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IEEE Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities

IEEE Industry Applications Society

Sponsored by the
Marine Industry Standards Committee

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USA

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Marine Industry Standards Committee
of the
IEEE Industry Applications Society

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Abstract: Requirements are given for single or multiconductor cables, with or without metal armor and/or jacket, and rated 300 V to 35 kV, intended to be installed aboard marine vessels, fixed and floating offshore facilities, and in accordance with industry installation standards and the regulations of the authorities having jurisdiction (AHJ).

Keywords: marine cable, offshore facilities, platforms, shipboard

The Institute of Electrical and Electronics Engineers, Inc.
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Mohammed Ahmed
Richard Barker
Walter Constantine
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Michael Hammons
Wayne Madden
Dieter Popoff
H. R. Stewart
Austin Wetherell
John Zachrison

The following members of the individual balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

John R. Barker
Charles Barlow
Ettore Bartolucci
Tirlochan S. Bhat
Rudy Bright
Michael Brown
John Cancelosi
Weijen Chen
Keith Chow
Walter Constantine
Thomas Cybula
Tony Davenport
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Randall Groves
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IEEE Standards Program Manager, Technical Program Development

Contents

IEEE Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities

1. Overview

1.1 Scope

This recommended practice contains the requirements for single or multiconductor cables, with or without metal armor and/or jacket, and rated 300 V to 35 kV (RMS phase-to-phase), intended to be installed aboard marine vessels, fixed and floating offshore facilities, and in accordance with industry installation standards and the regulations of the authorities having jurisdiction (AHJ).

The recommendations define what is considered good engineering practice with reference to the reliability and durability of the cable.

1.2 Purpose

This revision will incorporate the latest developments in marine cable materials and performance enhancements.

1.3 Vessel classification

Marine vessels and offshore facilities are grouped as follows:

— *Group 1:* Ocean-going vessels that navigate on any ocean, gulf, bay, sound, lake, or river.

— *Group 2:* Fixed and floating offshore facilities on any ocean, gulf, bay, sound, lake, or river.

These recommendations have been prepared for application to all vessels in groups 1 and 2. Recreational vessels are governed by other standards.

1.4 Cable construction, testing, and certification

Electrical cable should be constructed and tested in accordance with this recommended practice and referenced industry standards. The cable should be listed or classified by a nationally recognized testing laboratory (NRTL) in accordance with this recommended practice.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

API RP 2A-WSD, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design.[1]

API RP 14F, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations.

API RP 14FZ, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Zone 0, Zone 1 and Zone 2 Locations.

ASTM B3, Standard Specification for Soft or Annealed Copper Wire.[2]

ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

ASTM B33, Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

ASTM B172, Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.

[1]API publications are available from the Publications Section, American Petroleum Institute, 1200 L Street NW, Washington, DC 20005, USA (http://www.api.org/).

[2]ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).

ASTM B173, Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors.

ASTM B174, Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors.

ASTM B496, Standard Specification for Compact Round Concentric Lay Stranded Copper Conductor.

ASTM D470, Standard Methods of Testing Crosslinked Insulations and Jackets for Wire and Cable.

ASTM D4066 Type VIII, Standard Classification System for Nylon Injection and Extrusion Materials (PA).

CSA C22.2 No. 0.3, Test Methods for Electrical Wires and Cables.[3]

ICEA P-45-482, Short Circuit Performance of Metallic Shields and Sheaths on Insulated Cables.[4]

ICEA T-28-562, Test Method for Measurement of Hot Creep of Polymeric Insulations.

IEC 60068-2-6, Environmental testing.[4]

IEC 60228, Conductors of insulated cables.

IEC 60331-11, Tests for electric cables under fire conditions—Circuit Integrity.

IEC 60331-21, Tests for electric cables under fire conditions—Circuit Integrity-Cables of rated voltage up to and including 0.6/1.0 kV.

IEC 60331-23, Tests for electric cables under fire conditions—Circuit Integrity-Electric data cable.

IEC 60331-25, Tests for electric cables under fire conditions—Circuit Integrity-Optical fibre cable.

IEEE Std 45™, IEEE Recommended Practice for Electric Installations on Shipboard.[5, 6]

IEEE Std 1202™, IEEE Standard for Flame Propagation Testing of Wire and Cable.

MIL-STD-167-1 (ships), Mechanical Vibrations of Shipboard Equipment.[7]

NEMA WC 54/ICEA T-26-465, Guide for Frequency of Sampling Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test.[8]

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[3]CSA publications are available from the Canadian Standards Association (Standards Sales), 178 Rexdale Blvd., Etobicoke, Ontario, Canada M9W 1R3 (http://www.csa.ca/).

[4]IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

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[7] MIL publications are available from Customer Service, Defense Printing Service, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.

[8]NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com/).

NEMA WC 57/ICEA S-73-532, Standard for Control, Thermocouple Extension, and Instrumentation Cables.

NEMA WC 70/ICEA S-95-658, Standard for Nonshielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.

NEMA WC 71/ICEA S-96-659 Standards for Nonshielded Cable Rated 2001-5000V for use in the Distribution of Electrical Energy.

NEMA WC 74/ICEA S-93-639, 5-46 kV Shielded Power Cable For Use in the Transmission and Distribution of Electrical Energy.

UL 44, Thermoset-Insulated Wires and Cables.[9]

UL 1072, Medium-Voltage Power Cables.

UL 1569, Metal-Clad Cables.

UL 1581, Reference Standard for Electrical Wires, Cables, and Flexible Cords.

UL 1685, Standard Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

UL 2196, Tests for Fire Resistive Cables.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.[10]

3.1.1 alternating current (ac): A periodic current with an average value over a period of time of zero. (The term refers to a current that reverses at regularly recurring intervals of time and that has alternately positive and negative values.)

3.1.2 ampacity: The current that a device can carry within specified temperature limitations in a specified environment.

3.1.3 approved: Acceptable to the authority having jurisdiction (AHJ). Electrical devices, which carry NRTL approval, are normally acceptable.

[9] UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com/).
[10] *The IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at http://shop.ieee.org/.

3.1.4 bending radius: The minimum inside radius at which a cable can be bent without causing damage to the cable.

3.1.5 capacitance (capacity): That property of a system of conductors and dielectrics that permits the storage of electricity when potential differences exist between the conductors. Its value is expressed as the ratio of a quantity of electricity to a potential difference. A capacitance value is always positive.

3.1.6 continuous duty: A requirement of service that demands operation at a constant load for an indefinite period of time.

3.1.7 continuously welded and corrugated metal-clad cable (CWCMC): *See:* **MC cable.**

3.1.8 copper-free or low copper content aluminum: Aluminum alloys containing 0.4% or less copper.

3.1.9 current: The rate of transfer of electricity.

3.1.10 cycle: The complete series of values of a periodic quantity that occurs during a period. (It is one complete set of positive and negative values of an alternating current.)

3.1.11 derating: Lowering of the cable ampacity.

3.1.12 direct current (dc): A unidirectional current in which the changes in polarity are zero or so small that they may be neglected. (As ordinarily used, the term designates a nonpulsating current.)

3.1.13 discharge resistant cable: Cable that has been deemed to be highly resistant to corona discharge in accordance with the requirements of NEMA WC 74, subclauses 3.3.2 and 9.16, for discharge resistant cables.

3.1.14 festooned cable: Flexible cable that is installed in hanging loops to facilitate movement as on a trolley system used to move cargo or equipment as part of a crane or hoisting device.

3.1.15 frequency: The number of periods occurring in unit time of a periodic quantity, in which time is the independent variable.

3.1.16 halogen-free: A material with a halogen content of less than 0.2% by weight.

3.1.17 hertz (Hz): The unit of frequency, one cycle per second.

3.1.18 incidental motion: Repeated flexing as listed in Title 46 CFR Subchapter J, clause 111.60-23, and defined in MC cable with the test in 5.17.14 of IEEE Std 977-2010.

3.1.19 jacket/sheath: a nonmetallic protective covering over the cable core is considered a jacket. When it is applied over the armor, it is considered a sheath.

3.1.20 marine cable: *See:* **shipboard cable, marine.**

3.1.21 metal-clad (MC) cable: Continuously welded and corrugated metal-clad cable as defined by UL 1569.

The following definitions apply to the use of continuously welded and corrugated metal (CWCMC) armored cables:

3.1.21.1 flexing, repeated: Items that exceed the average wave motion of one wave every 13 s (4.6 waves per minute) as defined in API RP 2A-WSD for platforms, or for ships the average revolutions of a ship propeller times the number of blades on the propeller.

NOTE—The repeated flexing test in 5.17.14 reflects the actual type of incidental motion that the cable would be subjected to when installed aboard ship with the cable securely fastened at intervals not exceeding 2 m or installed in a raceway.[11]

3.1.21.2 movement, excessive: Any motion at less than the bending radius of the cable.

3.1.21.3 twisting: Flexing and bending at less than the bending radius of the cable.

3.1.21.4 vibration, high: Items that exceed the vibration limitations shown in Table 1.

Table 1—Vibration limitations

Frequency range (Hz)	Amplitude, mm (in)
4–15	0.763 ± 0.152 (0.030±0.006)
16–25	0.508 ± 0.102 (0.020±0.004)
26–33	0.254 ± 0.051 (0.010±0.002)
34–40	0.128 ± 0.025 (0.005±0.001)
40–50	0.076 + 0.000 – 0.025(0.003+0.000-0.001)

3.1.22 medium voltage (MV) cable: Medium voltage cable rated 2.4 kV to 35 kV as defined by UL 1072.

3.1.23 oil-resistant: Ability to withstand exposure to oil.

NOTE—As defined in 5.17.8.

3.1.24 shipboard cable, marine: Armored or unarmored cable constructed in accordance with this recommended practice, and listed or classified by a nationally recognized testing laboratory (NRTL).

3.1.25 sunlight-resistant: Ability to withstand exposure to direct sunlight as defined by UL 1581 Section 1200 using a 720 h exposure.

3.2 Acronyms and abbreviations

ABS American Bureau of Shipping

AHJ authority having jurisdiction

API American Petroleum Institute

AWG American Wire Gauge

CDA Copper Development Association

[11] Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

CFR	Code of Federal Regulations
CSA	Canadian Standards Association
CWCMC	continuously welded and corrugated metal clad
ETL	Intertek Testing Services
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
NEMA	National Electrical Manufacturer Association
NRTL	nationally recognized testing laboratory (as recognized by OSHA)
OSHA	Occupational Safety and Health Administration
UL	Underwriters Laboratories Inc.
USCG	United States Coast Guard
VFD	variable frequency drive

4. Government codes, rules, and regulations

Federal regulatory agencies have established certain requirements for the design, installation, and operation of facilities in marine applications. These requirements may influence the design, installation, and operation of the electrical systems. The following codes may pertain to offshore oil and gas producing operations and should be used when applicable:

a) CFR Title 30, Part 250, Oil and Gas and Sulfur Operation in the Outer Continental Shelf (U.S. Department of the Interior, Minerals Management Service).

b) CFR Title 33, Subchapter N, Outer Continental Shelf Activities, Parts 140–147 (USCG).

c) CFR Title 46, Shipping Subchapter I-A, Parts 107-108, Mobile Offshore Drilling Units (USCG).

d) CFR Title 46, Shipping Subchapter J. Electrical Engineering, Parts 110–113 (USCG).

5. Cable construction

5.1 Conductors

5.1.1 General

The conductors should be of soft annealed copper wire. All conductors should be tin-coated where necessary for the application. Solid conductors shall not be used.

5.1.2 Composition

Conductors should be manufactured in accordance with the most current edition of following: ASTM B3, B8, B33, B172, B173, B174, B496, B784, B787, or in accordance with IEC 60228 Class 2 or Class 5.

CAUTION

Care should be taken when mixing IEC and ASTM conductors due to the inherent differences in conductor resistance values.

Verification of conductor size shall be determined by the maximum DC resistance value given in Table 10 or Table 11. The nominal cross sectional area of a conductor is also shown in these tables for reference purposes only and is not a requirement.

5.1.3 Stranding

The construction requirements and nominal resistance of standard Class B concentric conductors shall be in accordance with Table 10. Compact stranded conductors may not be used in cables rated 0–2000 V in areas that are subject to vibration or flexing.

Combination stranded, compressed stranded to a reduction in diameter of 3% maximum of concentric stranded conductors, flexible stranded conductors, or conductors as described in Table 11 may be substituted for Class B concentric stranded conductors.

5.1.4 Separator

Where required to ensure free stripping, a suitable separator tape may be applied to the conductor.

The separator shall be colored or shall be opaque to make the separator clearly distinguishable from the conductor once the insulation is removed. The color shall be other than copper, silver, green, or green and yellow and shall be solid, striped, or in some other pattern.

5.2 Conductor shield

A conductor shield should be used on conductors of cables rated 2001 V or higher.

The conductor shield should be an extruded semiconducting compound to a minimum thickness of 0.305 mm (0.012 in). The semiconducting compound should have an operating temperature equal to or greater than that of the overlying layer of insulation. It should be firmly bonded to the overlying layer of insulation with no protrusions into the insulation exceeding 0.254 mm (0.010 in). A semiconducting nonmetallic tape with a minimum thickness of 0.0635 mm (0.0025 in) may be used over the conductor and under the extruded semiconducting layer.

The extruded conductor shield should have a maximum volume resistivity of 100 000 Ω·cm (39 370 Ω·in) at room temperature and at the maximum normal operating temperature of the cable. The extruded

conductor shield should meet the following requirements when tested according to procedure in UL 1072 or NEMA WC 74.

a) Elongation after air oven at 121 ± 1 °C (249 ± 2°F) for 168 h, minimum 100%
b) Brittleness temperature, not warmer than –10 °C (14°F)

For discharge resistant cables the conductor shield shall consist of a nonconducting high permittivity extruded compound as designated in NEMA WC 74, subclauses 3.3.2 and 9.16.

5.3 Insulation

5.3.1 General

The insulation should be one of the types shown in Table 2. For 5000 V and above, Type E(EP) or Type X(XL) rated at 105 °C (221°F) meeting UL 1072 may be used.

Table 2—Insulation types

Insulation-type designation			Max conductor temperature °C (°F)
T	PVC	Polyvinylchloride	75 (167)
T/N	PVC/polyamide	Polyvinylchloride/nylon	90 (194)
E	EPR	Ethylene propylene rubber	90 (194)
X	XLPE	Cross-linked polyethylene	90 (194)
LSE	LSEPR	Low-smoke, halogen-free ethylene propylene rubber	90 (194)
LSX	LSXLPO	Low-smoke, halogen-free cross-linked polyolefin	90 (194)
LSS[a]	LS-Silicone	Low-smoke, halogen-free silicone rubber	100 (212)
S[a]	Silicone	Silicone rubber	100 (212)
P	XLPO	Cross-linked polyolefin	100 (212)

[a]Where specifically listed by an NRTL, Composite Insulation consisting of silicone rubber with a crosslinked polyolefin outer covering in accordance with Table 15 of UL-44 is acceptable.

5.3.2 Properties

The physical and electrical properties of Type(s) T, T/N, E, X, LSE, LSX, LSS, S, and P insulation materials should meet the requirements of Table 12, Table 13, or Table 14. The material of the nylon jacket for Type T/N should additionally meet the requirements of ASTM-D4066 Type VIII. The manufacturer should perform type tests and periodic testing to ensure insulation materials meet these requirements.

5.3.3 Thickness of insulation

The insulation thicknesses of 300–2000 V rated cables shall be in accordance with Table 15 with the minimum thickness at any point being not less than 90% of the minimum average.

Insulation thicknesses of 2001–35000 V rated cables shall be in accordance with UL 1072 or NEMA WC74. For non-shielded 2.4 kV cables, the insulation and jacket thicknesses shall be in accordance with those for wet location use. When the fault clearing time exceeds one hour, a 173% insulation level thickness shall be used.

5.4 Insulation shield (5–35 kV shielded cable)

Shielded cable rated 5–35 kV shall contain an insulation shield in accordance with UL 1072.

The insulation shield compound should be free stripping from the underlying insulation. Minimum adhesion requirements, per UL 1072, shall be maintained.

Cables described in 5.18.4, 5.18.6, 5.18.8, and 5.18.9 shall have nonmagnetic metallic shielding.

5.4.1 Rating of metallic shield

When specified by the user, the metallic shield, or combination of metallic shield and grounding conductors (optional), shall have sufficient cross-sectional area to carry the ground fault current for the time duration specified. The ICEA P-45-482 method shall be used for calculating the cross-sectional area.

5.5 Tapes

Where binder or separator tapes are provided, a polyester film tape or compound-filled tape should be used. Where a compound-filled tape is used, the tape should be made from fabric treated on one or both sides with an insulating compound.

5.6 Glass braid

Silicone rubber insulated conductors should be covered with a glass braid with a minimum of 80% coverage. The glass braid, if used, shall be treated with a suitable antifraying coating. The glass braid is optional for silicone insulated cables that meet the IEC 60331 or UL-2196 circuit integrity flame test.

5.7 Conductor identification

Conductor identification of distribution and control cables should be printed with alphanumeric characters on solid colored insulation. Example: “1-ONE,” “2-TWO,” etc. or “1-BLACK,” “2-WHITE,” etc., per color code in Table 22 or Table 23. The legend shall be repeated at intervals not exceeding 8 cm (3 in). The characters shall be clear and legible. Colored insulation may be used as an alternate.

An insulated conductor functioning as a grounding conductor (normally not a current carrying conductor) in a distribution system shall be colored green or green with yellow stripe.

Conductor identification of signal cable is as follows:

a) Pairs should contain one black insulated conductor and one white (or red) insulated conductor. The pair number should be identified on the pair. Pair numbering should be sequential.
b) Triads should contain one black insulated conductor, one white insulated conductor, and one red insulated conductor. The triad number should be identified on the triad. Triad numbering should be sequential.
c) Quads should contain one black insulated conductor, one white insulated conductor, one red insulated conductor, and one green (or blue) insulated conductor. The quad number should be identified on the quad. Quad numbering should be sequential.

5.8 Equipment grounding conductor (optional)

5.8.1 Equipment grounding conductors

Cables are manufactured with or without a bare or insulated equipment grounding (or bonding) conductor. When an insulated equipment grounding (or bonding) conductor is provided, the color of the insulation shall be green or green with yellow stripes. The insulation shall be of the same material and, for cables rated 2 kV or less, have the same voltage rating as the circuit conductors. The minimum size of the grounding conductor shall be in accordance with Table 3. The grounding conductor (bare or insulated) may be a single conductor or segmented (see 5.8.2 for size limitations).

5.8.2 Segmentation

A grounding conductor smaller than 14 AWG shall not be segmented. A segmented grounding conductor shall not have any part (segment) smaller than 18 AWG. A copper grounding conductor shall not be distributed helically (concentric).

5.8.3 Grounding conductors for cables rated 2001 V and higher

Grounding conductors for cables rated 2001 V and higher shall be in accordance with UL 1072.

5.8.4 Cables installed in parallel

When cables are installed in parallel, the grounding conductor sizes given in this subclause may not be adequate.

Table 3—Grounding conductor sizes (for cables rated 2 kV or less)

	Minimum grounding conductor size, AWG		
AWG or kcmil size of circuit conductors	**75ºC (167ºF) rated conductors**	**90ºC (194ºF) rated conductors**	**100ºC (212ºF) rated conductors**
20	20	20	20
18	18	18	18
16	16	16	16
14	14	14	14
12	12	12	12
10	10	10	10
8	10	10	8
6	8	8	8
5	8	8	6
4	8	6	6
3	6	6	6
2	6	6	6
1	6	6	6
1/0	6	6	6
2/0	6	4	4
3/0	4	4	4
4/0	4	4	3
250	4	3	3
263	4	3	3
313	3	3	3
350	3	3	2
373	3	2	2
444	3	2	1
500	2	2	1
535	2	2	1
646	2	1	1/0
750	1	1/0	1/0
777	1	1/0	1/0

5.9 Cabling

Conductors, pairs, triads, quads, or groups of conductors should be cabled in concentric layers. Lay lengths should be in accordance with Table 4.

Table 4—Cable or unit lay

No. of conductors or units	Maximum lay length
2 conductors or units	30 × individual conductor or unit diameter
3 conductors or units	35 × individual conductor or unit diameter
4 conductors or units	40 × individual conductor or unit diameter
5 or more conductors or units	15 × calculated overall diameter of the outer layer

5.10 Fillers

Fillers should be non-hygroscopic and compatible with other cable components. Fillers may be used, as necessary, to give the completed cable a substantially circular cross section.

Fillers used in low-smoke, halogen-free cables shall comply with the halogen content requirements for Type LSE, LSX, and LSS insulations per Table 13.

5.11 Specialty cables

Special cables for specific applications shall be in accordance with 24.6 of IEEE Std 45-2002. Cables covered in Clause 5 may include optical fiber members or other specialty cables to form a composite cable. Composite cables must pass the IEEE 1202 flame test.

5.12 Shielding

When required, instrumentation and signal cables shall contain shielded components, which may consist of shielding over single conductors, pairs, triads, groups, and/or the completed cable core.

5.12.1 Individually shielded components and overall shielding

5.12.1.1 Shield types and drains

The shielding should consist of either aluminum/polyester or copper/polyester tape applied helically with a minimum overlap of 25% with a drain wire or a bare or tin coated copper braid. Where an aluminum/polyester tape shield is used, a tin coated copper, stranded drain wire should be applied in contact with the aluminum side.

The size of the drain wire should be no less than two sizes smaller than the circuit conductor size. The smallest acceptable drain wire size shall be a 22 AWG or 0.32 mm^2.

Where a braided tin coated or bare copper shield is used, it should be constructed using a minimum of 36 AWG wire. The minimum coverage should be 85%.

Individually shielded components shall be isolated from each other. The measured shield-to-shield insulation resistance shall not be less than 0.305 megohm-km (1.0 megohm-1000 ft) after a one minute application of 500 VDC.

5.12.1.2 Shield identification

Cables with individual and overall shielding should be identified as such in accordance with 5.19.

5.13 Cable jackets

5.13.1 General

The jacket should be thermoplastic Type T (PVC) or TPO (TPPO), Thermoset Type CP (CSPE), CPE, N (PCP), P (XLPO) or L (XLPO) complying with the requirements of Table 14, Table 16, or Table 17. The manufacturer should perform type tests and periodic testing to insure jacket materials meet these requirements. The temperature rating of a jacket may be less than that of the insulation with the difference in temperature ratings not exceeding 15 °C (27 °F).

5.13.2 Thickness of overall jacket

The minimum average thickness of the cable jacket is shown in Table 18. The minimum thickness at any point should not be less than 80% of the minimum average values shown. For cables armored with CWCMC, the outer sheath thicknesses should be in accordance with UL 1569.

5.14 Armor

5.14.1 General

Armor should be basket-weave type braid or continuously welded and corrugated metal. The armor is not to be used as a shield or grounding conductor but must be grounded.

5.14.2 Basket-weave armor

The armor should consist of wire laid closely together, flat and parallel, and forming a basket weave that should firmly grip the cable. The wire should be 0.32 mm diameter ± 0.01 mm (0.0126 in diameter ± 0.0004 in), and should be free from cracks, splits, or other flaws. The wire should be commercial bronze, aluminum, stainless steel, or tinned copper. The weave should be either the one-over-one under or the two-over-two under type. The selection of the number of ends per carrier and the number of carriers per braider should be such as to produce a basket weave with a braid angle and coverage within the limits shown in Table 5.

Table 5—Braid angle and coverage

Diameter over jacket (mm)	Diameter over jacket (in)	Percent coverage		Braid angle	
		Min	Max	Min	Max
0–15.24	0–0.600	88	94	30	60
15.25–25.4	0.601–1.000	88	94	35	60
25.41–38.1	1.001–1.500	88	94	40	70
38.11–50.8	1.501–2.000	88	94	45	70
50.81 and larger	2.001 and larger	88	94	50	80

The percent coverage = $(2F - F^2)$ 100 and

$$F = \frac{NPd}{\sin a}$$

where

a = angle of braid with axis of cable:

$$\tan a = \frac{2 \pi DP}{C}$$

d = diameter of individual braid wire (mm)
C = number of carriers
D = diameter of cable under armor (mm)
N = number of wires per carrier
P = picks per mm of cable length

5.14.2.1 Aluminum armor

Aluminum armor braid should be aluminum alloy 5154 or an equivalent alloy having a minimum tensile strength of 350 N/mm^2 (50000 lbf/in^2) and a minimum elongation of 2% in 254 mm (10 in). An overall sheath is required on cables with an aluminum braid armor when installed in wet environments.

5.14.2.2 Commercial bronze armor

Commercial bronze armor braid should be annealed 90-10 bronze; Copper Development Association (CDA) alloy number 220.

5.14.2.3 Tin-coated copper armor

Tin-coated copper armor braid should meet the requirements of ASTM B33. An overall sheath is required on cables with a tin-coated armor.

5.14.2.4 Stainless steel armor

Stainless steel armor braid should be made out of annealed austenitic steel, American Iron and Steel Institute, AISI steel no. 304, 304L or 316, 316L. The suffix "L" denotes a stainless steel grade with a carbon content below 0.03%.

5.14.3 Continuously welded and corrugated metal armor

This armor should be a continuously welded and corrugated metal tube in accordance with the requirements of UL 1569 (Type MC cable). The armor material should be copper free aluminum alloy (containing no more than 0.4% of copper), commercial bronze, copper, or stainless steel. An overall sheath is required on cables with a continuously welded and corrugated metal armor of aluminum or copper.

5.15 Overall sheath

Where an overall sheath is applied, the sheath material should be in accordance with the requirements for cable jackets in 5.13. An optional separator may be used over the armor to ensure strippability.

5.16 Dimension and weight tolerances

The dimensional and weight values given in Table B.1 through Table B.16 are for informational purposes only. As these values vary from manufacturer to manufacturer, a consultation is recommended with individual manufacturers for specific dimensional and weight values.

5.17 Performance tests on finished cable

Finished cable should be tested in accordance with the requirements shown in Table 6.

Table 6—Performance test requirements

Test to be performed	Test categories		
	Type test (TT)[a]	Production sample (PST) [b]	Routine test (RT) [c]
Insulation (Table 12, Table 13, Table 14, and Table 15)	X	X[i]	—
Jacket (Table 16, Table 17, and Table 18)	X	X [d,i]	—
High voltage (5.17.1)	—	X	X
Partial discharge (5.17.2)	—	—	X
Conductor resistance (5.17.3)	—	—	X
Insulation resistance (5.17.4)	—	—	X
Flammability (5.17.5)	X	X [e]	—
Ease of stripping (5.17.6)	—	X	—
Salt water immersion (5.17.7)	X	—	—
Cable immersion in oil (5.17.8)	X	—	—
Pull-through metal plates (5.17.9)	X	—	—
Bending endurance (5.17.10)	X	—	—
Cold bend test (5.17.11)	X	—	—
Cold impact test (5.17.12) (optional)	X [f]	—	—
Vibration (5.17.13)	X [g]	—	—
Incidental motion (repeated flexing) (5.17.14)	X [h]	—	—

Table 6—Performance test requirements

Test to be performed	Test categories		
	Type test (TT)[a]	Production sample (PST) [b]	Routine test (RT) [c]
Insulation discharge resistance test (5.17.15)	X	—	—

[a]Type tests (TT)—Type tests are the minimum initial testing for a manufacturer to determine compliance with this recommended practice. TT should be qualified by a third party NRTL as meeting this recommended practice. Unless otherwise specified, TT should be performed on a 3 conductor 6 AWG cable for power and distribution, 7 conductor 12 or 14 AWG cable for control, and a 7 or 8 pair 18 AWG for signal cables. Any other cables in their respective cable designation for distribution, control, or signal that are 23 mm (0.9 in) in diameter or larger may also be considered representative. This does not relieve the manufacturer from ensuring compliance with the test requirements for all cable types and sizes.

[b]Production sample tests (PST)—Production sample tests should be performed at the frequency established in NEMA WC 54 (ICEA T-26-465). Where no frequency is identified for a particular test in NEMA WC 54 (ICEA T-26-465), the testing frequency should be determined by the NRTL .

[c]Routine tests (RT)—Routine tests should be performed on each length of finished cable.

[d]PST for Sunlight Resistance and mechanical water absorption as related to the jacket/sheath shall be done at a frequency of every three years.

[e]PST for flammability, as related to the insulation/jacket/sheath shall be done at a frequency of every three years.

[f]This test applies to Transport Canada requirements test at –35 °C (–31 °F) cold impact test per subclause 4.13 of CSA 22.2 No. 03.

[g]This test applies to Type MC (CWCMC) for use in areas of high vibration.

[h]This test applies to Type MC (CWCMC) for use in areas of repeated flexing.

[i]PST for smoke, acid gas, and toxicity tests as related to the insulation/jacket/sheath shall be done at a frequency of every three years.

5.17.1 High-voltage test

Each reel of finished cable should be tested and successfully withstand for a period of five minutes the high-voltage ac test potential given in Table 19, as applicable. The ac potential should be applied between conductor (or conductors) and the metallic sheath, metallic shield, metallic armor, or water, as applicable, as described in 5.17.1.1, 5.17.1.2, 5.17.1.3, or 5.17.1.4. The voltage shall be applied in accordance with UL 1581 Section 820.4.

5.17.1.1 Nonshielded or unarmored cable

Each reel of single conductor nonshielded or unarmored cable should be immersed in water for at least 6 h. The ac test potential should be applied between the insulated conductor and the metal water tank or other electrode immersed in the water if the tank is nonmetallic. For single conductor cables, rated 0–2000 V manufactured without shield or armor, the spark test requirement of UL 1581, section 900, with the values of Table 20 may be used in lieu of wet tank testing.

5.17.1.2 Shielded or armored cable

For shielded or armored single conductor cables, the voltage tests should be applied between the conductor and the shield or armor.

5.17.1.3 Cables having 2 to 5 conductors

For cables having from 2 to 5 conductors, with or without metallic armor, the voltage tests should be applied in turn between each conductor and all other conductors connected together and to the metal covering, if any.

5.17.1.4 Cables having more than five conductors

For cables having more than five conductors, the voltage test should be applied as follows:

a) Between all conductors of uneven number in all layers and all conductors of even number in all layers
b) Between all conductors of even layers and all conductors of uneven layers
c) Between the first and last conductors of each layer where there are an uneven number of conductors

5.17.2 Partial discharge test

Shielded cables rated 5 kV and higher shall comply with the partial discharge test requirements as follows. In every length of finished cable, the partial discharge extinction level of each shielded circuit conductor shall not exceed 5 picocoulombs at the AC test voltage given in Table 19. This test is not applicable to discharge resistant cables.

5.17.3 Conductor resistance test

Conductor resistance should be measured on finished cable in accordance with the procedures outlined in UL 1581, section 220, and corrected to 20 °C (68 °F) or 25 °C (77 °F). Maximum resistance values should be in accordance with the appropriate standards referenced in 5.1.2.

5.17.4 Insulation resistance test (see Annex E for metric version)

Each reel of finished multiconductor cable should have the insulation resistance measured between each conductor and all other conductors, including other metallic components if present, tied together.

For shielded single conductor cables, the insulation resistance is measured between the conductor and shield.

For single conductor cables rated 0–2000 V manufactured without shield or armor, the insulation resistance test is not required when spark tested according to the spark test requirement of UL 1581, section 900, with the values of Table 20 in this recommended practice.

5.17.4.1 Method of test

Compliance with the insulation resistance test is determined in accordance with the method described in Clause 4.28.2 of CSA Standard C22.2 No. 03 or UL 1581. The insulation resistance constant K can be obtained from Table 12, Table 13, or Table 14 for the specific insulation under test.

The current should be measured after one minute with a continuous dc potential of not less than 100 V nor more than 500 V, the conductor being negative to ground. If the test for insulation resistance is carried out in water or air having a temperature differing from 60 ºF, the measured value should be multiplied by the proper correction factor, *M*, obtained from Table 21. This factor appears in the formula for insulation resistivity as follows:

$$R = \mathrm{K}M \log10(D/d)$$

where

R = insulation resistivity [**MΩ**·1000 ft]
K = insulation resistance constant (from Table 12, Table 13, or Table 14) (**MΩ**·1000 ft)
M = temperature correction factor to 60 ºF
D = diameter over the insulation
d = diameter under the insulation

The factor *M* should be determined in accordance with the method of 5.17.4.2.

The measured insulation resistivity is related to the measured insulation resistance of the sample under test by the following formula:

$$R = 0.001\ R_{meas}L$$

where

R = insulation resistivity [**MΩ**·1000 ft]
R_{meas} = measured insulation resistance (**MΩ**)
L = length of the test sample (ft)

5.17.4.2 Test procedure for determining the multiplying-factor column for adjusting insulation resistance (see Annex E for metric version)

5.17.4.2.1 Samples

Two samples, conveniently of a No. 14, 12, or 10 AWG solid conductor with a 0.045 in or 45 mil wall of insulation, are to be selected as representative of the insulation under consideration. The samples are to be of a length (at least 200 ft) that yields insulation-resistance values that are stable within the calibrated range of the measuring instrument at the lowest water-bath temperature.

5.17.4.2.2 Water bath temperature

The two samples are to be immersed in a water bath equipped with heating, cooling, and circulating facilities. The ends of the samples are to extend at least 2 ft above the surface of the water to reduce electrical leakage. The samples are to be left in the water at room temperature for 16 h before adjusting the bath temperature to 50.0 °F or before transferring the samples to a 50.0 °F bath.

5.17.4.2.3 DC resistance

The dc resistance of the metal conductor is to be measured at applicable intervals of time until the temperature remains unchanged for at least five minutes. The insulation is then to be considered as being at the temperature of the bath indicated on the bath thermometer.

5.17.4.2.4 Test temperatures

Each of the two samples is to be exposed (5.17.4.2.3 applies) to successive water temperatures of 50.0 °F, 61.0 °F, 72.0 °F, 82.0 °F, and 95.0 °F, and returning 82.0 °F, 72.0 °F, 61.0 °F, and 50.0 °F. Insulation-resistance readings are to be taken at each temperature after equilibrium is established.

5.17.4.2.5 Plot

The two sets of readings (four readings in all) taken at the same temperature are to be averaged for the two samples. These four average values and the average of the single readings at 95.0 °F are to be plotted on semilog paper. A continuous curve (usually a straight line) is to be drawn through the five points. The value of insulation resistance at 60.0 °F is then to be read from the graph.

5.17.4.2.6 Results

The resistivity coefficient C for a 1 ºF change in temperature is to be calculated to two decimal places by dividing the insulation resistance at 60.0 ºF read from the graph by the insulation resistance at 61.0 ºF. The temperature correction factor M required to correct to the standard test temperature of 60.0 ºF is then calculated from the following formula:

$$M = C^{(t-60)}$$

where
t is the actual test temperature in degrees Fahrenheit

5.17.5 Flammability test

All cable constructions covered in Clause 5 should be flame retardant and should meet IEEE Std 1202.

Cables meeting the flame and smoke requirements of UL 1685, Vertical Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables (FT4/IEEE 1202 flame test with optical density check) may bear the "ST1" (limited smoke) marking. Cable damage height may not exceed 1.5 m (4.9 ft) as measured from the lower edge of the burner face and total smoke release may not exceed 150 m^2 (1615 ft^2) with a peak rate of smoke release not to exceed 0.40 m^2/s (4.3 ft^2/s).

Cables designated fire resistant (-FS), in addition to meeting the flame test of IEEE Std 1202, should also meet the circuit integrity flame test with the equipment of IEC 60331-11 and the procedures of IEC 60331-21 for cables rated to and including 1000 V; IEC 60331-23 for electric data cable; or IEC 60331-25 for

optical fiber cable. Optionally, and in addition to the IEC 60331 testing stated previously, cables that pass the UL 2196 (tested without conduit) test may be so identified.

UL 1581 VW-1 is a requirement for insulated conductors installed as single conductors outside a metallic enclosure (switchboard, conduit, pipe, electrical box, etc.). Compliance should be determined by testing a 14 AWG or smaller insulated conductor.

5.17.6 Ease of stripping test

Cable should be tested in accordance with the following procedure:

a) A specimen of multiple conductor cable approximately 38 cm (15 in) long should have its jacket and filler material cut using a razor blade or similar instrument.

b) The cut should be longitudinally and vertically down to the insulation for approximately 15 cm (6 in).

c) A second cut around the circumference of the cable is to be made at the end of the first cut.

d) The resulting jacket piece is then to be removed by pulling at right angles away from the cable. When the jacket is removed, the cable core should show no evidence of damage. Remaining particles, which can be removed by light brushing, are acceptable.

e) A 76 mm (3 in) length of the insulation should be stripped from a sample length of the finished stranded conductor and the outer layer of strands opened. When the insulation is removed, there should be no evidence of insulation compound beneath the outer layer of conductor strands.

5.17.7 Salt water immersion test

Cable should be tested in accordance with the following procedure:

Three 1.1 m (3.6 ft) lengths of cable should be immersed in a 20% (by weight) common salt (sodium chloride) solution at 60°C ± 1°C (140 °F ± 2°F) for 240 h. The cable should be immersed in a U-bend such that each leg of the U-bend of the cable is 30 cm (12 in) above the water.

After immersion in salt water, the cable should comply with the following:

a) The cable should pass the dielectric voltage withstand test described in 5.17.1.

b) The mechanical properties of the jacket or insulation should not be degraded to the point where they will crack when wound around a mandrel having a diameter equal to nine times the sample overall diameter.

c) The insulation and jacket should not degrade to the point where either will crack or separate from the cable during the conditioning or during the testing described in items a) or b) above.

5.17.8 Cable immersion in oil test

Cable should be tested in accordance with the following procedure:

Three 1.1 m (3.6 ft) jacketed lengths of cable should be immersed in IRM 902 oil at 100 °C ± 1 °C (212 °F ± 2 °F) for 96 h or as an alternative at 60 °C ± 1 °C (140 °F ± 2 °F) for 60 days. The cable should be immersed in the oil in a U-bend such that each leg of the U-bend is 30 cm (12 in) above the surface of the oil.

After immersion in oil, the cable should comply with the following:

a) The cable should pass the dielectric voltage withstand test described in 5.17.1.

b) The mechanical properties of the jacket or insulation should not be degraded to the point where they will crack when wound around a mandrel having a diameter equal to nine times the sample overall diameter.

c) The insulation and jacket should not degrade to the point where either will crack or separate from the cable during the conditioning or during the testing described in items a) or b) above.

5.17.9 Pull-through metal plates test

Cable should be tested using the apparatus and procedure described as follows:

Apparatus

— The metal plates for the test set up shown in Figure 1 are to be four 150 mm (6 in) or longer lengths of 12 mm (0.5 in) × 100 mm (4 in) cold rolled steel. Both ends of each length are to be cut perpendicular to the long surfaces.

— Three holes of the size given in Table 7 are to be bored through the broad faces of each plate as shown in Figure 1 (view of broad face). The longitudinal axis of the holes are to be parallel and at an angle of 15° to the horizontal as shown in the end view, and 38 mm (1.5 in) apart. The edges of the hole are to be reamed sufficiently to remove burrs and rough edges caused by the drilling.

Table 7—Hole diameters for pull-through test

Calculated diameter over finished round cable or length of major axis of finished flat cable, mm (in)	Nominal diameter of each hole, mm (in)
0–18.04 (0–0.710)	28.6 (1.125)
18.05–20.32 (0.711–0.800)	31.8 (1.250)
20.33–22.22 (0.801–0.875)	34.9 (1.375)
22.23–24.13 (0.876–0.950)	38.1(1.500)
24.14–26.03 (0.951–1.025)	41.3 (1.625)
26.04 and larger (1.026 and larger)	1-1/2 times cable OD

An open, rigid metal frame is to be provided on which the four plates are to be supported on edge (broad faces vertical) at approximately 2.13 m (7 ft) above the floor. The centerlines are to be 406 mm (16 in) apart and parallel to one another in a horizontal plane. The plates are to be secured to the frame with all of their holes inclined in the same direction (longitudinal axis of holes parallel); see the four end views in Figure 1 (top view). The plates are also to be progressively offset a horizontal distance of 150 mm (6 in) as also shown in Figure 1, which is a view looking down from above the plates.

a) A reel of finished cable mounted on a stand should be located so that the distance between the bottom of the cable reel and a line perpendicular to the center of the plates is 2 m (6.5 ft). The distance between the first plate and a line tangent to the coil at the point where the cable comes off the coil is 450 mm (18 in). Upon completion of the period of cooling [24 h at –10°C (14°F) in air], the procedures described in the following paragraphs are to be carried out immediately.

b) One end of the sample is to be threaded in succession through the holes labeled A, B, C, and D in Figure 1. As soon as the first part of the sample has been threaded through the four holes, the end of the sample emerging from hole D (head end) is to be grasped manually so that the cable emerges from hole D at an angle of about 45° to the vertical. While maintaining this angle, pull 15 m (49 ft) of the sample entirely through the holes until the end of this sample (tail end) emerges from hole D. The sample is to be pulled through rapidly, and no effort is to be made to straighten or adjust the sample except to remove kinks that would prevent the sample from being pulled completely through the four holes. All of the pulling is to be done from beyond hole D, not from between plates.

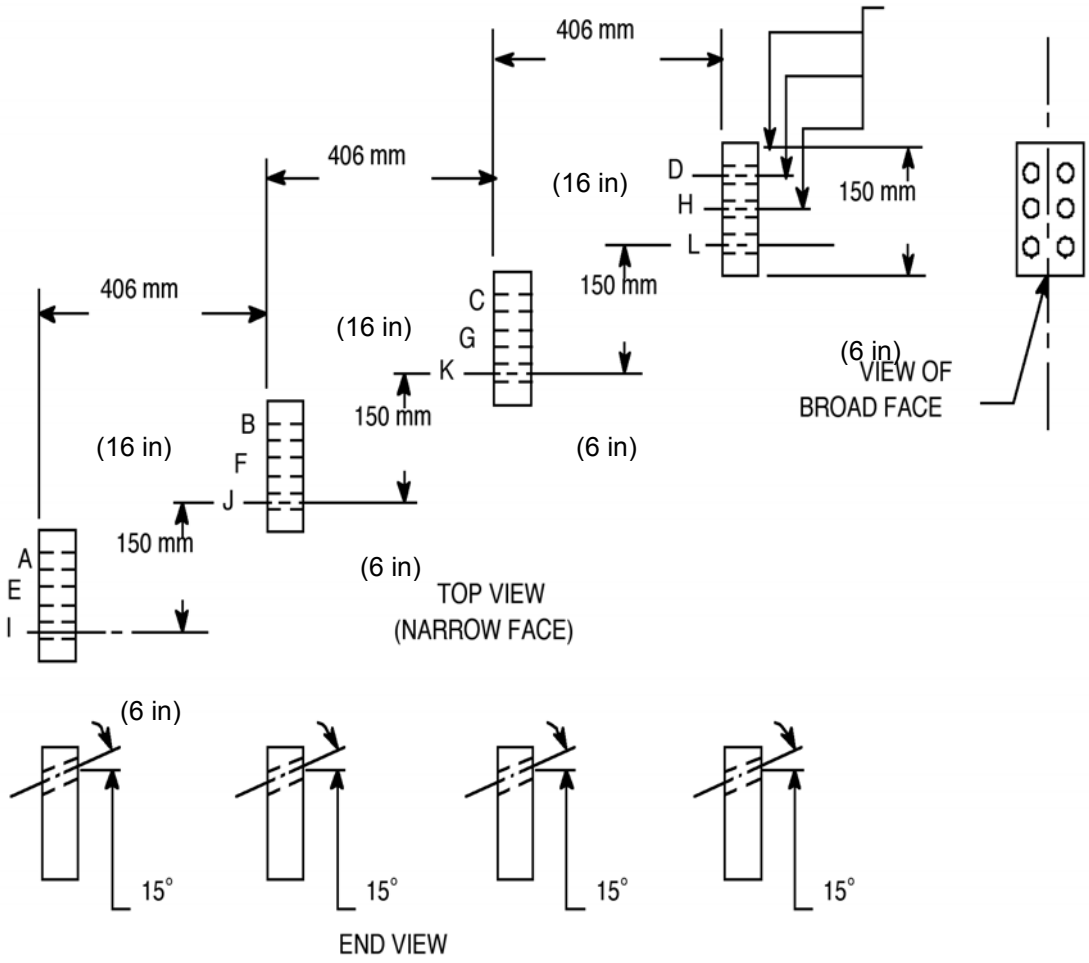

Figure 1—Test setup for pull-through metal plates test

c) As soon as the tail end of the sample emerges from hole D, the sample is to be cut to provide a 15 m (49 ft) length. The head end of this sample is to be threaded in succession through holes E, F, G, and H. The entire length of the sample is to be pulled through in the manner indicated in the preceding paragraph.

d) As soon as the tail end of the sample emerges from hole H, the head end of the sample is to be threaded in succession through holes I, J, K, and L. The entire length of the sample is to be pulled through in the manner indicated in item b). The overall sample is to be examined visually to determine if the cable is damaged and the degree of damage.

There should be no damage to the overall covering or jacket to the extent that the parts of the cable underlying the covering or jacket are exposed to view.

5.17.10 Bending endurance test

Cable should be tested in accordance with the following procedure:

After a period of 4 h in a cold chamber at a temperature of –25 °C (–13 °F) and while at that temperature, each sample is to be tightly wound for three turns around a mandrel having a diameter equal to 12 times the overall diameter of the specimen. The specimen is to be straightened to its original position, and then bent for three turns in the opposite direction and then straightened. This procedure is to be repeated 9 more times for a total of 10 times.

There should be no evidence of the cable insulation or jacket cracking because of this bending test. The specimens are then to be subjected to the dielectric withstand test described in 5.17.1. The results of the dielectric withstand test should meet the requirements specified for that test.

5.17.11 Cold bend test

Cable should be tested in accordance with the following procedure:

After a period of 4 h in a cold chamber at the temperature shown in Table 8 and while at that temperature, each sample is to be tightly bent 180° around a mandrel having a diameter equal to eight times the overall diameter of the specimen. The test should be conducted in accordance with 4.12.1 of CSA Standard C22.2 No. 0.3 or Section 580 of UL 1581.

There should be no evidence of cracking, when examined under normal or corrected to normal vision of the cable insulation, insulation shield, or jacket as a result of this bending test.

Table 8—Temperature requirements for cold bend test

Cable jacket		Test temperature, °C ± 1ºC (°F ± 2ºF)
T	PVC	–25[a] (–13)
CP	CSPE	–40 [a] (–40)
N	PCP	–40 [a] (–40)
CPE		–40 [a] (–40)
L	XLPO	–40 [a] (–40)
TPO	TPPO	–25[a] (–13)
P (integral insulation/jacket)		–55 (–67)

[a]If the cable passes a –40 ºC (–40 ºF) cold bend, it may be marked "–40C Cold Bend".

5.17.12 Cold impact (optional)

Cold impact testing shall be conducted in accordance with CSA C22.2 No. 0.3. Cables meeting the appropriate cold impact test shall be marked "–35C" (Transport Canada requirement), "–40C", or "–55C".

5.17.13 Vibration

Cable that is armored with continuously corrugated metal for use in areas of high vibration shall pass the vibration test of MIL-STD-167-1 or IEC 60068-2-6 to a frequency range of 50 Hz, as shown in Table 9.

Table 9—Vibration amplitude

Frequency range (Hz)	Amplitude, mm (in)
4–15	0.763 ± 0.152 (0.030 ± 0.006)
16–25	0.508 ± 0.102 (0.020 ± 0.004)
26–33	0.254 ± 0.051 (0.010 ± 0.002)
34–40	0.128 ± 0.025 (0.005 ± 0.001)
40–50	0.076 + 0.000 – 0.025 (0.003 + 0.000 – 0.001)

5.17.14 Incidental motion test

(Repeated flexing as listed in Title 46 CFR, subchapter J, subclause 111.60-23 and defined in Clause 3 of this recommended practice.)

Cable that is armored with continuously corrugated metal for use in areas of repeated flexing, on fixed or floating facilities, should pass this test. The apparatus (see Annex A) is comprised of a rocker assembly mechanism and a cable support fixture. The rocker mechanism is two vertical stanchions 2 m (6.5 ft) apart on a common base. Each stanchion is fitted with a set of rollers that provide a cradle configuration to support the wheels that carry the cable support fixture. The cable support fixture is a suitable metallic conduit 2.25 m (7.4 ft) long with two 20 cm (8 in) long windows cutting away approximately one-half the diameter of the conduit. The far ends of the windows are 2 m (6.5 ft) apart and are equidistant from the midpoint of the conduit. The windows align in the same plane along the axis of the conduit.

The test sample is 2.75 m (9.0 ft) long, marked to identify 104 cm (41 in) from the center on each side of the center. The cable sample is installed into the conduit through the windows. The 104 cm (41 in) marks are aligned with the 2 m (6.5 ft) edges of the conduit to form a catenary outside the conduit. The conduit section containing the cable is filled with a potting compound to encapsulate and anchor the cable sample in the conduit. The ends of the cable sample are exposed for voltage termination.

The sample fixture is securely set in the rocker assembly with the axis of the support fixture conduit concentric to the axis of the rocker assembly so the catenary loop hangs vertically into the neutral position.

The drive is a gear-motor with a crank and connecting rod that rotates the sample along the horizontal axis. The drive mechanism provides motion to the rocker assembly plus and minus 30° from the vertical at 60 cycles per minute. A counter registers each total cycle.

The specimens are to be subjected to the dielectric withstand test described in 5.17.1 prior to starting the test to assure sample integrity. The results of the dielectric withstand test shall meet the requirements specified for those tests. The flexibility test will be run for a total of 500 000 cycles with the dielectric test in 5.17.1 performed after every 100 000 cycles. Any failure will result in conclusion of the testing. After 500 000 cycles, the sample shall meet the dielectric test in 5.17.1. The sample will then be dissected. If any deterioration (cracking or splitting) is found in any of the cable components, the cable fails the test.

Type CWCMC cables that meet the test above may be marked "-IM".

5.17.15 Insulation discharge resistance test

Shielded cable rated 5 kV and higher that is discharge resistant should comply with the requirements of the insulation corona discharge test prescribed in NEMA WC 74 (ICEA S-93-639) subclause 9.16.

5.18 Basic construction details for various cable types

5.18.1 Halogen free constructions

For halogen-free constructions, Type LSE, LSX, or LSS insulation shall be used with a Type L or TPO jacket/sheath.

5.18.2 Single conductor 600/1000 V or 2000 V

Single conductor, thermoset or thermoplastic insulated, jacketed, with or without armor or armor and sheath, 600/1000 V (Table B.1 or Table B.3) or 2000 V (Table B.2 or Table B.4).

Construction details are as follows:

1) Stranded copper conductor tin or alloy coated where necessary for the application
2) Separator tape (optional)
3) Insulation, Type X, E, T, T/N, S, P, LSX, LSS or LSE
4) Shielding (optional)
5) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for Type P with HD thicknesses)
6) Armor (optional and shall be nonmagnetic)
7) Sheath, Type T, CP, N, CPE, L, P, or TPO sheath (optional except for tinned copper braid armored cables)

5.18.3 Multiconductor 300V, 600/1000 V, or 2000 V

Multiconductor thermoset or thermoplastic insulated, jacketed with or without armor and armor and sheath, 300V, 600/1000 V (Table B.1, Table B.2, or Table B.5) or 2000 V (Table B.2 or Table B.4).

Construction details are as follows:

1) Stranded copper conductor tin or alloy coated where necessary for the application
2) Separator tape (optional)
3) Insulation, Type X, E, T, T/N, S, P, LSX, LSS or LSE
4) Conductors cabled with fillers, where necessary, to form a round foundation
5) Grounding conductor (optional)
6) Binder tape (optional)
7) Shielding (optional)
8) Jacket, Type T, CP, N, CPE, L, P, or TPO jacket (optional for CWCMC cables)
9) Armor (optional)
10) Sheath, Type T, CP, N, CPE, L, P, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.4 Single conductor 5 kV–35 kV

Single-conductor, thermoset insulated, jacketed, with or without armor or armor and sheath, 5 kV–35 kV.

Construction details are as follows:

1) Stranded copper conductor tin or alloy coated where necessary for the application
2) Conductor shield of semiconducting extruded compound or tape and extruded compound in accordance with UL 1072 or NEMA WC 74
3) Insulation, Type X or E with semi-conducting shield in accordance with UL 1072 or NEMA WC 74
4) Metallic shield, copper tape, or braid
5) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for CWCMC cables)
6) Armor (optional and shall be nonmagnetic)
7) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.5 Single conductor 2.4 kV

Single-conductor, thermoset insulated, jacketed, with or without armor or armor and sheath, 2.4 kV. Construction details are as follows:

1) Stranded copper conductor tin or alloy coated where necessary for the application
2) Conductor shield of semiconducting extruded compound or tape and extruded compound in accordance with UL 1072 or NEMA WC 71
3) Insulation, Type X or E in accordance with Table 4-3 of NEMA WC-71
4) Barrier tape (optional)
5) Jacket, Type T, CP, N, CPE, L, or TPO jacket in accordance with Table 4-3 of NEMA WC-71 (optional for CWCMC cables)
6) Armor (optional and shall be nonmagnetic)
7) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.6 Single conductor 5 kV–35 kV discharge resistant

Single-conductor, discharge resistant, jacketed, with or without armor or armor and sheath, 5 kV–35 kV.

Construction details are as follows:

1) Stranded copper conductor tin or alloy coated where necessary for the application
2) Conductor shield of nonconducting high permittivity extruded compound or tape and extruded compound in accordance with UL 1072 or NEMA WC 74
3) Insulation, Type E (discharge resistant with semiconducting shield) in accordance with UL 1072 or NEMA WC 74
4) Metallic shield, copper tape, or braid
5) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for CWCMC cables)
6) Armor (optional and shall be nonmagnetic)
7) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.7 Three conductor 2.4 kV

Three-conductor, thermoset insulated, nonshielded, jacketed, with or without armor or armor and sheath, 2.4 kV.

Construction details are as follows:

1) Stranded copper conductors tin or alloy coated where necessary for the application
2) Conductor shield of semiconducting extruded compound or tape and extruded compound in accordance with UL 1072 and NEMA WC 71
3) Insulation, Type X or E in accordance with UL 1072 or NEMA WC 71
4) Three conductors cabled with fillers, where necessary
5) Grounding conductor (optional)
6) Binder tape, as required
7) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for CWCMC cables)
8) Armor (optional)
9) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.8 Three conductor 5 kV–35 kV

Three-conductor, thermoset insulated, jacketed, with or without armor or armor and sheath, 5 kV–35 kV

Construction details are as follows:

1) Stranded copper conductors tin or alloy coated where necessary for the application
2) Conductor shield of semiconducting extruded compound or tape and extruded compound in accordance with UL 1072 or NEMA WC 74
3) Insulation, Type X or E with semiconducting shield in accordance with UL 1072 or NEMA WC 74
4) Metallic shield, copper tape, or braid
5) Three conductors cabled with fillers, where necessary
6) Grounding conductor (optional)
7) Binder tape, as required
8) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for CWCMC cables)
9) Armor (optional)
10) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.9 Three conductor 5 kV–35 kV discharge resistant

Three-conductor, discharge resistant, jacketed, with or without armor or armor and sheath, 5 kV–35 kV.

Construction details are as follows:

1) Stranded copper conductors tin or alloy coated where necessary for the application
2) Conductor shield of nonconducting high permittivity extruded compound or tape and extruded compound in accordance with UL 1072 or NEMA WC 74
3) Insulation, Type E (discharge resistant) with semiconducting shield in accordance with UL 1072 or NEMA WC 74
4) Metallic shield, copper tape, or braid
5) Three conductors cabled with fillers, where necessary
6) Grounding conductor (optional)
7) Binder tape, as required
8) Jacket, Type T, CP, N, CPE, L, or TPO jacket (optional for CWCMC cables)
9) Armor (optional)
10) Sheath, Type T, CP, N, CPE, L, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.10 Signal cable, twisted pair/triad/quad, 300 or 600/1000 V

Signal cable, twisted pair/triad/quad, thermoset or thermoplastic insulated, jacketed, with or without armor or armor and sheath, 300 V or 600/1000 V; pairs (Table B.11, Table B.12, Table B.13, Table B.14, or Table B.16); triads (Table B.15).

Construction details are as follows:

1) Stranded conductors
2) Insulation, Type X, E, T, T/N, S, P, LSX, LSS, or LSE
3) Two/three/four conductors twisted together to form a pair/triad/quad
4) Component shield (optional)
5) Fillers (optional)
6) Binder tape (optional)
7) Overall shield (optional)
8) Jacket, Type T, CP, N, CPE, L, P, or TPO jacket (optional for CWCMC cables)
9) Armor (optional)
10) Sheath, Type T, CP, N, CPE, L, P, or TPO sheath [optional except for tinned copper braid armor and CWCMC (see 5.14.3)]

5.18.11 Recommended guidelines for power cables used in variable frequency drive (a type of non-linear load) applications:

The interconnecting cable between the motor and drive is an integral part of the entire system. Every variable frequency drive system is different and typically has manufacturer's recommendations for cables and installation. Therefore, consultation between the system designer, drive manufacturer, and cable manufacturer is important for the proper cable selection and termination.

In addition to the guidelines that follow, cables used in variable frequency drive (VFD) power applications should meet all of the requirements of Table 6 in this document.

5.18.11.1 General

Cables for VFD applications require special consideration because of harmonics, electromagnetic interference (EMI), reflected wave voltages, common mode current, and induced voltages in adjacent cables.

5.18.11.2 Construction notes

5.18.11.2.1 Insulation

Depending on the nominal voltage rating and the reflected voltage, over insulated conductor ratings may be considered. (Example: If the VFD has a nominal voltage rating of 600 V, there is the potential for reflected voltages of up to 3X this voltage. Thus, the cable may have a 2 kV voltage rating to reduce the potential for early failure.) Selection of the insulation thickness will also be dependant on the switching frequency and length of cable installed. Reducing the capacitance of the cable reduces common mode current. It is recommended that the insulation material used on these cables have a dielectric constant less than 3.0 to reduce cable capacitance. PVC should not be used as an insulating material.

5.18.11.2.2 Grounding conductors (if the system design requires)

In order to reduce voltage imbalances, the cable should have segmented grounding conductors, one in each interstice. The size of the segmented grounding conductors should be in accordance with Table 3 for applications up to 2 kV or should be in accordance with UL 1072 for 2.4 kV to 35 kV. The size of the segmented grounding conductors will also depend on the trip setting of the overcurrent protection device. When cables are paralleled, the size of the grounding conductor must be increased to reflect the higher rating of the trip setting of the overcurrent protection device. For system grounding applications, the total circular mil area of grounding conductors shall not be less than the circular mil area of one phase conductor.

5.18.11.2.3 EMI shielding

VFD power cables should have an overall non-ferrous shield with a coverage of 100%. The purpose of this overall shield is to minimize EMI emissions.

5.18.11.2.4 Cable marking

These cables should be identified by incorporating “VFD” in the cable marking.

5.18.11.2.5 Voltage drop

Voltage drop on VFD power cables require special consideration when loads with transients related to high starting torques are involved.

5.19 Cable markings

Cable identification shall be provided by a durable printing or embossing or indenting on the jacket or a tape marker under the cable jacket. The marker material shall be suitable for its service. Marking shall show the following information at intervals not exceeding 1 m (40 in.):

a) Manufacturer's identification (name or tradename or NRTL file number)

b) Year of manufacture

c) Circuit conductor size(AWG/kcmil)

d) Number of circuit conductors/pairs/triads/quads, etc.

e) Grounding conductor, if included, "+G" or "+GND" or "+GRD" or "+GRND"

f) Shielding (see 5.12)

No marking	Nonshielded
"OS"	Overall shield
"IS"	Individual shield
"IS-OS"	Individual and overall shield
"OBS"	Overall braid shield

g) Voltage rating

h) Temperature rating (see Table 2)

i) Insulation type (see Table 2)/ Jacket Type (see 5.13)

j) Armor type (see 5.14)

No marking	Unarmored
"AL ARMOR"	Aluminum armor
"BRONZE ARMOR"	Bronze armor
"TINNED CU ARMOR"	Tinned copper armor
"SS ARMOR"	Stainless steel armor
"CWCMC"	Continuously welded and corrugated metal armor

k) Additional markings ("FS", "VFD", "–40C", etc.)

l) NRTL certification mark

m) IEEE Std 1580

n) Other information that does not confuse or mislead may be added to the marking

Examples:

Signal/Instrumentation cable: XYZ CABLE CO. 2005 16 AWG 4PR IS-OS 600/1000V 100C P/CPE BRONZE ARMOR –40C (UL) CLASSIFIED TO IEEE 1580

Control cable: ABC CABLE CO. 2005 14 AWG 7C 600/1000V 90C E/CP TINNED CU ARMOR (ETL) IEEE 1580

Power cable: EFG CABLE CO. 2005 350 kcmil 3C+G 5KV SHLD 90C X/T CWCMC CSA IEEE 1580

Table 10—Construction and resistance of standard class B concentric conductors

		Class B stranding					Maximum dc resistance					
Conductor area in circular mils	AWG or kcmil	Number of wires	Wire dia. (mils)	mm^2	Conductor dia.		Ohms per 1000 ft at 25 °C		Ohms per 1000 ft at 20 °C		Ohms per km at 20 °C	
					mm	in	Bare	Coated	Bare	Coated	Bare	Coated
640	22	7	10.0	0.32	0.737	0.029	15.1	16.9	14.8	16.6	48.6	54.4
1020	20	7	12.6	0.52	0.914	0.036	9.51	10.5	9.33	10.3	30.6	33.8
1620	18	7	15.9	0.82	1.168	0.046	5.97	6.58	5.86	6.45	19.2	21.2
2580	16	7	19.2	1.31	1.473	0.058	4.17	4.56	4.09	4.47	13.4	14.6
4110	14	7	24.2	2.08	1.854	0.073	2.68	2.78	2.62	2.73	8.62	8.96
6530	12	7	30.5	3.31	2.337	0.092	1.68	1.75	1.65	1.72	5.43	5.64
10 380	10	7	38.5	5.26	2.946	0.116	1.06	1.10	1.04	1.08	3.41	3.55
16 510	8	7	48.6	8.37	3.708	0.146	0.666	0.693	0.654	0.68	2.14	2.23
20 820	7	7	54.5	10.55	4.166	0.164	0.528	0.550	0.518	0.539	1.70	1.77
26 240	6	7	61.2	13.30	4.674	0.184	0.419	0.436	0.411	0.428	1.35	1.40
33 090	5	7	68.8	16.77	5.232	0.206	0.332	0.346	0.326	0.339	1.07	1.11
41 740	4	7	77.2	21.15	5.893	0.232	0.264	0.274	0.259	0.269	0.848	0.882
52 620	3	7	86.7	26.66	6.604	0.260	0.209	0.218	0.205	0.213	0.673	0.700
66 360	2	7	97.4	33.67	7.417	0.292	0.166	0.172	0.163	0.169	0.534	0.555
83 690	1	19	66.4	44.47	8.433	0.332	0.131	0.136	0.129	0.134	0.423	0.440
105 600	1/0	19	74.5	53.50	9.474	0.373	0.104	0.108	0.102	0.106	0.335	0.349
133 100	2/0	19	83.7	67.44	10.643	0.419	0.083	0.086	0.0811	0.0843	0.266	0.277
167 800	3/0	19	94.0	85.02	11.938	0.470	0.0656	0.068	0.0643	0.0669	0.211	0.219
211 600	4/0	19	105.5	107.20	13.411	0.528	0.0520	0.0535	0.0501	0.0525	0.167	0.172
250 000	250	37	82.2	126.70	14.605	0.575	0.0440	0.0458	0.0432	0.0449	0.142	0.147
300 000	300	37	90.0	152.00	16.002	0.630	0.0367	0.0381	0.0359	0.0374	0.118	0.123
350 000	350	37	97.3	177.30	17.297	0.681	0.0314	0.0327	0.0308	0.0321	0.101	0.105
400 000	400	37	104.0	203.00	18.491	0.728	0.0275	0.0283	0.0270	0.0278	0.0885	0.0911
500 000	500	37	116.2	253.30	20.650	0.813	0.0220	0.0226	0.0216	0.0222	0.0780	0.0729
600 000	600	61	99.2	304.00	22.682	0.893	0.0183	0.0191	0.0180	0.0187	0.0590	0.0613
750 000	750	61	110.9	380.00	25.349	0.998	0.0147	0.0151	0.0144	0.0148	0.0472	0.0486
1 000 000	1000	61	128.0	506.70	29.261	1.152	0.0110	0.0113	0.0108	0.0111	0.0354	0.0364
1 250 000	1250	91	117.2	633.30	32.741	1.289	0.00882	0.00904	0.00866	0.00888	0.0283	0.0291
1 500 000	1500	91	128.4	760.00	35.865	1.412	0.00738	0.00755	0.00725	0.00740	0.0236	0.0243
2 000 000	2000	127	125.5	1013.30	41.453	1.632	0.00555	0.00565	0.00544	0.00555	0.0177	0.0182

Tolerance for maximum resistance[a]

Single conductor	R_{max} = value from Table 10
Multiple conductor cable	
One layer of conductors	R_{max} = value from Table 10 × 1.02
More than one layer of conductors	R_{max} = value from Table 10 × 1.03
Pairs or other precabled units	R_{max} = value from Table 10 × 1.04
More than one layer of pairs or other precabled units	R_{max} = value from Table 10 × 1.05

[a]From NEMA WC-55

Table 11—Construction and resistance of flexible stranded conductors

AWG or Kcmil	Conductor area in circular mils	Nominal mm²	Nominal stranding			Max. cond diameter		Max. DC resistance			
			Number of wires	Individual wire diameter		Max. cond diameter		Ohms per 1000-ft at 25 °C		Ohms per km at 25 °C	
				in	mm	in	mm	Bare	Coated	Bare	Coated
22	754	0.38	19	0.0063	0.160	0.0315	0.80	17.19	18.46	56.4	60.6
20	1216	0.62	19	0.0080	0.203	0.0400	1.02	10.83	11.62	35.5	38.1
18	1900	0.96	19	0.0100	0.254	0.052	1.32	5.91	6.342	19.4	20.8
16	2601	1.32	19	0.0117	0.297	0.062	1.56	4.26	4.527	14.0	14.9
or 16	2426	1.23	19	0.0113	0.287	0.060	1.51	4.63	4.915	15.2	16.1
14	4106	2.08	19	0.0147	0.373	0.076	1.92	2.67	2.835	8.76	9.30
or 14	3831	1.94	19	0.0142	0.361	0.073	1.85	2.93	3.110	9.61	10.2
12	6503	3.29	19	0.0185	0.470	0.095	2.40	1.68	1.784	5.51	5.85
or 12	6088	3.08	19	0.0179	0.455	0.092	2.32	1.84	1.958	6.05	6.42
10	10908	5.53	27	0.0201	0.511	0.128	3.25	1.048	1.101	3.44	3.61
or 10	10319	5.23	37	0.0167	0.424	0.117	2.97	1.045	1.110	3.43	3.64
8	16564	8.4	41	0.0201	0.511	0.147	3.73	0.659	0.692	2.16	2.27
or 8	14948	7.6	37	0.0201	0.511	0.147	3.73	0.728	0.765	2.39	2.51
6	26261	13.3	65	0.0201	0.511	0.207	5.26	0.423	0.445	1.39	1.46
or 6	24645	12.5	61	0.0201	0.511	0.207	5.26	0.455	0.478	1.49	1.57
5	36765	18.6	91	0.0201	0.511	0.244	6.20	0.336	0.353	1.10	1.16
4	41668	21.1	133	0.0177	0.450	0.258	6.55	0.269	0.286	0.88	0.94
or 4	42421	21.5	105	0.0201	0.511	0.264	6.71	0.266	0.279	0.87	0.92
3	53733	27.2	133	0.0201	0.511	0.295	7.49	0.211	0.221	0.69	0.73
or 3	50501	25.6	125	0.0201	0.511	0.290	7.37	0.220	0.231	0.72	0.76
2	66140	33.5	133	0.0223	0.566	0.324	8.23	0.183	0.193	0.60	0.63
or 2	60602	30.7	150	0.0201	0.511	0.325	8.23	0.183	0.193	0.60	0.63
or 2	65046	33.0	161	0.0201	0.511	0.325	8.26	0.167	0.175	0.55	0.58
1	84438	42.8	209	0.0201	0.511	0.361	9.17	0.133	0.140	0.44	0.46
or 1	90902	46.1	225	0.0201	0.511	0.390	9.91	0.122	0.128	0.40	0.42
1/0	107467	54.5	266	0.0201	0.511	0.407	10.34	0.1058	0.111	0.35	0.37
or 1/0	111103	56.3	275	0.0201	0.511	0.440	11.18	0.1009	0.106	0.33	0.35

Table 11—Construction and resistance of flexible stranded conductors

AWG or Kcmil	Conductor area in circular mils	Nominal mm^2	Nominal stranding			Max. cond diameter		Max. DC resistance			
			Number of wires	Individual wire diameter		Max. cond diameter		Ohms per 1000-ft at 25 °C		Ohms per km at 25 °C	
				in	mm	in	mm	Bare	Coated	Bare	Coated
2/0	131303	66.5	325	0.0201	0.511	0.477	12.12	0.0854	0.090	0.28	0.29
or 2/0	138171	70.0	342	0.0201	0.511	0.461	11.71	0.0842	0.0885	0.28	0.29
3/0	168876	85.6	418	0.0201	0.511	0.510	12.95	0.0669	0.0703	0.22	0.23
or 3/0	181805	92.1	450	0.0201	0.511	0.565	14.35	0.0615	0.0646	0.20	0.21
4/0	214933	109	532	0.0201	0.511	0.575	14.61	0.0530	0.0557	0.17	0.183
or 4/0	222206	113	550	0.0201	0.511	0.620	15.75	0.0505	0.0530	0.17	0.174
262	262607	133	650	0.0201	0.511	0.660	16.76	0.0437	0.0459	0.14	0.151
313	313108	159	775	0.0201	0.511	0.725	18.42	0.0365	0.0383	0.12	0.126
373	373709	189	925	0.0201	0.511	0.795	20.19	0.0304	0.0319	0.10	0.105
444	444411	225	1100	0.0201	0.511	0.870	22.10	0.0256	0.0269	0.08	0.088
535	535313	271	1325	0.0201	0.511	0.970	24.64	0.0213	0.0223	0.07	0.073
597	597935	303	1480	0.0201	0.511	1.020	25.91	0.0207	0.0217	0.07	0.071
646	646416	328	1600	0.0201	0.511	1.060	26.92	0.0177	0.0186	0.06	0.061
777	777719	394	1925	0.0201	0.511	1.130	28.70	0.0147	0.0154	0.05	0.051
1111	1111028	563	2750	0.0201	0.511	1.340	34.04	0.0105	0.0110	0.03	0.036

NOTE 1—The total number of wires should be as specified ± 1% providing that the maximum conductor diameter and conductor resistance does not exceed the values indicated.

NOTE 2—The resistance values of 22 AWG & 20 AWG have been increased to account for stretching of the conductor during the insulating operations in accordance with ASTM B286.

Tolerance for maximum resistance:[a]

Single Conductor: R_{max} = value from Table 11

Multi-Conductor Cables:

One layer of conductor: R_{max} = value from Table 11 × 1.02
More than one layer of conductors: R_{max} = value from Table 11 × 1.03
Pairs or other precabled units: R_{max} = value from Table 11 × 1.04
More than one layer of pairs or other precabled units: R_{max} = value from Table 11 × 1.05

[a]From NEMA WC-55

Table 12—Insulation, electrical, and physical requirements—Types E, X, S, T, and T/N

Insulation material	Ethylene propylene rubber		Cross-linked polyethylene rubber		Silicone	Polyvinyl chloride	Polyvinyl chloride/nylon
Insulation-type designation	E	E[a,b]	X	X	S	T	T/N
Voltage rating (V)	0–2000	2001–35 000	0–2000	2001–35 000	0–600	0–600/1000	0–600/1000
Insulation resistance constant (*K*) at 15.6 °C (60°F), MΩ·km (MΩ·1000 ft), min	3050 (10000)	6100 (20000)	3050 (10000)	6100 (20,000)	1220 (4000)	610 (2000)	610 (2000)
Accelerated water absorption:[c] Electrical method 75°C (167°F) water:							
Dielectric constant after 1 day, max	6.0	4.0	6.0	3.5	6.0	10.0	10.0
Increase in capacitance, max 1–14 days, %	5.0	3.5	4.0	3.0	10.0	4.0	4.0
7 to 14 days, %	3.0	1.5	2.0	1.5	3.0	2.0	2.0
Stability factor after 14 days, max	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Physical requirements: unaged							
Tensile strength, N/mm^2 (lbf/in^2), min	8.2 (1200)	4.8 (700)	12.5 (1800)	12.5 (1800)	5.5 (800)	13.8 (2000)	13.8 (2000)
Elongation at rupture, min, %	150	200	150	250	250	150	150
Aging requirements: After air oven test							
Temperature, °C (°F)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	158 ± 1 (316 ± 2)	121 ± 1 (249 ± 2)	136 ± 1 (277 ± 2)
Duration (hours)	168	168	168	168	168	168	168
Tensile strength % of unaged, min	75	75	85	75	65	75	75
Elongation at rupture, min, % of unaged value	75	75	60	75	50	65[d]	65[d]
Heat distortion, 121 °C (249°F), max, %							
4/0 AWG and smaller	—	—	30	25	—	25	25
Larger than 4/0 AWG	—	—	10	15	—	25	25
Mandrel test for nylon jacket	—	—	—	—	—	—	no cracks
VW-1 Flame Test[e]	optional	N/A	optional	N/A	optional	optional	Optional
Test procedure reference	NEMA WC 70	NEMA WC 74	NEMA WC 70	NEMA WC 74	NEMA WC 57	UL 1581	UL 1581

[a]If using discharge resistant cable insulations, the insulation should meet the requirements of NEMA WC 74 subclause 4.3.2 in lieu of the values above.
[b]Insulations for use at 105 °C (221°F) should meet the requirements of UL 1072 in lieu of the above requirements.
[c]For test procedures, refer to NEMA WC 57.
[d]For 6 AWG and larger, buffed samples, value is 45%.
[e]For test procedures, refer to UL 1581. Compliance should be determined by testing a 14 AWG or smaller insulated conductor.

Table 13—Insulation, electrical, and physical requirements for low-smoke, halogen-free types LSE, LSX, and LSS

Insulation material	Ethylene propylene rubber	Cross-linked polyolefin	Silicone rubber
Insulation-type designation	LSE	LSX	LSS
Voltage rating (V)	0–600/1000	0–600/1000	0–600/1000
Insulation resistance constant (K) at 15.6 °C (60 °F), MΩ·km (MΩ·1000 ft), min	3050 (10000)	3050 (10000)	1220 (4000)
Accelerated water absorption:[a] electrical method in 75 °C (167 °F) water:			
Dielectric constant, max	6.0	6.0	6.0
Increase in capacitance, max 1–14 days, %	10.0	10.0	10.0
7–14 days, %	4.0	4.0	4.0
Stability factor after 14 days, max	1.0	1.0	1.0
Physical requirements: unaged			
Tensile strength, N/mm^2 (lbf/in^2), min	8.2 (1200)	10.3 (1500)	5.5 (800)
Elongation at rupture, %, min	150	150	150
Aging requirements: after air oven test			
Temperature °C (°F)	121 (249)	121 (249)	158 (316)
Duration (hours)	168	168	168
Tensile strength, % of unaged, min	75	80	65
Elongation at rupture, % of unaged value, min	75	80	50
Heat distortion at 121°C (249°F) , max, %			
4/0 AWG and smaller	30	30	—
Larger than 4/0 AWG	10	10	—
Acid gas equivalent[b]			
pH min~~,~~	3.56	3.56	3.56
Smoke index, max[d]	25	25	25
Toxicity index, max[e]	1.5	1.5	1.5
Halogen content, percent, max[a]	0.2	0.2	0.2
Hot creep test per ICEA T-28-562			
Temperature of air oven	150°C ± 2°C	150°C ± 2°C	150°C ± 2°C

Table 13—Insulation, electrical, and physical requirements for low-smoke, halogen-free types LSE, LSX, and LSS

	(302°F ± 3°F)	(302°F ± 3°F)	(302°F ± 3°F)
Hot creep elongation, max	50%	50%	50%
Hot creep set, max	5%	5%	5%
VW-1 flame test[c]	Pass	Pass	Pass
NEMA test procedure reference	NEMA WC 70	NEMA WC 70	NEMA WC 70

[a]For test procedures, refer to NEMA WC 57, part 7.
[b]For test procedures, refer to IEC 60754-2.
[c]For test procedures, refer to UL 1581. Compliance should be determined by testing a 14 AWG or smaller insulated conductor.
[d]For test procedures, refer to NES 711.
[e]For test procedures, refer to NES 713.

Table 14—Insulation or Jacket,[d] electrical, and physical requirements for crosslinked polyolefin (Type P), voltage rating 0–2000 V

Insulation resistance constant (K) at 15.6 °C (60 °F), MΩ·km (MΩ·1000 ft), min	3050 (10000)
Accelerated water absorption:[a] Electrical method in 75 °C (167 °F) water:	
Dielectric constant, max	6.0
Increase in capacitance, max 1–14 days	3.0
7–14 days	1.5
Stability factor after 14 days, max	0.5
Physical requirements: unaged	
Tensile strength, N/mm^2 (lbf/in^2), min	12.5 (1800)
Elongation at rupture, min, %	250
Aging requirements:	
After air oven test temperature °C (°F)	158 ± 1 (316± 2)
Duration (hours)	168
Tensile strength % of unaged, min	90
Elongation at rupture, min % of unaged values	50
Heat distortion at 150 °C (302 °F), max, % of unaged value	
4/0 AWG and smaller	20
Larger than 4/0 AWG	10
Ozone after 24 h exposure in concentration of .03% by volume at 90 °C ± 2 °C[b] (194 °F ± 2 °F)	No cracks
Set NEMA WC 57 Clause 6.8 except gauge marks 101.6 mm (4 in) apart	Three specimens not to exceed tension set of 30%

Table 14—Insulation or Jacket,[d] electrical, and physical requirements for crosslinked polyolefin (Type P), voltage rating 0–2000 V

VW-1 flame test[c]	Pass
Hot creep test per ICEA T-28-562 with following modifications:	
Temperature of air oven	175°C ± 1°C (347°F ± 2°F)
Hot creep elongation, max	25%
Hot creep set, max	2%
NEMA test procedure reference	NEMA WC 70
Sunlight Resistance[d]	Pass

Hot oil resistance

The insulated conductor cable diameter increase (swell) shall not exceed values shown below after the center 30 cm (12 in) section of a 60 cm (24 in) length of insulated conductor cable with ends stripped of 5 cm (2 in) of insulation and exposed for 100 h to the following fluids and temperatures:

Fluid	Temperature	Allowable % swell
IRM 902	150 °C (302 °F)	60
Diesel (fuel) oil	60 °C (140 °F)	60

The hot oil resistance test shall be performed on 12 AWG cable. Swelling should be evaluated no sooner than 24 h and no later than 48 h after immersion. The specimens should additionally show no cracks in insulation following immersion. The insulation should withstand an AC rms potential of 3500 V for 5 min conducted between conductor and aluminum foil wrapped around insulation.

[a]For test procedures, refer to NEMA WC57.
[b]For test procedures, refer to NEMA WC 57 or CSA C22.2 No. 0.3.
[c]For test procedures, refer to UL 1581. Compliance should be determined by testing a 14 AWG or smaller insulated conductor.
[d]This requirement is only applicable when used as an integral insulation/jacket or overall jacket. For test procedures and requirements, refer to UL 1581 Section 1200 using the 720 h exposure.

Table 15—Thickness of extruded insulations

Rated voltage	Conductor		Insulation thickness minimum average wall											
			Type E or X		Type LSE or LSX		Type P		Type S or LSS[a]		Type T		Type T/N	
Phase to phase (V)	(mm^2)	(AWG or kcmil)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)
0–300	0.32–0.68	(22–19)	0.38	(0.015)	0.63	(0.025)	0.38	(0.015)	0.88	(0.035)	0.63	(0.025)	0.38 /0.10	(0.015/ 0.004)
	0.69–1.31	(18–16)	0.51	(0.020)	0.63	(0.025)	0.51	(0.020)	0.88	(0.035)	0.63	(0.025)	0.38/0.10	(0.015/ 0.004)
301–1000	0.32– 0.68	(22–19)	0.76	(0.030)	0.76	(0.030)	0.76	(0.030)	1.14	(0.045)	—		—	
	0.69–1.50	(18–15)	0.76	(0.030)	0.76	(0.030)	0.76	(0.030)	1.14	(0.045)	0.76	(0.030)	0.38/0.10	(0.015/ 0.004)
	1.51–4.00	(14–11)	0.76	(0.030)	0.76	(0.030)	0.76	(0.030)	1.14	(0.045)	1.14	(0.045)	0.38/0.10	(0.015/ 0.004)
	4.01–7.00	(10–9)	0.76	(0.030)	0.76	(0.030)	0.76	(0.030)	1.14	(0.045)	1.14	(0.045)	0.51/0.10	(0.020/ 0.004)
	7.01–17.0	(8–5)	1.14	(0.045)	1.14	(0.045)	1.14	(0.045)	1.52	(0.060)	1.52	(0.060)	0.76/0.13	(0.030/ 0.005)
	17.1–34.0	(4–2)	1.14	(0.045)	1.14	(0.045)	1.14	(0.045)	1.52	(0.060)	1.52	(0.060)	1.02/0.15	(0.040/ 0.006)
	34.1–107	(1–4/0)	1.40	(0.055)	1.40	(0.055)	1.40	(0.055)	2.03	(0.080)	2.03	(0.080)	1.27/0.18	(0.050/ 0.007)
	108–254	(213–500)	1.65	(0.065)	1.65	(0.065)	1.65	(0.065)	2.41	(0.095)	2.41	(0.095)	1.52/0.20	(0.060/ 0.008)
	255–400	(501–777)	2.03	(0.080)	2.03	(0.080)	2.03	(0.080)	2.79	(0.110)	2.79	(0.110	1.78/0.23	(0.070/ 0.009)
	401–508	(778–1000)	2.03	(0.080)	2.03	(0.080)	2.03	(0.080)	2.79	(0.110)	2.79	(0.110)	1.78/0.23	(0.070/ 0.009)

	509–1015	(1001-2000)	2.41	(0.095)	2.41	(0.095)	2.79	(0.110)	—		—		—	

NOTE—Minimum point is 90% of minimum average.

[a] Where specifically listed by an NRTL, Composite Insulation consisting of silicone rubber with a crosslinked polyolefin outer covering in accordance with Table 15 of UL-44 is acceptable.

Rated voltage	**Conductor**			**Type E or X**			**Type LSE or LSX**			**Type P**				
Phase to phase (V)	**(mm^2)**	**(AWG or kcmil)**		**(mm)**	**(in)**		**(mm)**	**(in)**		**(mm)**	**(in)**			
1001–2000	0.96-7.00	(18–9)		1.14	(0.045)		1.14	(0.045)		1.14	(0.045)			
	7.01–34.0	(8–2)		1.40	(0.055)		1.40	(0.055)		1.40	(0.055)			
	34.1–85.0	(1–3/0)		1.65	(0.065)		1.65	(0.065)		1.65	(0.065)			
	85.1–107	(4/0)		1.65	(0.065)		1.65	(0.065)		1.65	(0.065)			
				—			—			2.67	(0.105)	(HD)		
	108–254	(213–500)		1.90	(0.075)		1.90	(0.075)		1.90	(0.075)			
				—			—			2.67	(0.105)	(HD)		
	255–400	(501–777)		2.29	(0.090)		2.29	(0.090)		2.29	(0.090)			
				—			—			3.05	(0.120)	(HD)		
	401–508	(778–1000)		2.29	(0.090)		2.29	(0.090)		2.29	(0.090)			
				—			—			3.05	(0.120)	(HD)		
	509–1015	(1001–2000)		2.79	(0.110)		2.79	(0.110)		2.79	(0.110)			
				—			—			3.05	(0.120	(HD)		
2.4 kV to 35 kV	Refer to UL 1072 or NEMA WC74 for insulation thicknesses. For non-shielded 2.4kV cables, the insulation and jacket thicknesses shall be in accordance with those for wet location use.													

NOTE—Minimum point is 90% of minimum average for 0–2000 volt cables.

(HD) Heavy-duty insulation thicknesses should be considered for applications where installations and service conditions are such that the additional mechanical protection is considered necessary. Heavy-duty (HD) constructions are permitted supplied in single conductor sizes 4/0 AWG and larger for applications as cable external to enclosures for interconnection purposes. Where HD thicknesses are used on single conductor cables, and the thickness is applied in two layers, both layers of material should be Type P material.

Table 16—Jacket properties; types T, CP, N, and CPE

Jacket material	Thermo-plastic polyvinyl chloride	Thermoset chloro-sulfonated polyethylene	Thermoset neoprene	Thermoset chlorinated polyethylene
Jacket type designation	T[a]	CP[b]	N[c]	CPE[c]
Physical requirements unaged				
Tensile strength, N/mm^2 (lbf/in^2), min	10.3 (1500)	12.5 (1800)	12.5 (1800)	12.5 (1800)
Elongation at rupture, min %	100	300	300	300
Set, max %	—	30	20	30
For 60 °C (140 °F) rated jacket, aging requirements:				
After air oven at °C (°F)	100 ± 1 (212 ± 2)	100 ± 1 (212 ± 2)	100 ± 1 (212 ± 2)	100 ± 1 (212 ± 2)
Hours	120	168	168	168
Tensile strength, % of unaged, min	85	85	50	85
Elongation at rupture, % of unaged, min	60	65	50	55
For 75 °C (167 °F) rated jacket, aging requirements:				
After air oven at °C (°F)	100 ± 1 (212 ± 2)	113 ± 1 (235 ± 2)	100 ± 1 (212 ± 2)	113 ± 1 (235 ± 2)
Hours	240	168	240	168
Tensile strength, % of unaged, min	85	85	50	85
Elongation at rupture, % of unaged, min	60	65	50	55
For 90 °C (194 °F) rated jacket, aging requirements:				
After air oven at °C (°F)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)
Hours	168	168	240	168
Tensile strength, % of unaged, min	85	85	6.2 N/mm^2[d] (900 lbf/in^2)	85
Elongation at rupture, % of unaged, min	60	65	50%[d]	55
After oil immersion at °C (°F)	70 ± 1 (158 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)	121 ± 1 (249 ± 2)
Hours	4	18	18	18

Table 16—Jacket properties; types T, CP, N, and CPE

Jacket material	Thermo-plastic polyvinyl chloride	Thermoset chloro-sulfonated polyethylene	Thermoset neoprene	Thermoset chlorinated polyethylene
Tensile strength, % of unaged, min	80	60	80	60
Elongation at rupture, % of unaged, min	60	60	60	60
Sunlight Resistance[e]	Pass	Pass	Pass	Pass
Heat distortion at 121°C ± 1°C (249°F ± 2°F), max %	50	—	—	—
Heat shock, at 121°C ± 1°C (249°F ± 2°F)	no cracks	—	—	—
Mechanical water absorption, mg/cm^2 (mg/in^2), max	3.88 (25)	15.5 (100)	20.2 (130)	20.2 (130)
Tear, N/mm (lbf/in), min[f]	6.1 (35)	6.1 (35)	6.1 (35)	6.1 (35)

[a]For test procedures, refer to NEMA WC 57.
[b]For test procedures, refer to NEMA WC 70.
[c]For test procedures, refer to NEMA WC 70 for 0–2000 V or NEMA WC 74 for 2001 V and greater.
[d]Actual values, not retention of unaged values.
[e]For test procedures, refer to UL 1581 Section 1200 for a 720 h exposure.
[f]For test procedures, refer to ASTM D470.

Table 17—Low-smoke, halogen-free jacket properties: types L (XLPO) and TPO (TPPO)

Jacket material	Thermoset cross-linked polyolefin (XLPO)	Thermoplastic polyolefin (TPPO)
Jacket type designation	L	TPO
Physical requirements Unaged:		
Tensile strength, N/mm^2 (lbf/in^2), min	8.9 (1300)	9.6 (1400)
Elongation at rupture, min %	160	100
Aging requirements: after air oven at		
Temperature °C (°F)	121 ±1 (249 ±2)	100 ± 1 (212 ±2)
Duration (hours)	168	168

Table 17—Low-smoke, halogen-free jacket properties: types L (XLPO) and TPO (TPPO)

Jacket material	Thermoset cross-linked polyolefin (XLPO)	Thermoplastic polyolefin (TPPO)
Tensile strength, % of unaged, min	60	75
Elongation at rupture, % of unaged, min	60	60
After oil immersion (ASTM No. 2 or IRM 902)		
Temperature °C (°F)	121 ± 1 (249 ±2)	70 ± 1 (158 ±2)
Duration (hours)	18	4
Tensile strength, % retention	50	60
Elongation, % retention	50	60
Heat distortion at °C (°F)	121 ± 1 (249 ±2)	90 ± 1 (194 ±2)
Max %	30	25
Sunlight Resistance[a]	Pass	Pass
Acid gas equivalent, pH min[b]	3.56	3.56
Halogen content, % max[c]	0.2	0.2
Smoke index, max[e]	25	25
Toxicity index, max[f]	5	5
Hot creep test per ICEA T-28-562 with following modifications:		
Temperature of air oven °C (°F)	200 ± 2 (392 ±3)	
Hot creep elongation, max	25%	—
Hot creep set, max	5%	—
Tear, N/mm (lbf/in), min[d]	6.1 (35)	6.1 (35)
NEMA test procedure reference	NEMA WC 57, Part 7	NEMA WC 57, Part 7

[a]For test procedures, refer to UL 1581 Section 1200 for a 720 h exposure.
[b]For test procedures, refer to IEC 60754-2.
[c]For test procedures, refer to NEMA WC 57.
[d]For test procedures, refer to ASTM D470.
[e]For test procedures, refer to NES 711.
[f]For test procedures, refer to NES 713.

Table 18—Thickness of jackets

Calculated diameter of cable under jacket, mm (in)	Jacket thickness minimum average, mm (in)
0–10.79 (0–0.425)	1.14 (0.045)[a]
10.80–17.78 (0.426–0.700)	1.52 (0.060)
17.79–38.10 (0.701–1.500)	2.03 (0.080)
38.11–63.50 (1.501–2.500)	2.79 (0.110)
63.51 and larger (2.501 and larger)	3.56 (0.140)

[a]1.52 mm (060 in) is optional for a heavy-duty jacket. Minimum point is 80% of minimum average wall.

Table 19—High-voltage ac test potentials; types E, S, X, T, T/N, LSE, LSX, LSS, and P cables

	Test potentials (kV)					
	0–300 V	301–600/1000 V	1001–2000 V		2400 V	
					Nonshielded	
Conductor AWG or circular mil						
22–19	1.5	1.5	—		—	
18–15	1.5	1.5	—		—	
14–9	—	3.5	5.5		—	
8–2	—	5.5	7.0		13.0	
1–4/0	—	7.0	8.0		13.0	
250 000–525 000	—	8.0	9.5		13.0	
525 001 and larger	—	10.0	11.5		13.0	

Rated circuit voltage phase to phase	Conductor size	100% insulation level (grounded neutral)	133% insulation level (ungrounded neutral)
2001 – 5000	8 AWG – 1111 kcmil	18	18
5001 – 8000	6 AWG – 1111 kcmil	23	28
8001 – 15000	2 AWG – 1111 kcmil	35	44
15001 – 25000	1 AWG – 1111 kcmil	52	64
25001 – 28000	1 AWG – 1111 kcmil	56	69
28001 – 35000	1/0 AWG – 1111 kcmil	69	84

Table 20—AC spark test voltage

Cable voltage rating		0–300 V	301–600/1000 V	1001/2000 V
Conductor AWG or kcmil	mm^2	AC spark test voltage (kV)		
22–20	0.32–0.52	1.75	—	—
19–16	0.53–1.31	1.75	7.5	—
15–10	1.32–5.26	1.75	7.5	10.0
9–8	5.27–8.38	—	10.0	12.5
7–2	8.39–31.3	—	10.0	12.5
1–4/0	1.4 –107.0	—	12.5	15.0
250–500	107.1– 254.0	—	15.0	17.5
501–1000	254.1–508.0	—	17.5	20.0
1001–2000	508.1–1015.0	—	20.0	22.5

Table 21—Temperature correction factor *M* [a] for adjusting insulation resistance to 15.6°C (60°F)

Temp °C (°F)	Resistivity coefficient *C* (see Results)										
	1.02	**1.04**	**1.06**	**1.08**	**1.10**	**1.12**	**1.14**	**1.16**	**1.18**	**1.20**	**1.22**
5.0 (41.0)	0.81	0.66	0.54	0.44	0.36	0.30	0.25	0.21	0.17	0.14	0.12
6.0 (42.8)	0.83	0.69	0.57	0.48	0.40	0.34	0.28	0.24	0.20	0.17	0.15
7.0 (44.6)	0.84	0.71	0.61	0.52	0.44	0.38	0.32	0.28	0.24	0.21	0.18
8.0 (46.4)	0.86	0.74	0.64	0.56	0.48	0.42	0.37	0.32	0.28	0.25	0.22
9.0 (48.2)	0.88	0.77	0.68	0.60	0.53	0.47	0.42	0.38	0.34	0.30	0.27
10.0 (50.0)	0.90	0.80	0.72	0.65	0.59	0.53	0.48	0.44	0.40	0.36	0.33
11.0 (51.8)	0.91	0.83	0.76	0.70	0.65	0.59	0.55	0.51	0.47	0.43	0.40
12.0 (53.6)	0.93	0.87	0.81	0.76	0.71	0.66	0.62	0.59	0.55	0.52	0.49
13.0 (55.4)	0.95	0.90	0.86	0.82	0.78	0.74	0.71	0.68	0.65	0.62	0.60
14.0 (57.2)	0.97	0.94	0.91	0.88	0.86	0.83	0.81	0.79	0.77	0.75	0.73
15.0 (59.0)	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89
15.6 (60.0)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16.0 (60.8)	1.01	1.02	1.02	1.03	1.04	1.05	1.05	1.06	1.07	1.08	1.08
17.0 (62.6)	1.03	1.06	1.08	1.11	1.14	1.17	1.20	1.23	1.26	1.29	1.32
18.0 (64.4)	1.05	1.10	1.15	1.20	1.26	1.31	1.37	1.43	1.49	1.55	1.61
19.0 (66.2)	1.07	1.14	1.22	1.30	1.38	1.47	1.56	1.66	1.76	1.86	1.97
20.0 (68.0)	1.09	1.19	1.29	1.40	1.52	1.65	1.78	1.92	2.07	2.23	2.40
21.0 (69.8)	1.11	1.24	1.37	1.52	1.67	1.84	2.03	2.23	2.44	2.68	2.93
22.0 (71.6)	1.14	1.29	1.45	1.64	1.84	2.07	2.31	2.59	2.88	3.21	3.57

Table 21—Temperature correction factor *M* [a] for adjusting insulation resistance to 15.6°C (60°F)

Temp °C (°F)	Resistivity coefficient *C* (see Results)										
	1.02	**1.04**	**1.06**	**1.08**	**1.10**	**1.12**	**1.14**	**1.16**	**1.18**	**1.20**	**1.22**
23.0 (73.4)	1.16	1.34	1.54	1.77	2.02	2.31	2.64	3.00	3.40	3.85	4.36
24.0 (75.2)	1.18	1.39	1.63	1.91	2.23	2.59	3.01	3.48	4.02	4.63	5.31
25.0 (77.0)	1.20	1.45	1.73	2.06	2.45	2.90	3.43	4.04	4.74	5.55	6.48
26.0 (78.8)	1.23	1.50	1.83	2.23	2.69	3.25	3.91	4.68	5.59	6.66	7.91
27.0 (80.6)	1.25	1.56	1.94	2.40	2.96	3.64	4.45	5.43	6.60	7.99	9.65
28.0 (82.4)	1.28	1.63	2.06	2.60	3.26	4.08	5.08	6.30	7.79	9.59	11.77
29.0 (84.2)	1.30	1.69	2.18	2.80	3.59	4.57	5.79	7.31	9.19	11.51	14.36
30.0 (86.0)	1.33	1.76	2.31	3.03	3.95	5.11	6.60	8.48	10.84	13.81	17.52
31.0 (87.8)	1.36	1.83	2.45	3.27	4.34	5.73	7.52	9.83	12.79	16.57	21.38
32.0 (89.6)	1.38	1.90	2.60	3.53	4.77	6.41	8.58	11.41	15.10	19.89	26.08
33.0 (91.4)	1.41	1.98	2.76	3.82	5.25	7.18	9.78	13.23	17.81	23.86	31.82
34.0 (93.2)	1.44	2.06	2.92	4.12	5.78	8.05	11.14	15.35	21.02	28.64	38.82
35.0 (95.0)	1.47	2.14	3.10	4.45	6.35	9.01	12.70	17.80	24.80	34.36	47.36

[a]Calculated from the formula $M = C^{(t - 15.6)}$ in which C is determined as described in 5.17.4 and t is the temperature of the cable in degrees Celsius.

Table 22—Color code (NEMA WC 57 Table E-1)

Conductor Number	Base color	Tracer color	Tracer color	Conductor number	Base color	Tracer color	Tracer color
1	Black			35	White	Red	Orange
2	White			36	Orange	White	Blue
3	Red			37	White	Red	Blue
4	Green			38	Black	White	Green
5	Orange			39	White	Black	Green
6	Blue			40	Red	White	Green
7	White	Black		41	Green	White	Blue
8	Red	Black		42	Orange	Red	Green
9	Green	Black		43	Blue	Red	Green
10	Orange	Black		44	Black	White	Blue
11	Blue	Black		45	White	Black	Blue
12	Black	White		46	Red	White	Blue
13	Red	White		47	Green	Orange	Red
14	Green	White		48	Orange	Red	Blue
15	Blue	White		49	Blue	Red	Orange
16	Black	Red		50	Black	Orange	Red
17	White	Red		51	White	Black	Orange
18	Orange	Red		52	Red	Orange	Black
19	Blue	Red		53	Green	Red	Blue
20	Red	Green		54	Orange	Black	Blue
21	Orange	Green		55	Blue	Black	Orange
22	Black	White	Red	56	Black	Orange	Green
23	White	Black	Red	57	White	Orange	Green
24	Red	Black	White	58	Red	Orange	Green
25	Green	Black	White	59	Green	Black	Blue
26	Orange	Black	White	60	Orange	Green	Blue
27	Blue	Black	White	61	Blue	Green	Orange
28	Black	Red	Green	62	Black	Red	Blue
29	White	Red	Green	63	White	Orange	Blue
30	Red	Black	Green	64	Red	Black	Blue
31	Green	Black	Orange	65	Green	Orange	Blue
32	Orange	Black	Green	66	Orange	White	Red
33	Blue	White	Orange	67	Blue	White	Red
34	Black	White	Orange	68	Black	Green	Blue

Table 22—Color code (NEMA WC 57 Table E-1)

Conductor Number	Base color	Tracer color	Tracer color	Conductor number	Base color	Tracer color	Tracer color
69	White	Green	Blue	99	Yellow	White	
70	Red	Green	Blue	100	Yellow	Red	
71	Green	White	Red	101	Yellow	Green	
72	Orange	Red	Black	102	Yellow	Orange	
73	Blue	Red	Black	103	Yellow	Blue	
74	Black	Orange	Blue	104	Black	Yellow	
75	Red	Orange	Blue	105	White	Yellow	
76	Green	Red	Black	106	Red	Yellow	
77	Orange	White	Green	107	Green	Yellow	
78	Blue	White	Green	108	Orange	Yellow	
79	Red	White	Orange	109	Blue	Yellow	
80	Green	White	Orange	110	Black	Yellow	Red
81	Blue	Black	Green	111	White	Yellow	Red
82	Orange	White		112	Green	Yellow	Red
83	Green	Red		113	Orange	Yellow	Red
84	Black	Green		114	Blue	Yellow	Red
85	White	Green		115	Black	Yellow	White
86	Blue	Green		116	Red	Yellow	White
87	Black	Orange		117	Green	Yellow	White
88	White	Orange		118	Orange	Yellow	White
89	Red	Orange		119	Blue	Yellow	White
90	Green	Orange		120	Black	Yellow	Green
91	Blue	Orange		121	White	Yellow	Green
92	Black	Blue		122	Red	Yellow	Green
93	White	Blue		123	Orange	Yellow	Green
94	Red	Blue		124	Blue	Yellow	Green
95	Green	Blue		125	Black	Yellow	Blue
96	Orange	Blue		126	White	Yellow	Blue
97	Yellow			127	Red	Yellow	Blue
98	Yellow	Black					

Table 23—Color code without white and green (NEMA WC 57 Table E-2)

Conductor number	Base color	Tracer color
1	Black	
2	Red	
3	Blue	
4	Orange	
5	Yellow	
6	Brown	
7	Red	Black
8	Blue	Black
9	Orange	Black
10	Yellow	Black
11	Black	Red
12	Blue	Red
13	Blue	Red
14	Orange	Red
15	Yellow	Red
16	Brown	Red
17	Black	Blue
18	Red	Blue
19	Orange	Blue
20	Yellow	Blue
21	Brown	Blue
22	Black	Orange
23	Red	Orange
24	Blue	Orange
25	Yellow	Orange
26	Brown	Orange
27	Black	Yellow
28	Red	Yellow
29	Blue	Yellow
30	Orange	Yellow
31	Brown	Yellow
32	Black	Brown
33	Red	Brown
34	Blue	Brown
35	Orange	Brown
36	Yellow	Brown

Table 23—Color code without white and green (NEMA WC 57 Table E-2)

Conductor number	Base color	Tracer color

NOTE—If an insulated conductor is functioning as a grounding conductor (normally not a current carrying conductor), then it shall be identified as green or green and yellow. The grounding conductor is not counted in the number of conductors in the cable and is designated as: X/C W Z INSULATED GROUNDS.

where

X is the number of conductors excluding the insulated grounding conductor.

Z is the number of grounding conductors.

6. Cable application and installation

For cable application and installation guidelines refer to API RP14F or API RP14FZ, as applicable, for fixed and floating offshore facilities and IEEE Std 45 for shipboard. Other cables not listed in this document are provided in API RP14F, API RP14FZ, and IEEE Std 45.

Annex A

(informative)

Repeated flexing test equipment

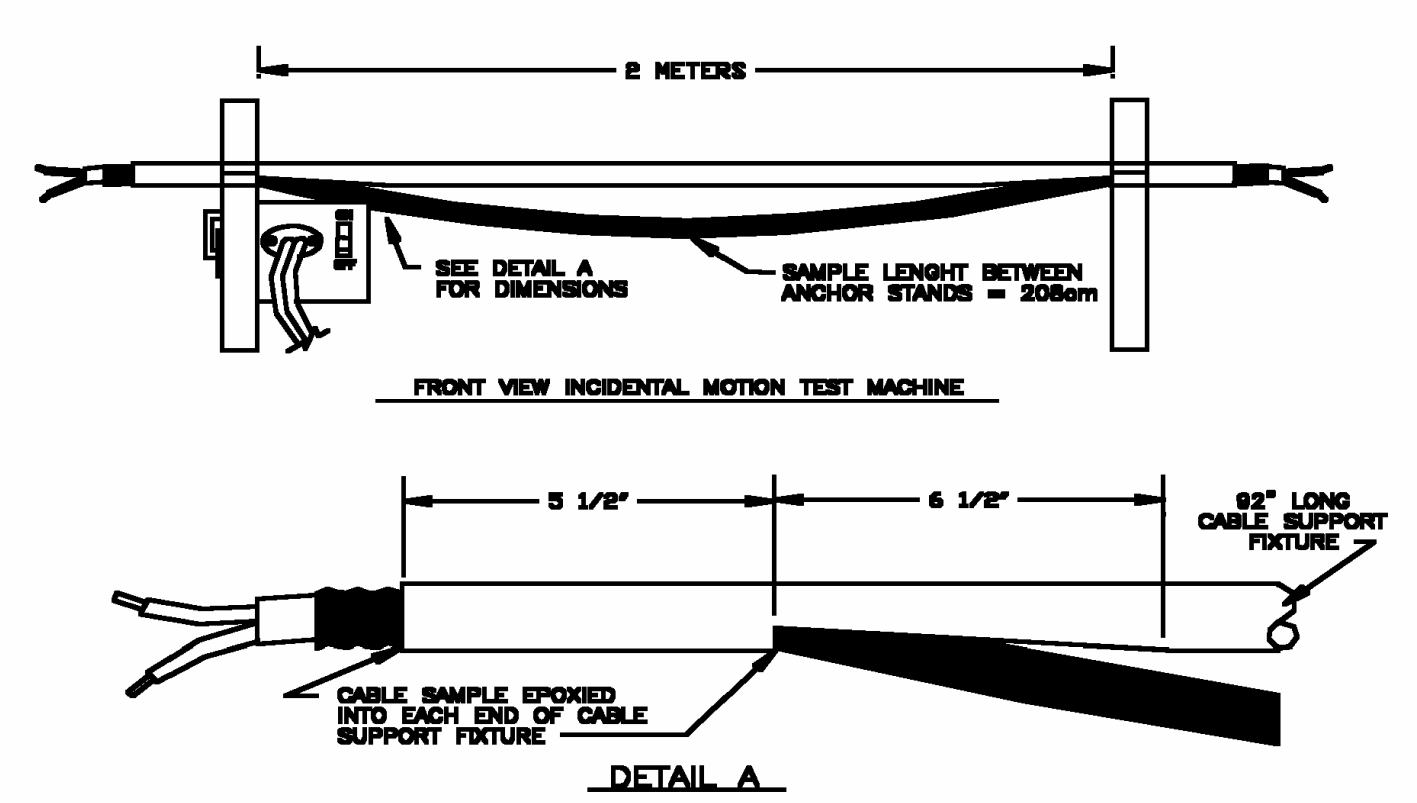

Figure A.1—Front view with cable support detail

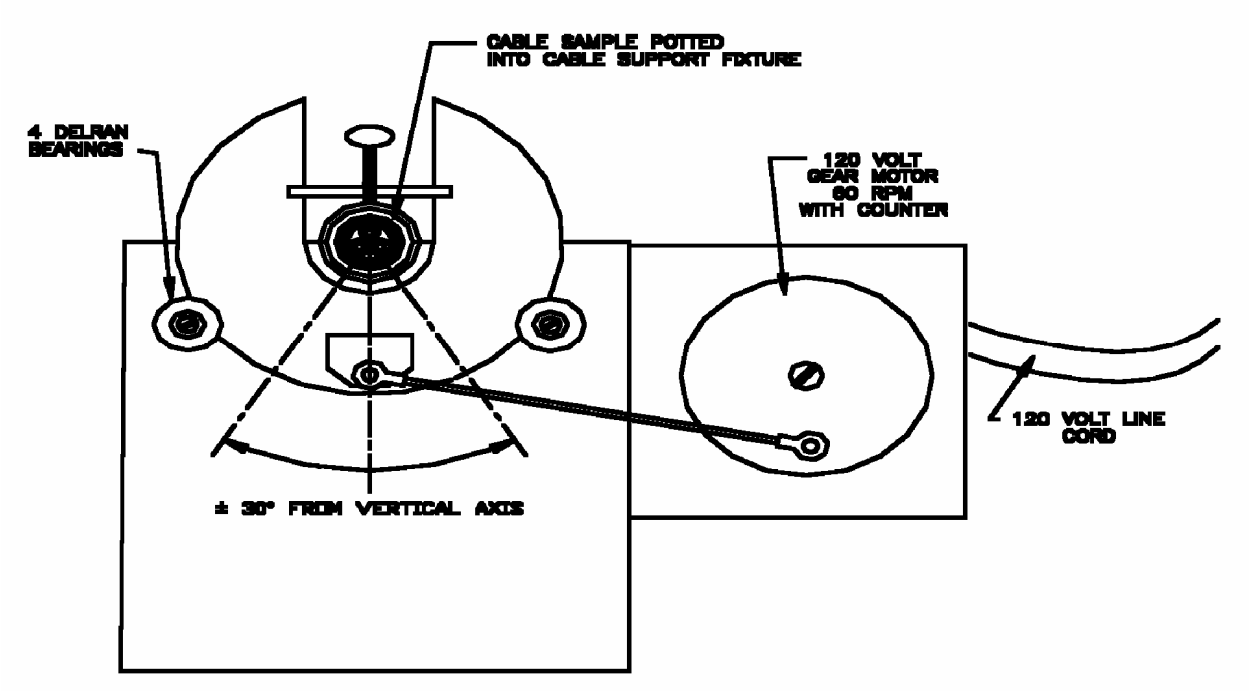

Figure A.2—Motion mechanism detail

Annex B

(informative)

Typical cable dimensions and weights

Table B.1—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type E, X, S, LSE, LSX, LSS, and T distribution cables

Number of conductors	AWG /kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1	14	0.22	32	0.28	45	0.38	77
1	12	0.24	42	0.30	55	0.40	89
1	10	0.27	58	0.33	74	0.43	111
1	8	0.33	87	0.39	105	0.49	147
1	6	0.36	121	0.42	142	0.52	187
1	4	0.41	177	0.47	201	0.60	268
1	2	0.47	261	0.53	288	0.66	363
1	1	0.57	348	0.63	379	0.75	459
1	1/0	0.61	423	0.67	456	0.79	540
1	2/0	0.66	519	0.72	554	0.88	678
1	3/0	0.71	635	0.77	672	0.93	803
1	4/0	0.77	781	0.83	821	0.99	962
1	250	0.88	954	0.94	999	1.11	1167
1	300	0.93	1122	0.99	1169	1.16	1345
1	350	0.98	1289	1.04	1339	1.21	1524
1	400	1.03	1453	1.09	1506	1.26	1698
1	500	1.11	1783	1.17	1839	1.34	2045
1	600	1.22	2136	1.28	2201	1.45	2425
1	750	1.33	2628	1.39	2699	1.56	2941
1	1000	1.48	3440	1.54	3518	1.77	3884
2	14	0.36	72	0.42	93	0.52	138

Table B.1—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type E, X, S, LSE, LSX, LSS, and T distribution cables

Number of conductors	AWG /kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	12	0.40	95	0.46	116	0.59	182
2	10	0.46	134	0.52	161	0.65	235
2	8	0.61	217	0.67	250	0.80	342
2	6	0.67	312	0.73	347	0.90	480
2	4	0.77	440	0.83	480	1.00	630
2	2	0.93	685	0.99	732	1.16	908
2	1	1.05	847	1.11	900	1.28	1095
2	1/0	1.13	1020	1.19	1076	1.36	1285
2	2/0	1.23	1230	1.29	1295	1.46	1521
2	3/0	1.33	1489	1.39	1560	1.56	1802
2	4/0	1.45	1821	1.51	1897	1.75	2274
2	250	1.59	2157	1.65	2240	1.89	2650
2	300	1.76	2660	1.82	2754	2.05	3183
2	350	1.86	3031	1.92	3131	2.15	3583
2	400	1.96	3442	2.02	3548	2.25	4022
2	500	2.12	4193	2.18	4307	2.41	4816
2	600	2.34	5015	2.40	5142	2.63	5700
2	750	2.56	6106	2.62	6249	2.91	7022
3	14	0.38	93	0.44	114	0.57	177
3	12	0.42	123	0.48	147	0.61	215
3	10	0.49	176	0.55	203	0.68	280
3	8	0.65	290	0.71	323	0.88	453
3	6	0.72	409	0.78	446	0.94	578
3	4	0.82	591	0.88	634	1.05	793
3	2	0.99	903	1.05	953	1.22	1139
3	1	1.12	1138	1.18	1194	1.35	1401
3	1/0	1.21	1379	1.27	1444	1.44	1666
3	2/0	1.32	1693	1.38	1764	1.55	2004
3	3/0	1.43	2093	1.49	2169	1.65	2412
3	4/0	1.56	2553	1.62	2636	1.85	3020
3	250	1.77	3114	1.83	3208	2.06	3640

Table B.1—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type E, X, S, LSE, LSX, LSS, and T distribution cables

Number of conductors	AWG /kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
3	300	1.88	3666	1.94	3766	2.17	4222
3	350	1.99	4218	2.05	4324	2.28	4804
3	400	2.09	4776	2.15	4887	2.39	5412
3	500	2.27	5850	2.33	5973	2.56	6515
3	600	2.51	7015	2.57	7153	2.86	7912
3	750	2.81	8797	2.87	8953	3.16	9796
4	14	0.42	117	0.48	141	0.60	203
4	12	0.46	156	0.52	183	0.65	257
4	10	0.57	241	0.63	272	0.75	352
4	8	0.71	361	0.77	398	0.94	538
4	6	0.79	523	0.85	563	1.01	707
4	4	0.95	805	1.01	852	1.18	1032
4	2	1.09	1174	1.15	1230	1.32	1433
4	1	1.24	1485	1.30	1550	1.47	1777
4	1/0	1.34	1814	1.40	1885	1.56	2113
4	2/0	1.46	2224	1.52	2302	1.75	2664
4	3/0	1.58	2719	1.64	2802	1.87	3192
4	4/0	1.79	3434	1.85	3528	2.08	3964
4	250	1.96	4058	2.02	4164	2.25	4638
4	350	2.20	5506	2.26	5622	2.49	6148
4	400	2.32	6242	2.38	6369	2.61	6922
4	500	2.51	7664	2.57	7802	2.87	8588
4	600	2.84	9357	2.90	9513	3.20	10 395
4	750	3.11	11 506	3.17	11 682	3.46	12 609

NOTE 1—Cables with Type T, S, LSE, and LSX insulated conductors will vary from those shown.

NOTE 2—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.2—Typical dimensions and weights; single-, two-, three-, and four-conductor 2000 V; Type E and X distribution cables

Number of conductors	AWG/kc mil size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1	14	0.25	37	0.31	50	0.41	85
1	12	0.27	48	0.33	64	0.43	101
1	10	0.30	63	0.36	79	0.46	119
1	8	0.35	91	0.41	109	0.51	153
1	6	0.38	127	0.44	148	0.57	211
1	4	0.43	183	0.49	207	0.62	276
1	2	0.49	268	0.55	295	0.68	372
1	1	0.59	356	0.65	387	0.77	469
1	1/0	0.63	432	0.69	465	0.81	552
1	2/0	0.68	527	0.74	562	0.90	688
1	3/0	0.73	645	0.79	682	0.95	816
1	4/0	0.79	792	0.85	832	1.01	976
1	250	0.90	966	0.96	1011	1.13	1182
1	300	0.95	1134	1.01	1181	1.18	1361
1	350	1.00	1302	1.06	1352	1.23	1540
1	400	1.05	1469	1.11	1522	1.28	1717
1	500	1.13	1798	1.19	1854	1.36	2063
1	600	1.24	2153	1.30	2218	1.47	2445
1	750	1.35	2646	1.41	2717	1.58	2962
1	1000	1.50	3460	1.56	3538	1.79	3910
2	14	0.42	82	0.48	106	0.61	174
2	12	0.46	108	0.52	135	0.65	209
2	10	0.55	162	0.61	191	0.74	276
2	8	0.65	229	0.71	262	0.88	392
2	6	0.71	326	0.77	363	0.94	503
2	4	0.81	453	0.87	496	1.04	652
2	2	0.97	702	1.03	752	1.20	935
2	1	1.09	864	1.15	920	1.32	1123
2	1/0	1.17	1041	1.23	1103	1.40	1318

Table B.2—Typical dimensions and weights; single-, two-, three-, and four-conductor 2000 V; Type E and X distribution cables

Number of conductors	AWG/kc mil size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	2/0	1.27	1249	1.33	1317	1.50	1549
2	3/0	1.37	1512	1.43	1586	1.60	1834
2	4/0	1.49	1844	1.55	1922	1.79	2308
2	250	1.63	2182	1.69	2268	1.93	2687
2	300	1.80	2688	1.86	2782	2.09	3220
2	350	1.90	3062	1.96	3162	2.19	3622
2	400	2.00	3473	2.06	3579	2.29	4061
2	500	2.16	4227	2.22	4341	2.45	4859
2	600	2.38	5053	2.44	5167	2.67	5733
2	750	2.60	6146	2.66	6260	2.95	7044
3	12	0.49	141	0.55	168	0.68	245
3	10	0.59	211	0.65	242	0.77	324
3	8	0.69	303	0.75	338	0.92	475
3	4	0.91	648	0.97	695	1.14	868
3	2	1.04	933	1.10	986	1.27	1180
3	1	1.17	1168	1.23	1230	1.40	1445
3	1/0	1.25	1404	1.31	1469	1.48	1698
3	2/0	1.36	1714	1.42	1788	1.59	2035
3	4/0	1.60	2580	1.66	2663	1.89	3057
3	250	1.81	3146	1.87	3243	2.10	3683
3	300	1.92	3698	1.98	3801	2.21	4265
3	350	2.03	4252	2.09	4360	2.32	4849
3	400	2.14	4833	2.20	4947	2.43	5460
3	500	2.31	5890	2.37	6004	2.60	6555
3	600	2.55	7060	2.61	7174	2.90	7944
3	750	2.85	8847	2.91	8961	3.20	9815
4	14	0.49	131	0.55	158	0.67	228
4	10	0.64	261	0.70	294	0.83	390
4	8	0.76	381	0.82	421	0.99	569
4	4	1.00	831	1.06	881	1.22	1056

Table B.2—Typical dimensions and weights; single-, two-, three-, and four-conductor 2000 V; Type E and X distribution cables

Number of conductors	AWG/kc mil size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
4	2	1.14	1205	1.20	1261	1.37	1472
4	1	1.29	1516	1.35	1584	1.52	1819
4	1/0	1.38	1840	1.44	1914	1.61	2164
4	2/0	1.51	2260	1.57	2340	1.80	2714
4	3/0	1.63	2762	1.69	2848	1.92	3248
4	4/0	1.83	3463	1.89	3560	2.13	4025
4	250	2.00	4091	2.06	4197	2.29	4679
4	300	2.12	4812	2.18	4926	2.42	5458
4	350	2.25	5562	2.31	5676	2.54	6214
4	400	2.37	6302	2.43	6416	2.66	6980
4	500	2.56	7729	2.62	7843	2.91	8616
4	600	2.89	9433	2.95	9547	3.24	10 412
4	750	3.16	11 587	3.22	11 701	3.51	12 642

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.3—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type T/N distribution cables

Number of conductors		Unarmored		Armored		Armored and sheathed	
	AWG/kc mil size	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1	14	0.21	31	0.27	44	0.37	74
1	12	0.23	41	0.29	54	0.39	87
1	10	0.26	58	0.32	74	0.42	110
1	8	0.32	90	0.38	108	0.48	149
1	6	0.34	123	0.40	141	0.50	184
1	4	0.42	188	0.48	212	0.61	280

Table B.3—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type T/N distribution cables

Number of conductors		Unarmored		Armored		Armored and sheathed	
	AWG/kc mil size	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1	1	0.58	364	0.64	395	0.76	476
1	1/0	0.63	440	0.69	473	0.81	560
1	2/0	0.67	536	0.73	571	0.89	696
1	3/0	0.73	653	0.79	690	0.95	824
1	4/0	0.79	801	0.85	841	1.01	985
1	250	0.89	977	0.95	1022	1.12	1192
1	300	0.96	1163	1.02	1213	1.19	1394
1	350	1.00	1315	1.06	1365	1.23	1553
1	400	1.05	1505	1.11	1558	1.28	1753
1	500	1.13	1811	1.19	1867	1.36	2076
1	600	1.24	2225	1.30	2290	1.47	2517
1	750	1.34	2686	1.40	2757	1.57	3001
1	1000	1.49	3530	1.55	3608	1.78	3978
2	14	0.34	68	0.40	86	0.50	129
2	12	0.38	94	0.44	115	0.57	178
2	10	0.44	134	0.50	158	0.63	228
2	8	0.59	223	0.65	254	0.78	343
2	6	0.63	316	0.69	349	0.82	444
2	4	0.79	463	0.85	503	1.02	656
2	2	0.95	711	1.01	758	1.18	938
2	1	1.07	881	1.13	937	1.30	1137
2	1/0	1.17	1058	1.23	1120	1.40	1335
2	2/0	1.25	1266	1.31	1331	1.48	1560
2	3/0	1.37	1529	1.43	1603	1.60	1851
2	4/0	1.49	1863	1.55	1941	1.79	2327
2	250	1.61	2203	1.67	2289	1.91	2703
2	300	1.82	2748	1.88	2845	2.11	3287
2	350	1.90	3088	1.96	3188	2.19	3648
2	400	2.00	3548	2.06	3654	2.29	4136
2	500	2.16	4254	2.22	4368	2.45	4886

Table B.3—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type T/N distribution cables

Number of conductors		Unarmored		Armored		Armored and sheathed	
	AWG/kc mil size	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	600	2.38	5201	2.44	5331	2.67	5897
2	750	2.58	6226	2.64	6369	2.93	7147
3	12	0.40	122	0.46	143	0.59	209
3	10	0.47	177	0.53	204	0.65	272
3	8	0.63	300	0.69	333	0.81	420
3	6	0.67	411	0.73	446	0.90	579
3	4	0.89	664	0.95	709	1.11	868
3	2	1.02	949	1.08	1002	1.24	1181
3	1	1.15	1197	1.21	1256	1.37	1454
3	1/0	1.25	1429	1.31	1494	1.48	1723
3	2/0	1.34	1743	1.40	1814	1.57	2058
3	3/0	1.47	2145	1.53	2223	1.76	2587
3	4/0	1.60	2608	1.66	2691	1.89	3085
3	250	1.79	3181	1.85	3275	2.08	3711
3	300	1.94	3783	2.00	3886	2.23	4355
3	350	2.03	4292	2.09	4400	2.32	4889
3	400	2.14	4944	2.20	5058	2.43	5571
3	500	2.31	5930	2.37	6057	2.60	6608
3	600	2.55	7283	2.61	7421	2.90	8191
3	750	2.83	8972	2.89	9128	3.18	9976
4	14	0.39	108	0.45	129	0.58	193
4	12	0.44	155	0.50	179	0.63	249
4	10	0.51	223	0.57	252	0.70	332
4	8	0.69	377	0.75	412	0.92	549
4	6	0.74	532	0.80	569	0.97	714
4	4	0.97	846	1.03	896	1.20	1079
4	2	1.12	1230	1.18	1286	1.35	1493
4	1	1.26	1546	1.32	1614	1.49	1844
4	1/0	1.38	1873	1.44	1947	1.61	2197
4	2/0	1.48	2288	1.54	2366	1.77	2732

Table B.3—Typical dimensions and weights; single-, two-, three-, and four-conductor 600/1000 V; Type T/N distribution cables

Number of conductors		Unarmored		Armored		Armored and sheathed	
	AWG/kcmil size	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
4	3/0	1.63	2795	1.69	2881	1.92	3281
4	4/0	1.83	3500	1.89	3597	2.13	4062
4	250	1.98	4142	2.04	4248	2.27	4726
4	300	2.15	4942	2.21	5056	2.44	5572
4	350	2.25	5616	2.31	5735	2.54	6273
4	400	2.37	6450	2.43	6580	2.66	7144
4	500	2.56	7782	2.62	7925	2.91	8698
4	600	2.89	9730	2.95	9889	3.24	10 754
4	750	3.13	11 731	3.19	11 907	3.49	2873

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.4—Typical dimensions and weights; single conductor 2000 V; Type P distribution cables

Conductor size in AWG or kcmil	Unarmored		Armored		Armored and sheathed	
	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
18	0.143	16	0.193	29	0.324	38
16	0.153	18	0.203	32	0.334	42
14	0.168	25	0.218	45	0.349	60
12	0.187	32	0.237	58	0.368	80
10	0.207	51	0.257	93	0.388	127
8	0.255	71	0.305	116	0.436	159
6	0.295	108	0.345	155	0.476	204
4	0.377	173	0.427	230	0.558	296
2	0.443	242	0.493	303	0.624	366
1	0.484	335	0.534	406	0.665	468

Table B.4—Typical dimensions and weights; single conductor 2000 V; Type P distribution cables

Conductor size in AWG or kcmil	Unarmored		Armored		Armored and sheathed	
	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1/0	0.548	420	0.598	494	0.729	571
2/0	0.615	494	0.665	579	0.796	662
3/0	0.663	734	0.713	776	0.886	900
4/0	0.729	820	0.779	889	0.952	1036
262 kcmil	0.888	945	0.938	1147	1.111	1295
313 kcmil	0.954	1113	1.004	1332	1.177	1491
373 kcmil	1.018	1419	1.068	1576	1.241	1741
444 kcmil	1.094	1578	1.144	1816	1.317	1992
535 kcmil	1.212	1976	1.262	2246	1.435	2425
646 kcmil	1.300	2348	1.350	2559	1.523	2757
777 kcmil	1.395	2795	1.445	3013	1.618	3205
1111kcmil	1.652	3982	1.702	4129	1.938	4484

NOTE—These values are for reference purposes only and should not be construed as requirements. Weights of armored constructions are based on bronze braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.5—Typical dimensions and weights; two-, three-, four-, and five-conductor 600/1000 V; Type P distribution cable

Number of conductors	Conductor size in AWG or kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	16	0.373	75	0.423	141	0.554	202
2	14	0.403	95	0.453	165	0.584	230
2	12	0.441	117	0.491	194	0.622	263
2	10	0.481	148	0.531	233	0.662	307
2	8	0.600	221	0.650	327	0.781	416
2	6	0.680	308	0.730	424	0.903	559

Table B.5—Typical dimensions and weights; two-, three-, four-, and five-conductor 600/1000 V; Type P distribution cable

Number of conductors	Conductor size in AWG or kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	4	0.887	516	0.937	664	1.110	835
2	1/0	1.224	1128	1.274	1334	1.447	1562
2	4/0	1.562	2003	1.612	2271	1.848	2680
3	16	0.392	66	0.442	128	0.573	182
3	14	0.424	102	0.474	176	0.605	236
3	12	0.465	133	0.515	212	0.646	276
3	10	0.508	189	0.558	281	0.689	352
3	8	0.637	274	0.687	385	0.818	477
3	6	0.723	390	0.773	519	0.946	650
3	4	0.942	678	0.992	843	1.165	1004
3	2	1.084	887	1.134	967	1.307	1194
3	1	1.208	1284	1.258	1458	1.431	1675
3	1/0	1.306	1448	1.356	1781	1.529	2015
3	2/0	1.422	1945	1.472	2082	1.645	2424
3	3/0	1.528	2379	1.578	2720	1.814	3106
3	4/0	1.670	2864	1.720	3233	1.956	3652
3	262	1.949	3452	1.999	3880	2.235	4434
3	313	2.092	4023	2.142	4434	2.378	4919
3	373	2.231	4772	2.281	5219	2.517	5718
3	444	2.394	5670	2.444	6176	2.680	6864
3	535	2.637	6784	2.687	7492	2.986	8250
3	646	2.890	7961	2.940	8414	3.239	9258
3	777	3.111	9573	3.161	10 065	3.460	10 945
4	16	0.423	99	0.473	154	0.604	227
4	14	0.459	128	0.509	213	0.640	275
4	12	0.505	168	0.555	256	0.686	323
4	10	0.553	243	0.603	313	0.734	390
4	8	0.698	355	0.748	466	0.921	591
4	6	0.794	533	0.844	669	1.017	808
4	4	1.035	879	1.085	1062	1.258	1236
4	2	1.194	1120	1.244	1345	1.417	1677

Table B.5—Typical dimensions and weights; two-, three-, four-, and five-conductor 600/1000 V; Type P distribution cable

Number of conductors	Conductor size in AWG or kcmil	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
4	1	1.332	1602	1.382	1909	1.555	2144
4	1/0	1.442	1907	1.492	2180	1.665	2434
4	2/0	1.573	2535	1.623	2665	.859	3050
4	3/0	1.754	3206	1.804	3578	2.040	4003
4	4/0	1.913	3765	1.963	4214	2.199	4670
4	262	2.155	4625	2.205	4795	2.441	5610
4	313	2.315	5367	2.365	5868	2.601	6395
4	373	2.471	6462	2.521	6853	2.820	7576
4	444	2.653	7560	2.703	7987	3.002	8760
4	535	2.989	9284	3.039	9762	3.338	105 70
4	646	3.201	10 571	3.251	10 946	3.550	11 840
5	18	0.431	100	0.481	171	0.612	221
5	16	0.458	110	0.508	189	0.639	264
5	14	0.498	149	0.548	234	0.679	301
5	12	0.550	196	0.600	266	0.731	334
5	10	0.604	296	0.654	406	0.785	494
5	8	0.765	453	0.815	569	0.988	704
5	6	0.914	653	0.964	813	1.137	973
5	4	1.137	1073	1.187	1292	1.360	1481
5	2	1.315	1361	1.365	1637	1.538	1856
5	1	1.470	2130	1.520	2192	1.756	2482
5	1/0	1.593	2550	1.643	2746	1.879	3108
5	2/0	1.802	2954	1.852	3301	2.088	3734
5	4/0	2.112	3615	2.162	3955	2.398	4592

NOTE—These values are for reference purposes only and should not be construed as requirements. Weights of armored constructions are based on bronze braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.6—Typical dimensions and weights; three-conductor 5000 V; Type E and X distribution cables

AWG/ kcmil size	Unarmored		Armored		Armored and sheathed	
	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
8	1.14	783	1.20	839	1.37	1050
6	1.21	934	1.27	999	1.44	1221
4	1.33	1163	1.39	1234	1.56	1476
2	1.46	1541	1.52	1619	1.75	1981
1	1.56	1760	1.62	1843	1.85	2227
1/0	1.63	2035	1.69	2121	1.92	2521
2/0	1.79	2498	1.85	2592	2.08	3028
3/0	1.91	2946	1.97	3049	2.20	3511
4/0	2.03	3476	2.09	3584	2.32	4073
250 kcmil	2.13	4006	2.19	4120	2.42	4631
300 kcmil	2.25	4611	2.31	4725	2.54	5263
350 kcmil	2.36	5210	2.42	5324	2.65	5886
400 kcmil	2.46	5767	2.52	5881	2.82	6653
500 kcmil	2.69	7008	2.75	7122	3.04	7932
600 kcmil	2.92	8331	2.98	8445	3.28	9350
750 kcmil	3.15	9068	3.21	9182	3.51	10 153

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.7—Typical Dimensions and weights; one conductor 5000 V; Type E and X distribution cables

AWG/ kcmil size	Unarmored		Armored		Armored and sheathed	
	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
8	0.58	234	0.64	265	0.76	346
6	0.61	279	0.67	312	0.79	396
4	0.66	345	0.72	380	0.89	512
2	0.72	453	0.78	490	0.95	632
1	0.77	525	0.83	565	1.00	715
1/0	0.80	608	0.86	648	1.03	802
2/0	0.89	755	0.95	800	1.12	970
3/0	0.94	883	1.00	930	1.17	1107
4/0	1.00	1050	1.06	1100	1.23	1288
250 kcmil	1.04	1192	1.10	1245	1.27	1439
300 kcmil	1.10	1376	1.16	1432	1.33	1636
350 kcmil	1.15	1557	1.21	1616	1.38	1828
400 kcmil	1.20	1740	1.26	1802	1.43	2023
500 kcmil	1.30	2111	1.36	2179	1.53	2416
600 kcmil	1.38	2462	1.44	2536	1.61	2786
750 kcmil	1.49	2669	1.55	2747	1.78	3117
1000 kcmil	1.64	3835	1.70	3921	1.93	4323

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.8—Typical dimensions and weights; multiconductor control 600/1000 V; type T, E, X, S, LSE, and LSX cables

Number of conductors	Conductor AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	18	0.32	43	0.38	61	0.48	102
3	18	0.34	53	0.40	71	0.49	110
4	18	0.37	65	0.43	86	0.55	143
7	18	0.43	94	0.49	118	0.62	187
10	18	0.57	145	0.63	176	0.76	263
14	18	0.62	187	0.68	220	0.80	306
16	18	0.65	206	0.71	239	0.88	369
19	18	0.68	233	0.74	268	0.91	403
24	18	0.79	288	0.85	328	1.02	481
30	18	0.88	380	0.94	425	1.11	593
37	18	0.94	444	1.00	491	1.17	668
40	18	1.01	483	1.07	536	1.24	725
61	18	1.16	678	1.22	740	1.39	954
2	16	0.34	50	0.40	68	0.50	111
3	16	0.36	64	0.42	85	0.51	125
4	16	0.39	77	0.45	98	0.58	162
7	16	0.46	119	0.52	146	0.65	220
10	16	0.61	181	0.67	214	0.80	306
14	16	0.66	233	0.72	268	0.89	400
16	16	0.70	263	0.76	298	0.93	437
19	16	0.73	309	0.79	346	0.96	490
24	16	0.89	404	0.95	449	1.12	619
30	16	0.94	480	1.00	527	1.17	704
37	16	1.01	570	1.07	623	1.24	812
40	16	1.09	623	1.15	679	1.32	882
61	16	1.25	881	1.31	946	1.48	1175
7	14	0.49	164	0.55	191	0.68	268
10	14	0.65	248	0.71	281	0.88	411
14	14	0.71	329	0.77	366	0.93	497
16	14	0.74	363	0.80	400	0.97	545
19	14	0.78	439	0.84	479	1.01	630

Table B.8—Typical dimensions and weights; multiconductor control 600/1000 V; type T, E, X, S, LSE, and LSX cables

Number of conductors	Conductor AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
37	14	1.08	810	1.14	866	1.31	1067
40	14	1.16	876	1.22	938	1.39	1152
61	14	1.34	1272	1.40	1343	1.57	1587

NOTE—Weights and diameters given are for cables with Type E and X insulated conductors. Cables with Type T, S, LSE, and LSX insulated conductors will vary from those shown.

These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer values.

Table B.9—Typical dimensions and weights; multiconductor control 600/1000 V; Type T/N cables

Number of conductors	Conductor AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
2	18	0.28	38	0.34	54	0.44	92
3	18	0.29	47	0.35	63	0.45	102
4	18	0.32	59	0.38	77	0.47	114
7	18	0.37	88	0.43	109	0.56	171
19	18	0.58	221	0.64	252	0.77	340
24	18	0.67	273	0.73	308	0.90	441
30	18	0.71	329	0.77	366	0.94	506
37	18	0.76	391	0.82	431	0.99	579
40	18	0.82	427	0.88	470	1.04	618
61	18	0.98	648	1.04	698	1.21	883
2	16	0.32	49	0.38	67	0.48	108
3	16	0.34	62	0.40	80	0.49	119
4	16	0.37	77	0.43	98	0.55	155
7	16	0.43	116	0.49	140	0.62	209
10	16	0.57	176	0.63	207	0.76	294
14	16	0.62	230	0.68	263	0.80	349

Table B.9—Typical dimensions and weights; multiconductor control 600/1000 V; Type T/N cables

Number of conductors	Conductor AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
16	16	0.65	255	0.71	288	0.88	418
19	16	0.68	303	0.74	338	0.91	473
24	16	0.79	362	0.85	402	1.02	555
30	16	0.88	473	0.94	518	1.11	686
37	16	0.94	558	1.00	605	1.17	782
40	16	1.01	606	1.07	659	1.24	848
61	16	1.16	866	1.22	928	1.39	1142
7	14	0.46	155	0.52	182	0.65	256
10	14	0.61	232	0.67	265	0.80	357
14	14	0.66	305	0.72	340	0.89	472
16	14	0.70	345	0.76	380	0.93	519
19	14	0.73	412	0.79	449	0.96	593
24	14	0.89	527	0.95	572	1.12	742
30	14	0.94	635	1.00	682	1.17	859
37	14	1.01	761	1.07	814	1.24	1003
40	14	1.09	829	1.15	885	1.32	1088
61	14	1.25	1195	1.31	1260	1.48	1489

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.10—Typical dimensions and weights; multiconductor control 600/1000 V; Type P cables

Number of conductors	Conductor size AWG	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
4	16	0.423	99	0.473	154	0.604	227
5	16	0.458	110	0.508	171	0.639	264
7	16	0.494	155	0.544	265	0.675	300
8	16	0.531	164	0.581	255	0.712	330

Table B.10—Typical dimensions and weights; multiconductor control 600/1000 V; Type P cables

Number of conductors	Conductor size AWG	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
10	16	0.615	206	0.665	366	0.796	445
16	16	0.700	299	0.750	465	0.923	602
20	16	0.773	360	0.823	560	0.996	724
24	16	0.899	462	0.949	718	1.122	809
37	16	1.020	658	1.070	819	1.243	989
44	16	1.096	807	1.146	980	1.319	1175
60	16	1.262	1053	1.312	1256	1.485	1496
91	16	1.504	1595	1.554	1896	1.790	2181
4	14	0.459	128	0.509	213	0.640	275
5	14	0.498	149	0.548	234	0.679	301
6	14	0.539	182	0.589	264	0.720	335
7	14	0.539	205	0.589	297	0.720	377
10	14	0.675	280	0.725	406	0.898	515
12	14	0.696	307	0.746	428	0.919	558
14	14	0.731	415	0.781	540	1.117	876
24	14	0.989	615	1.039	892	1.212	1132
30	14	1.045	780	1.095	965	1.268	1180
37	14	1.125	876	1.175	1135	1.348	1405
44	14	1.210	1087	1.260	1260	1.433	1477
91	14	1.669	2200	1.719	2465	1.955	2855
4	12	0.505	168	0.555	256	0.686	323
5	12	0.550	196	0.600	266	0.731	334
6	12	0.596	280	0.646	405	0.777	500
10	12	0.751	369	0.801	500	0.974	629
20	12	0.995	701	1.045	890	1.218	1055
24	12	1.103	861	1.153	1167	1.326	1468
37	12	1.258	1262	1.308	1467	1.481	1677

NOTE—These values are for reference purposes only and should not be construed as requirements. Weights of armored constructions are based on bronze braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.11—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T unshielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
1	20	0.28	35	0.34	51	0.44	88
2	20	0.39	58	0.45	79	0.57	139
3	20	0.44	76	0.50	100	0.62	165
4	20	0.48	92	0.54	119	0.66	189
5	20	0.56	127	0.62	158	0.75	241
6	20	0.58	142	0.64	173	0.77	260
8	20	0.64	174	0.70	207	0.82	298
10	20	0.72	210	0.78	247	0.95	391
15	20	0.80	283	0.86	323	1.03	480
20	20	0.91	392	0.97	439	1.14	610
25	20	1.04	477	1.10	530	1.27	726
30	20	1.09	550	1.15	606	1.32	806
40	20	1.22	698	1.28	763	1.45	989
50	20	1.34	845	1.40	916	1.56	1151
60	20	1.52	1002	1.58	1082	1.81	1465
1	18	0.30	43	0.36	59	0.46	98
2	18	0.42	74	0.48	98	0.61	166
3	18	0.48	98	0.54	125	0.66	196
4	18	0.55	138	0.61	167	0.74	250
5	18	0.61	165	0.67	198	0.80	289
6	18	0.63	186	0.69	219	0.82	312
8	18	0.69	232	0.75	267	0.92	402
10	18	0.78	281	0.84	321	1.01	471
15	18	0.91	424	0.97	471	1.14	640
20	18	0.99	533	1.05	583	1.22	765
25	18	1.13	652	1.19	708	1.36	912
30	18	1.19	758	1.25	820	1.42	1034
40	18	1.33	972	1.39	1043	1.56	1279
50	18	1.46	1185	1.52	1263	1.76	1637
60	18	1.66	1409	1.72	1498	1.96	1917
1	16	0.32	51	0.38	69	0.48	110
2	16	0.45	90	0.51	114	0.64	185

Table B.11—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T unshielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
3	16	0.51	121	0.57	150	0.70	227
4	16	0.59	169	0.65	200	0.78	287
5	16	0.66	202	0.72	237	0.89	369
6	16	0.68	231	0.74	266	0.91	400
8	16	0.75	290	0.81	327	0.98	475
10	16	0.89	388	0.95	433	1.12	604
15	16	0.99	532	1.05	582	1.22	770
25	16	1.23	827	1.29	892	1.46	1117
30	16	1.30	966	1.36	1034	1.52	1261
40	16	1.45	1246	1.51	1322	1.74	1682
50	16	1.59	1524	1.65	1607	1.88	1994
60	16	1.88	1928	1.94	2028	2.17	2491

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.12—Typical dimensions and weights; twisted-pair signal cable, 300 V; Type T cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
1	20	0.28	36	0.34	52	0.44	90
2	20	0.44	64	0.50	88	0.63	159
3	20	0.47	80	0.53	107	0.65	175
4	20	0.51	97	0.57	126	0.70	206
5	20	0.59	132	0.65	163	0.78	253
6	20	0.64	152	0.70	185	0.87	314
8	20	0.69	185	0.75	220	0.92	357
10	20	0.81	226	0.87	269	1.04	425
15	20	0.97	346	1.03	396	1.20	579

Table B.12—Typical dimensions and weights; twisted-pair signal cable, 300 V; Type T cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
20	20	1.08	429	1.14	485	1.30	673
25	20	1.22	519	1.28	584	1.45	808
30	20	1.26	592	1.32	660	1.49	890
40	20	1.42	750	1.48	826	1.64	1067
50	20	1.60	913	1.66	996	1.89	1390
60	20	1.77	1167	1.83	1261	2.06	1692
1	18	0.30	46	0.36	62	0.46	102
2	18	0.48	85	0.54	112	0.66	181
3	18	0.51	109	0.57	138	0.69	211
4	18	0.59	153	0.65	184	0.77	266
5	18	0.64	182	0.70	215	0.87	344
6	18	0.70	211	0.76	246	0.93	384
8	18	0.76	262	0.82	302	0.98	441
10	18	0.93	359	0.99	406	1.16	582
15	18	1.06	490	1.12	546	1.29	743
20	18	1.17	619	1.23	681	1.40	896
25	18	1.33	755	1.39	826	1.56	1068
30	18	1.38	872	1.44	946	1.61	1196
40	18	1.55	1119	1.61	1199	1.84	1581
50	18	1.82	1481	0.88	1578	2.11	2020
60	18	1.93	1726	1.99	1829	2.22	2296
1	16	0.32	56	0.38	74	0.48	115
2	16	0.51	104	0.57	133	0.70	213
3	16	0.58	153	0.64	184	0.76	265
4	16	0.63	190	0.69	223	0.82	318
5	16	0.69	227	0.75	262	0.92	399
6	16	0.75	265	0.81	302	0.98	449
8	16	0.82	332	0.88	375	1.04	523
10	16	1.00	449	1.06	499	1.23	687
15	16	1.15	621	1.21	680	1.37	879
20	16	1.27	790	1.33	858	1.50	1090
25	16	1.45	967	1.51	1043	1.74	1403

Table B.12—Typical dimensions and weights; twisted-pair signal cable, 300 V; Type T cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)
30	16	1.50	1125	1.56	1203	1.79	1574
40	16	1.75	1556	1.81	1648	2.04	2075
50	16	1.98	1904	2.04	2010	2.27	2488
60	16	2.10	2228	2.16	2339	2.39	2843

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of Armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.13—Typical dimensions and weights; paired shielded signal cable 600/1000 V; Type P cables

Number of pairs	Conductor size AWG	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
		Individual and overall aluminum/polyester tape shields					
1	18	0.392	63	0.442	123	0.607	176
2	18	0.551	131	0.601	204	0.766	335
3	18	0.581	163	0.631	265	0.796	343
4	18	0.630	195	0.680	317	0.845	410
5	18	0.685	243	0.735	395	0.900	511
7	18	0.742	340	0.792	457	0.957	575
8	18	0.800	388	0.850	521	1.015	752
10	18	0.933	495	0.983	699	1.148	874
12	18	0.962	581	1.012	780	1.177	982
16	18	1.066	748	1.116	833	1.281	1182
18	18	1.123	824	1.173	1050	1.338	1300
24	18	1.314	1069	1.364	1151	1.529	1720
1	16	0.412	77	0.462	120	0.627	203
2	16	0.585	160	0.635	249	0.800	377
3	16	0.617	200	0.667	311	0.832	410
4	16	0.671	239	0.721	389	0.886	569

Table B.13—Typical dimensions and weights; paired shielded signal cable 600/1000 V; Type P cables

Number of pairs	Conductor size AWG	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
		Individual and overall aluminum/polyester tape shields					
5	16	0.730	297	0.780	483	0.945	609
7	16	0.792	416	0.842	559	1.007	703
8	16	0.856	475	0.906	638	1.071	803
10	16	1.000	606	1.050	787	1.215	1098
12	16	1.032	711	1.082	923	1.247	1138
16	16	1.145	948	1.195	1231	1.360	1517
18	16	1.207	1100	1.257	1260	1.422	1570
24	16	1.415	1510	1.465	1625	1.630	2065
1	14	0.408	97	0.458	151	0.589	199
2	14	0.601	202	0.651	315	0.818	515
4	14	0.698	301	0.748	469	0.921	633
5	14	0.764	374	0.814	608	0.987	787
7	14	0.876	480	0.926	704	1.099	886
8	14	0.947	550	0.997	803	1.170	1011
10	14	1.109	747	1.159	1003	1.332	1196
12	14	1.145	896	1.195	1203	1.368	1434

NOTE—These values are for reference purposes only and should not be construed as requirements. Weights of armored constructions are based on bronze braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.14—Typical dimensions and weights; triad shielded signal cable 600/1000 V; Type P cables

Number of triads	Conductor size AWG	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
		Individual and overall aluminum/polyester tape shields					
1	18	0.380	75	0.430	144	0.561	199
2	18	0.624	183	0.674	290	0.805	380
3	18	0.662	190	0.712	305	0.885	393
4	18	0.726	281	0.776	408	0.949	551
5	18	0.796	286	0.846	419	1.019	561
7	18	0.911	409	0.961	565	1.134	724
8	18	0.985	515	1.035	680	1.208	870
12	18	1.193	766	1.243	965	1.416	1195
1	16	0.402	86	0.452	155	0.583	213
3	16	0.709	218	0.759	338	0.932	466
4	16	0.778	410	0.828	530	1.001	700
6	16	0.975	630	1.025	750	1.198	955
7	16	0.975	710	1.025	835	1.198	1050

NOTE—These values are for reference purposes only and should not be construed as requirements. Weights of armored constructions are based on bronze braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.15—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, unshielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
1	20	0.26	31	0.32	47	0.41	79
2	20	0.36	51	0.42	72	0.51	112
3	20	0.40	66	0.46	87	0.59	153
4	20	0.44	80	0.50	104	0.63	175
5	20	0.48	95	0.54	122	0.67	198
6	20	0.50	107	0.56	134	0.69	212
8	20	0.58	150	0.64	181	0.77	269

Table B.15—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, unshielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
10	20	0.65	180	0.71	213	0.88	343
15	20	0.72	242	0.78	279	0.95	421
20	20	0.79	303	0.85	343	1.02	496
25	20	0.94	408	1.00	455	1.17	608
30	20	0.99	469	1.05	519	1.22	697
40	20	1.10	594	1.16	650	1.33	836
50	20	1.21	717	1.27	782	1.44	986
60	20	1.37	850	1.43	924	1.60	1146
1	18	0.28	38	0.34	54	0.44	92
2	18	0.39	66	0.45	87	0.58	152
3	18	0.44	88	0.50	112	0.63	183
4	18	0.48	109	0.54	136	0.67	212
5	18	0.56	148	0.62	179	0.75	265
6	18	0.58	167	0.64	198	0.77	286
8	18	0.64	208	0.70	241	0.83	337
10	18	0.72	252	0.78	289	0.95	431
15	18	0.80	347	0.86	387	1.03	542
20	18	0.91	477	0.97	524	1.14	697
25	18	1.04	583	1.10	636	1.27	830
30	18	1.09	677	1.15	733	1.32	935
40	18	1.22	868	1.28	933	1.45	1157
50	18	1.34	1057	1.40	1128	1.57	1371
60	18	1.52	1257	1.58	1337	1.81	1713
1	16	0.32	49	0.38	67	0.48	108
2	16	0.45	85	0.51	109	0.64	181
3	16	0.51	115	0.57	144	0.70	224
4	16	0.59	160	0.65	191	0.78	281
5	16	0.66	192	0.72	227	0.89	359
6	16	0.68	218	0.74	253	0.91	388
8	16	0.75	273	0.81	310	0.98	457
10	16	0.89	367	0.95	412	1.12	582
15	16	0.99	500	1.05	550	1.22	736

Table B.15—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, unshielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
20	16	1.08	632	1.14	688	1.31	889
25	16	1.23	773	1.29	838	1.46	1063
30	16	1.30	901	1.36	969	1.53	1206
40	16	1.45	1160	1.51	1236	1.74	1596
50	16	1.59	1416	1.65	1499	1.88	1890
60	16	1.88	1797	1.94	1897	2.17	2353

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Table B.16—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
1	20	0.26	32	0.32	48	0.41	80
2	20	0.40	56	0.46	77	0.59	143
3	20	0.43	69	0.49	93	0.62	163
4	20	0.47	84	0.53	111	0.66	186
5	20	0.51	99	0.57	128	0.70	208
6	20	0.59	132	0.65	163	0.78	253
8	20	0.63	160	0.69	193	0.82	288
10	20	0.74	195	0.80	232	0.97	377
15	20	0.89	299	0.95	344	1.12	514
20	20	0.98	369	1.04	419	1.21	603
25	20	1.11	445	1.17	501	1.34	707
30	20	1.14	507	1.20	563	1.37	774
40	20	1.28	640	1.34	708	1.51	942
50	20	1.45	778	1.51	854	1.74	1214
60	20	1.54	903	1.60	983	1.83	1363

Table B.16—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)
1	18	0.28	43	0.34	59	0.44	97
2	18	0.44	80	0.50	104	0.63	175
3	18	0.47	103	0.53	130	0.66	205
4	18	0.51	128	0.57	157	0.70	237
5	18	0.59	172	0.65	203	0.78	293
6	18	0.64	199	0.70	232	0.83	328
8	18	0.69	248	0.75	283	0.92	420
10	18	0.81	305	0.87	348	1.04	504
15	18	0.97	463	1.03	513	1.20	696
20	18	1.08	586	1.14	642	1.31	843
25	18	1.22	714	1.28	779	1.45	1003
30	18	1.26	827	1.32	895	1.49	1125
40	18	1.42	1062	1.48	1138	1.65	1394
50	18	1.60	1302	1.66	1385	1.89	1779
60	18	1.77	1634	1.83	1728	2.06	2159
1	16	0.33	54	0.39	72	0.48	110
2	16	0.51	100	0.57	129	0.70	209
3	16	0.58	147	0.64	178	0.77	266
4	16	0.63	181	0.69	214	0.82	309
5	16	0.69	216	0.75	251	0.92	388
6	16	0.75	252	0.81	289	0.98	436
8	16	0.82	315	0.88	358	1.05	516
10	16	1.00	428	1.06	478	1.23	666
15	16	1.15	589	1.21	648	1.38	860
20	16	1.27	748	1.33	816	1.50	1048
25	16	1.45	914	1.51	990	1.74	1350
30	16	1.50	1061	1.56	1139	1.79	1510
40	16	1.75	1471	1.81	1563	2.04	1990
50	16	1.98	1798	2.04	1904	2.27	2382
60	16	2.10	2101	2.16	2212	2.39	2716

Table B.16—Typical dimensions and weights; twisted-pair signal cable 300 V; Type T/N cables, shielded pairs

Number of pairs	AWG size	Unarmored		Armored		Armored and sheathed	
		Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. dia. (in)	Approx. weight (lb/1000 ft)	Nom. Dia. (in)	Approx. weight (lb/1000 ft)

NOTE—These values are for reference purposes only and should not be construed as requirements. Dimensions are based on the use of Class B conductors. Weights of armored constructions are based on aluminum braid armor. It is recommended that the user/specifier contact the manufacturer for manufacturer specific values.

Annex C

(informative)

Conversion tables

Table C.1—Metric to English length conversions

Metric (mm)	English (in)	Metric (mm)	English (in)
0.00889	0.00035	0.01	0.0005
0.0127	0.0005	0.025	0.001
0.051	0.002	0.0635	0.0025
0.076	0.003	0.10	0.004
0.13	0.005	0.15	0.006
0.18	0.007	0.20	0.008
0.23	0.009	0.254	0.010
0.305	0.012	0.32	0.0126
0.38	0.015	0.51	0.020
0.63	0.025	0.76	0.030
0.88	0.035	1.02	0.040
1.14	0.045	1.27	0.050
1.40	0.055	1.52	0.060
1.65	0.065	1.90	0.075
2.03	0.080	2.29	0.090
2.41	0.095	2.67	0.105
2.79	0.110	2.92	0.115
3.05	0.120	3.56	0.140
4.44	0.175	5.46	0.215
6.60	0.260	7.11	0.280
8.76	0.345	10.16	0.400
10.17	0.401	10.66	0.420
10.80	0.426	12	0.5
15.24	0.600	15.25	0.601
17.78	0.700	18.04	0.710
20.32	0.800	20.33	0.801
22.23	0.876	24.13	0.950

Table C.1—Metric to English length conversions

Metric (mm)	English (in)	Metric (mm)	English (in)
24.14	0.951	25.4	1.000
25.41	1.001	26.03	1.025
26.04	1.026	28.6	1.125
31.8	1.250	34.9	1.375
38.1	1.500	38.11	1.501
41.3	1.625	50.8	2.000
50.81	2.001	63.50	2.500
76	3	100	4.0
150	6.0	254	10
380	15	406	16
450	18	1 m	39 in
1.1 m	42 in	1.5 m	4 ft 11 in
2 m	80 in	2.13 m	7 ft
15 m	50 ft	60 m	200 ft

Table C.2—Celsius to Fahrenheit temperature conversions

Temperature (°C)	Temperature (°F)	Temperature (°C)	Temperature (°F)	Temperature (°C)	Temperature (°F)
–25	–13	–10	14	0.55	1.0
1	1.5	4.4	40	5.0	41
5.6	42	6.1	43	6.7	44
7.2	45	7.8	46	8.3	47
8.9	48	9.4	49	10.0	50.0
10.6	51	11.1	52	11.7	53
12.2	54	12.8	55	13.3	56
13.9	57	14.4	58	15.0	59
15.6	60	16.1	61	16.7	62
17.2	63	17.8	64	18.3	65
18.9	66	19.4	67	20.0	68
20.6	69	21.1	70	22.2	72
22.8	72	22.8	73	23.3	74
23.9	75	24.4	76	25.0	77
25.6	78	26.1	79	26.7	80
27.2	81	27.8	82	28.3	83

Table C.2—Celsius to Fahrenheit temperature conversions

Temperature (°C)	Temperature (°F)	Temperature (°C)	Temperature (°F)	Temperature (°C)	Temperature (°F)
28.9	84	29.4	85		
35.0	95	60	140	75	167
90.0	194	100	212	121	249

Table C.3—Force conversions

N/mm^2	Lbf/in^2
4.8	700
5.5	800
6.2	900
8.2	1200
8.9	1300
9.6	1400
10.3	1500
12.5	1800
13.8	2000
350	50 000
61.3 N/cm	35 lbf/in

Table C.4—Insulation resistance constant conversions

MΩ·km	MΩ·(1000 ft)
610	2000
1220	4000
3050	10 000
6100	20 000

Table C.5—Water absorption conversions

mg/cm^2	Mg/in^2
3.88	25
15.5	100
20.2	130

Annex D

(informative)

Previously used cable designations

The following information is for historical purposes only. This has been replaced with 5.19 marking requirements.

D.5.19 Previously used cable designations

D.5.19.1.1 Cable type (service symbol)

"S"	Single conductor distribution
"D"	Two conductor distribution
"T"	Three conductor distribution
"F"	Four conductor distribution
"Q"	Five conductor distribution
"C"	Control cable (1)
"TP"	Twisted pair (1)
"TT"	Twisted triad (1)

(1) = Insert AWG size of conductors following service symbol for C, TP, and TT.

D.5.19.1.2 Shielding

No marking	Unshielded
"OS"	Overall shield
"IS"	Individual shield
"IS-OS"	Individual and overall shield
"OBS"	Overall braid shield

D.5.19.1.3 Insulation type (2)

"E"	Ethylene propylene rubber
"X"	Crosslinked polyethylene
"P"	Crosslinked polyolefin
"S"	Silicone rubber
"LSX"	Low smoke, halogen-free crosslinked polyolefin
"LSE"	Low smoke, halogen-free ethylene propylene rubber
"LSS"	Low smoke, halogen-free silicone rubber
"T"	Polyvinyl chloride
"T/N"	Polyvinyl chloride/nylon

(2) = For insulation types E, X, T, T/N, and S where the VW-1 is the option, the letter "V" is added after the insulation type to indicate compliance with this optional requirement.

D.5.19.1.4 Jacket type

"T"	Polyvinyl chloride
"CP"	Chlorosulfonated polyethylene
"N"	Polychloroprene (neoprene)
"L"	Low smoke, zero halogen crosslinked polyolefin
"TPO"	Low smoke, zero halogen thermoplastic polyolefin
"CPE"	Thermoset chlorinated polyethylene

D.5.19.1.5 Armor

No marking	Unarmored
"A"	Aluminum armor
"B"	Bronze armor
"T"	Tinned copper armor
"_S"	Armor and sheath (3)
"CWCMC"	Continuously corrugated metal armor

(3) = Add the type of armor, A, B, or T, before the S.

D.5.19.1.6 Size

The wire size is designated for distribution cable by adding a dash (-), followed by the conductor size in kcmil.

D.5.19.1.7 Voltage rating

The rated distribution cable voltage is added to the symbol following a dash (-), as follows:

2 000 V	2 kV
5 000 V	5 kV
8 000 V	8 kV
15 000 V	15 kV
25 000 V	25 kV
28 000 V	28 kV
35 000 V	35 kV

The complete type designation should include the following parts:

- Cable type (S, D, T, F, Q, C, TP, TT)
- Shielding designation, if applicable
- Insulation type
- Jacket type
- Armor, if applicable
- "S" if jacket over armor

For Types S, D, T, F, and Q, distribution cables.

Following a dash (-), the conductor size in kcmil is as follows:

- DTTB-4 = AWG 14 (4.11 kcmil), two-conductor, polyvinylchloride-insulated, thermoplastic polyvinyl chloride jacketed, and bronze armored
- SXNA-250 = 250 kcmil, single conductor, cross-linked polyethylene insulated, Thermoset neoprene jacketed, and aluminum armor
- TPNBS-313 = 3 conductor, 313 kcmil, polyolefin insulation with neoprene jacket, bronze armor, and overall sheath

Following a second dash (-), the voltage rating is as follows:

- TPNBS-313-5KV = 3 conductors, 313 kcmil, polyolefin insulation with neoprene jacket, bronze armor, and overall sheath, 5 kV.

For Types C, TP, and TT, the number of conductors, pairs or triads, as applicable; the number of conductors of control, and the number of conductor pairs/triads of signal cable, is added to the cable designation, as follows:

- C14TCPB-20 = 20 conductor control cable, 14 AWG, thermoplastic-insulated, Thermoset chlorosulfonated polyethylene jacketed, and bronze armor
- TP18TNA-10 = 10 twisted pair signal cable, 18 AWG, thermoplastic-insulated, Thermoset neoprene jacketed, and aluminum armor
- C14PCP-3 = 3 conductor, 14 AWG, polyolefin insulated, and chlorosulfonated polyethylene jacketed
- TP (OS) 18PNBS-2 = 2 twisted pairs, 18 AWG with polyolefin insulation, overall tape shield and drain wire, neoprene jacketed, with bronze armor and overall outer sheath

Annex E

(informative)

Metric treatment of 5.17.4—Insulation resistance test

E.5.17.4.1 Method of test

Compliance with the insulation resistance test is determined in accordance with the method described in subclause 4.28.2 of CSA Standard C22.2 No. 03 or UL 1581. The insulation resistance constant K for a test at 15.6 °C is obtained in Table 12, Table 13, or Table 14 for the specific insulation under test.

The current should be measured after one minute with a continuous direct-current potential of not less than 100 V nor more than 500 V, the conductor being negative to ground. If the test for insulation resistance is carried out in water or air having a temperature different from 15.6 °C, the measured value should be multiplied by the proper correction factor, *M,* obtained in Table 21. This factor appears in the following formula for insulation resistivity:

$$R = \mathrm{K}M \log 10(D/d)$$

where
R = Insulation resistivity (MΩ·km)
K = insulation resistance constant (from Table 12, Table 13, or Table 14) (MΩ·km)
M = Temperature correction factor to 15.6 °C
D = Diameter over the insulation
d = Diameter under the insulation

The factor M should be determined in accordance with the method of E.5.17.4.2.

The measured insulation resistivity is related to the measured insulation resistance of the sample under test by the following formula:

$$R = 0.001 R_{\mathrm{meas}} L$$

where
R = insulation resistivity (MΩ·km)
R_{meas} = measured insulation resistance (MΩ)
L = length of the test sample (m)

E.5.17.4.2 Test procedure for determining the multiplying-factor column for adjusting insulation resistance

E.5.17.4.2.1 Samples

Two samples, conveniently of a No. 14, 12, or 10 AWG solid conductor with a 1.14 mm wall of insulation, are to be selected as representative of the insulation under consideration. The samples are to be of a length (at least 60 m) that yields insulation-resistance values that are stable within the calibrated range of the measuring instrument at the lowest water-bath temperature.

E.5.17.4.2.2 Water bath temperature

The two samples are to be immersed in a water bath equipped with heating, cooling, and circulating facilities. The ends of the samples are to extend at least 60 cm above the surface of the water to reduce electrical leakage. The samples are to be left in the water at room temperature for 16 h before adjusting the bath temperature to 10.0 °C or before transferring the samples to a 10.0 °C bath.

E.5.17.4.2.3 DC Resistance

The dc resistance of the metal conductor is to be measured at applicable intervals of time until the temperature remains unchanged for at least five minutes. The insulation then is to be considered as being at the temperature of the bath indicated on the bath thermometer.

E.5.17.4.2.4 Test temperatures

Each of the two samples is to be exposed (E.5.17.4.2.3 applies) to successive water temperatures of 10.0, 16.1, 22.2, 27.8, and 35.0 °C and returning, 27.8, 22.2, 16.1, and 10.0 °C. Insulation-resistance readings are to be taken at each temperature after equilibrium is established.

E.5.17.4.2.5 Plot

The two sets of readings (four readings in all) taken at the same temperature are to be averaged for the two samples. These four average values and the average of the single readings at 35.0 °C are to be plotted on semilog paper. A continuous curve (usually a straight line) is to be drawn through the five points. The value of insulation resistance at 15.6 °C is then to be read from the graph.

E.5.17.4.2.6 Results

The resistivity coefficient C for a 1 °C change in temperature is to be calculated to two decimal places by dividing the insulation resistance at 15.0 °C read from the graph by the insulation resistance at 16.0 °C. The temperature correction factor M required to correct to the standard test temperature of 15.6 °C is then calculated from the following formula:

$$M = C^{(t-15.6)}$$

where

t is the actual test temperature in degrees Celsius.

The columns of Table 21 give M for various values of C and t.