900
800	2/0	67.4	9	6 400	2/0	67.4	9	5 050
1 000 or more	3/0	85.0	9	8 030	2/0	67.4	9	6 400

[a] For a joint between sections or fittings of different current ratings, the value of the lower rated unit shall be used.

[b] As specified in Table 14.

[c] As specified in Table 13.

8.2.3.3.2 After the test, continuity shall exist between enclosure sections, and between an enclosure section and a fitting.

8.2.3.3.3 Any indicating device such as an ohmmeter, battery and buzzer combination, or the like, may be used to determine if continuity exists.

8.2.4 Verification of electrical conductivity

8.2.4.1 Trolley busway

8.2.4.1.1 The resistance of a trolley busway measured between the metal of the busway enclosure and the metal of the trolley enclosure shall be no more than 0.06 ohm. The resistance shall be determined following the verification of trolley and trolley busway endurance.

8.2.4.2 Test arrangement

8.2.4.2.1 The trolley shall be attached to the busway in the intended manner and a direct current of 30 A shall be passed from the metal of the busway enclosure (at a point directly above a joint and directly above the trolley that is to be located at the joint) to the metal of the trolley enclosure. The voltage drop shall be measured between the points mentioned, and the resistance shall be computed therefrom.

8.2.4.3 Maximum resistance

8.2.4.3.1 Between plug-in device and busway

8.2.4.3.1.1 If the method of attaching a plug-in device to a busway does not result in positive metal-to-metal contact between the two enclosures, the resistance between the enclosures shall be no more than 0.06 ohm.

8.2.4.3.2 Between exposed metal and busway

8.2.4.3.2.1 If the method of attaching a cover or other exposed metal part of a busway or fitting required to be grounded in accordance with Clause 7.4.2 does not result in positive metal-to-metal contact, the resistance between the exposed metal part and the busway enclosure shall be no more than 0.06 ohm.

8.2.4.3.3 Between adjacent busway sections

8.2.4.3.3.1 Other than as covered in Clauses 8.2.4.1.1 – 8.2.4.3.2.1, the resistance between two adjacent busway sections shall be no more than 0.005 ohm.

8.2.4.3.4 Test arrangement

8.2.4.3.4.1 A direct current of 30 A shall be passed from the exposed metal part to the busway enclosure. The voltage drop shall be measured between the two parts, and the resistance shall be computed.

8.2.5 Verification of mechanical operation

8.2.5.1 Verification of trolley and trolley busway endurance

8.2.5.1.1 A trolley shall be operated manually or by means of a machine for 10 000 cycles of reciprocating travel across a joint between two sections of busway with the trolley carrying its rated current at rated voltage. The power factor of the load shall be 0.75 – 0.80 if the trolley busway is intended for use on alternating current. There shall be no electrical or mechanical failure of the device and no undue pitting, burning, or welding of the contacts.

8.2.5.1.2 The distance traveled and the velocity of the trolley assembly shall be determined by the conditions of service for which the busway is designed. If the trolley assembly is intended to carry a tool or

other mechanical load, a weight representing the intended load shall be suspended from the trolley assembly during the test.

8.2.5.2 Verification of strain relief strength

8.2.5.2.1 The strain-relief means provided on the flexible cord or bus drop cable, as covered in Clauses 7.8.3.18 – 7.8.3.20, shall withstand for 1 minute, without displacement, a direct pull applied to the cord, with the internal connections disconnected. At the point of disconnection of the conductors, there shall not be such movement of the cord to indicate that stress on the connections would have resulted.

8.2.5.2.2 A 15.8-kg (35-lb) weight shall be suspended on a cord incorporating 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) conductors, a 22.7-kg (50-lb) weight for a cord having 12 AWG (3.3 mm^2) or 14 AWG (2.1 mm^2) conductors, and a 45.4-kg (100-lb) weight for a cord having conductors 10 AWG (5.3 mm^2) or larger.

8.2.6 Verification of insulation resistance and dielectric withstand after exposure to rain

8.2.6.1 General

8.2.6.1.1 The construction of an outdoor busway shall be such that water is prevented from entering any opening in the bottom of the busway intended for the connection of equipment containing overcurrent protection. With regard to Clause 7.1.1.10, water inside a busway shall be prevented from passing beyond a moisture seal.

8.2.6.1.2 To determine if an outdoor busway or fitting complies with outdoor use requirements, the complete assembly shall be placed in each position as indicated by a marking, that the busway may be used in actual service. The performance shall be determined after the sample is exposed to the simulated rain applied to the joint between adjacent busway sections, between a busway and fitting, and to other equipment intended to be connected to the busway.

8.2.6.1.3 A dielectric voltage-withstand test shall be conducted and the insulation-resistance measurement shall be made on each of the 5 successive test days. The water spray shall be discontinued while the insulation-resistance measurement is being made. The insulation resistance test equipment shall be capable of measuring resistances in the range of 1 – 1 000 megohms with an accuracy of 10 percent or greater.

8.2.6.2 Exposure to rain simulation

8.2.6.2.1 The water spray shall be applied to the top and side of the assembly.

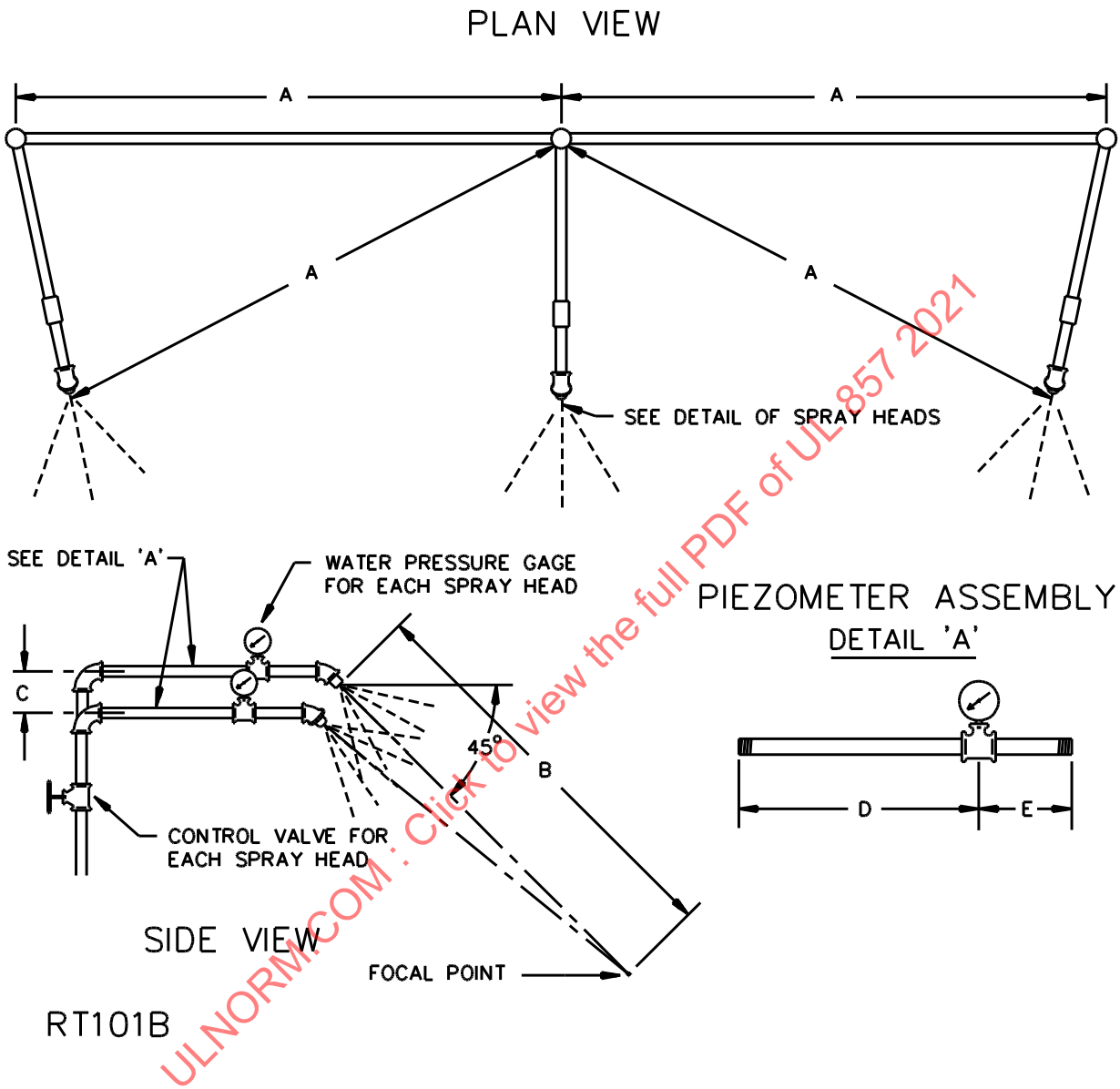
8.2.6.2.2 The sample shall be placed such that the top of the section under test is located 991 mm (39 in) below the level of the center spray head. Additionally, the test sample shall be located in such a position that the center point of the outermost part of the side being subjected to the spray is located within 610 mm – 1 220 mm (24 in – 48 in) in front of, and within 457 mm (18 in) to each side of the center spray head. Any joint, opening, or other discontinuity in the enclosure of a section or fitting marked for outdoor use shall be tested by connecting such a unit and length of busway sufficient to extend the assembly beyond the test exposure area.

8.2.6.2.3 The rain test apparatus shall consist of three spray heads mounted in a water supply pipe rack as shown in Figure 5.

8.2.6.2.4 Spray heads shall be constructed in accordance with the details as shown in Figure 6.

Figure 5

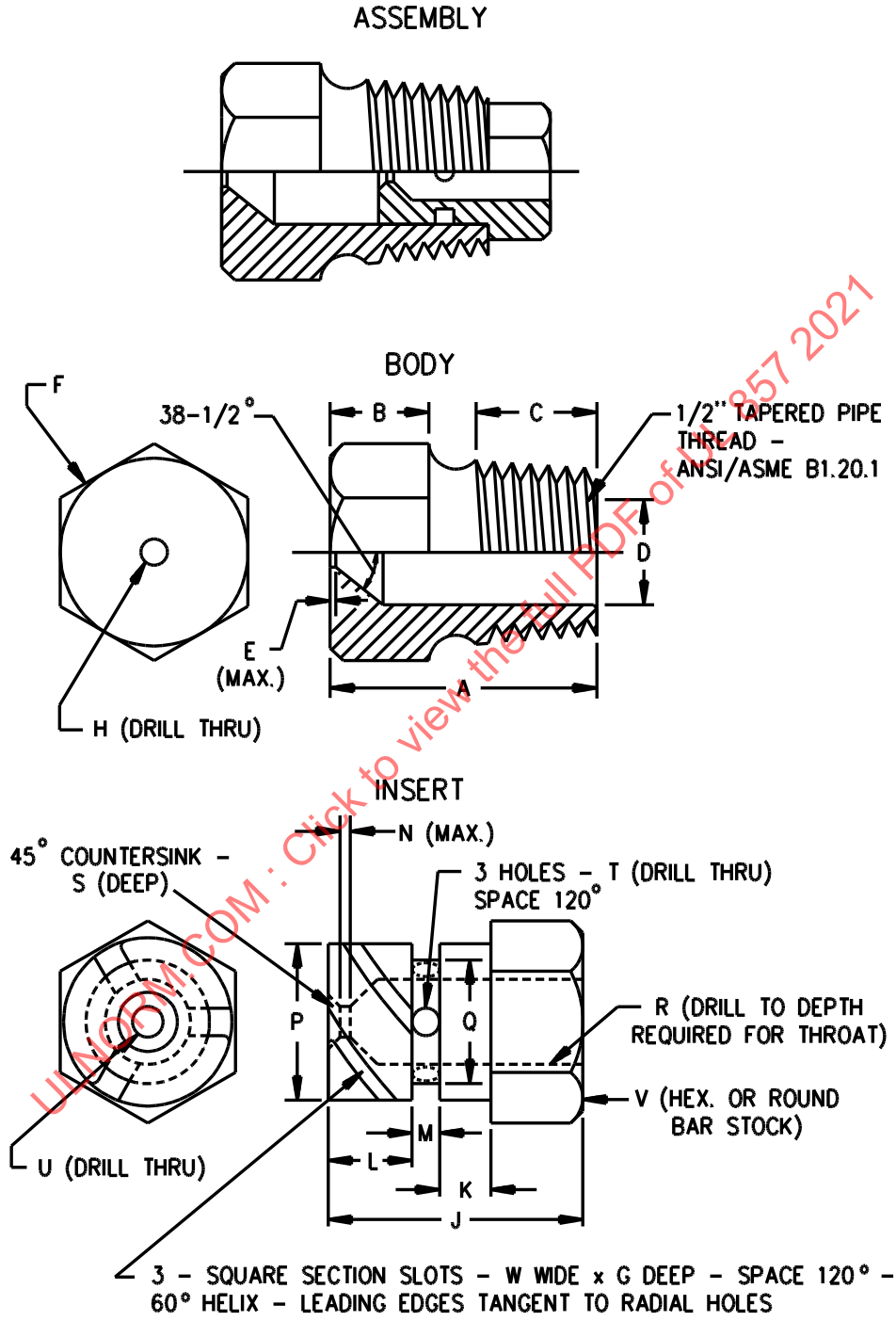
Spray head piping



Item	inch	(mm)
A	28	710
B	55	1 400
C	2 1/4	55
D	9	230
E	3	75

Figure 6

Spray head



Item	inch	(mm)	Item	inch	(mm)
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51

Item	inch	(mm)	Item	inch	(mm)
	.580	14.73		.454	11.53
E	1/64	0.0	R	1/4	6.35
F	a	a	S	1/32	0.80
G	.06	1.52	T	.110	2.79
H	.196	4.98	U	.098	2.49
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Optional – To serve as a wrench grip.

8.2.6.2.5 The water pressure for all tests shall be maintained at 34 474 Pa (5 psi) in each spray head.

8.2.6.2.6 The water spray shall be applied to the area of test for 8 hours per day for 5 successive days.

8.2.6.3 Results to be obtained

8.2.6.3.1 An outdoor busway and any fitting or section of a busway intended to prevent the passage of water between sections shall have an insulation resistance between each bus bar (whether these are single or multiple bus bars per phase) and the enclosure of no less than 1 megohm per 3.05 m (10 ft) length after being subjected to a simulated rain. The construction shall be such that the insulation resistance will not be reduced below 1 megohm per 3.05 m (10 ft) of length by condensation of moisture or by water entering the enclosure, as determined by an insulation resistance test conducted at the end of each test day of exposure.

8.2.6.3.2 Preceding each resistance measurement, each bus bar shall withstand for 1 minute without breakdown the application of 1 000 V plus twice rated voltage between adjacent bus bars and between the bars and ground.

8.2.7 Verification of structural strength

8.2.7.1 Verification of bending resistance

8.2.7.1.1 General

8.2.7.1.1.1 A bending test is not required for horizontal busway intended for a spacing of no more than 1.52 m (5 ft) between mounting supports, or a vertical busway intended for a spacing of no more than 3.05 m (10 ft) between mounting supports, that is constructed of sheet steel or sheet aluminum in accordance with Clause 7.1.1.51 and Table 5.

A busway rated greater than 100 A shall withstand for 5 minutes without:

a) Rupture of the joint;

b) Permanent distortion; or

c) Short-circuiting or grounding of the bus bars,

a bending moment of:

$$\frac{DW}{2} + 100 \quad D \quad in \quad N \cdot m \ (lb\text{-}ft)$$

where:

D is the intended spacing in integral values of meters (feet) between mounting supports, or for vertical busway marked for support spacings greater than 3.05 m (10 ft) and up to 4.88 m (16 ft), D is 3.05 m (10 ft) and

W is the weight in N (pounds) of a 3.05 m (10 ft) section of the busway.

8.2.7.1.2 Test arrangement

8.2.7.1.2.1 The bending moment may be applied in any convenient manner. The examples in Figure 7 indicate several ways this can be accomplished. The force shall be applied to the duct through members

126 mm – 152 mm (5 in – 6 in) wide extending across the full width of the busway. While the force is applied, a buzzer or equivalent shall be used to detect short-circuiting or grounding of the bus bars.