STANDARDS

American National Standard

ANSI/NECA/BICSI 607-2011

Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings

NECA
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

BICSI®

NECA/BICSI 607-2011

Standard for

Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings

An American National Standard

Published by
National Electrical Contractors Association

Developed jointly with
BICSI®

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(This foreword is not a part of the standard)

Foreword

Introduction

National Electrical Installation Standards™ (NEIS) are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. NEIS are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

> Telecommunications bonding and grounding planning and installations shall be installed in accordance with NECA/BICSI 607-2011, *Standard for Bonding and Grounding Planning and Installation Methods for Commercial Buildings.*

The National Electrical Contractors Association (NECA) asked BICSI®, a Telecommunications Association, together undertook the task of developing this grounding and bonding standard for telecommunications systems and equipment.

NECA-BICSI standards are developed within the Technical Committees of BICSI and NECA. Members of the respective committees serve voluntarily and without compensation. The companies they represent are not necessarily members of BICSI or NECA. The standards developed by these committees represent a consensus of the broad expertise from within BICSI and NECA as well as from those outside that have an expressed interest. The viewpoint expressed at the time this standard was approved was from the contributors' experience and the state of the industry at that time. Users are encouraged to confirm that they have the latest edition of this standard. NECA-BICSI reviews its standards, at the minimum, every 5 years. At that time standards are reaffirmed, rescinded or revised accordingly. Any suggested revisions to be included in the next edition should be sent to NECA or BICSI.

This standard has been prepared by BICSI/NECA under the joint jurisdiction of BICSI and NECA and approved by consensus ballot in accordance with the requirements of the American National Standards Association (ANSI). Use of NEIS is voluntary, and neither NECA nor BICSI assume any obligation or liability to users of this publication. Existence of a standard shall not preclude any member or non-member of either organization from specifying or using alternate construction methods permitted by applicable regulations. This publication is intended to comply with the edition of the *National Electrical Code® (NEC®)* in effect at the time of publication. Because they are quality standards, NEIS may exceed the minimum safety requirements of the NEC. It is the responsibility of users of this publication to comply with state and local regulations when installing electrical products and systems.

Suggestions for revisions and improvements to this standard should be addressed to:

NECA Standards & Safety
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 657-3110 telephone
(301) 215-4500 fax

Personnel safety and protection of susceptible electronic equipment from ground faults, lightning, ground potential rise, and electrical surges is of the utmost importance at telecommunications facilities.

Cloud to ground lightning discharges must find a path to ground; either discharging directly to the ground itself or to structures in contact with ground.

Electrical transients must return to their source, many times following similar ground paths. In either event, proper bonding reduces the harmful effects associated with these electrical events.

Metallic components for power distribution systems are bonded together to provide an effective ground-fault current path to allow proper operation of over-current devices. For telecommunications systems, metallic components are bonded to provide a low impedance path for electrical surges and transient voltages to return to their power source. The earth is also involved as a path for grounded (earthed) power systems and for lightning events. Lightning, fault currents, circuit switching (motors starting and stopping), and electrostatic discharge (ESD) are common causes of surges and transient voltages. An effective bonding and grounding system helps to minimize the damaging effects of electrical surges.

Proper bonding and grounding of electrical and information transport systems (ITS) infrastructure facilitates their intended operation. Improperly bonded and grounded electrical systems are a primary cause of power quality issues, which may affect information technology (IT) systems operation.

Other performance items related to bonding and grounding for telecommunications within a building involve power systems, surge protective devices, and electromagnetic compatibility (EMC). IEEE 1100-2005 contains recommended practices on these and related subjects.

Purpose

The purpose of this standard is to allow the designer and installer to enhance their knowledge of effective telecommunications bonding and grounding systems and to strive for installations in a neat and workmanlike manner. The principles and requirements of this standard are focused upon the North American region.

Specification of criteria

Two categories of criteria are specified; mandatory and advisory. The mandatory requirements are designated by the word "shall": advisory recommendations are designated by the words "should", "may", or "desirable", which are used interchangeably in this standard.

Mandatory criteria generally apply to protection, performance, administration, and compatibility; they specify the absolute minimum acceptable requirements. Advisory or desirable criteria are presented when their attainment would enhance the general performance of the cabling system in all its contemplated applications. A note in the text, table, or figure is used for emphasis or offering informative suggestions.

Metric equivalents of U.S. customary units

The majority of the metric dimensions in this standard are soft conversions of U.S. customary units (e.g., 100 millimeters [mm] is the soft conversion of 4 inches [in]). Wire diameters shown in brackets [ ] are approximate wire diameters (e.g., 6 AWG [(4.1 mm (0.16 in)])

Life of the standard

This standard is a living document. The criteria contained in this standard are subject to revisions and updating as warranted by advances in building construction techniques and telecommunications technology.

Annexes

Annex A is informative and not considered a requirement of this standard.

Photos and art provided by BICSI.

1. Scope

This American National Standard specifies aspects of planning and installation of telecommunications bonding and grounding systems within a commercial building (*see figure 1*). This standard is intended to enhance the planning, specification and layout of an effective telecommunications bonding and grounding system. Additionally, this standard specifies installation requirements for components of the telecommunications bonding and grounding system.

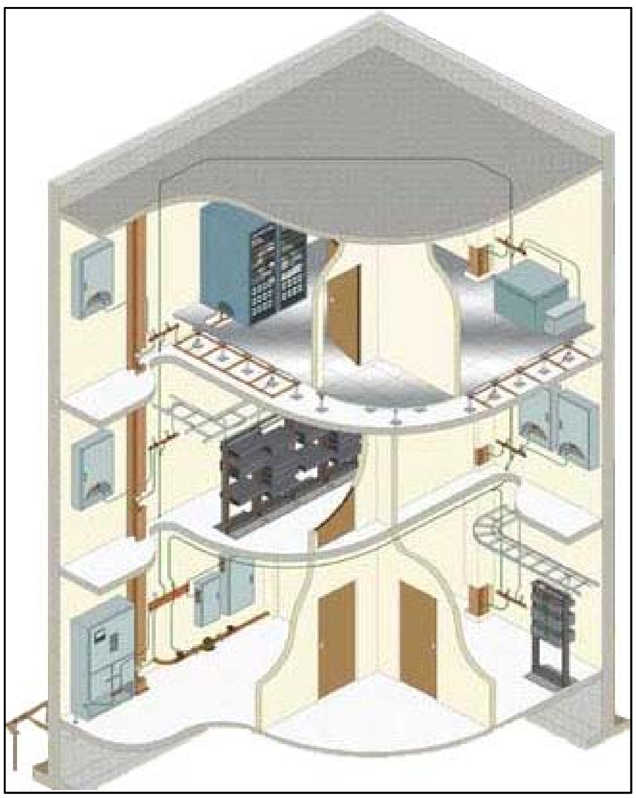

Figure 1. Example illustration of a telecommunications bonding and grounding system

2. Normative References

The following standards and related applicable addenda contain provisions that, through reference in this text, constitute provisions of this standard:

- IEEE C2-2007, National Electrical Safety Code®
- ANSI/J-STD-607-A-2002, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
- NFPA 70™–2011, National Electrical Code®
- NFPA 70E®–2004, Standard for Electrical Safety in the Workplace

At the time of publication, the editions listed above were current. As standards are subject to revision, users of this standard are encouraged to review and apply the latest published edition.

3. Definitions, Abbreviations and Acronyms, Units of Measurement

3.1 General

This clause contains definitions of terms, abbreviations, acronyms, and units of measurement that have a special meaning or that are unique to the technical content of this standard. Specific requirements are found in the normative subclauses of this standard. The terms that are used in only one clause may be defined at the beginning of that clause.

3.2 Definitions

bonded (bonding): Connected to establish electrical continuity and conductivity. *(NEC®)*

bonding conductor for telecommunications (BCT): A conductor that interconnects the building's service or building's feeder equipment (power) ground to the telecommunications grounding system.

common bonding network (CBN): The principal means for effecting bonding and grounding inside a telecommunication building. It is the set of metallic components that are intentionally or incidentally interconnected to form the principal bonding network (BN) in a building. These components include structural steel or reinforcing rods, plumbing, alternating current (ac) power conduit, ac equipment grounding conductors (ACEGs), cable racks, and bonding conductors. The CBN always has a mesh topology and is connected to the grounding electrode system.

coupled bonding conductor (CBC): A separate conductor in contact with, routed with, and secured to a communications cable. It may also be a metallic shield enclosing all of the conductors in a communications cable.

ground: The earth. *(NEC®)*

grounded (grounding): Connected (connecting) to ground or to a conductive body that extends the ground connection. *(NEC®)*

grounding equalizer (GE): A bonding conductor that interconnects TGBs on the same floor, (formerly TBBIBC).

primary protector: A surge protective device placed on telecommunications entrance conductors in accordance with ANSI/NFPA 70 and ANSI/ATIS 0600318.

point of entrance: Within a building, the point at which the wire or cable emerges from an external wall, from a concrete floor slab, or from a rigid metal conduit or an intermediate metal conduit grounded to an electrode.

rack bonding conductor (RBC): A bonding conductor used to connect the rack/cabinet directly to the telecommunications main grounding busbar (TMGB), telecommunications grounding busbar (TGB), telecommunications equipment bonding conductor (TEBC), or equipment room/computer room signal reference grid (SRG)/signal reference structure (SRS)/common bonding network (CBN).

signal reference structure (SRS): A system of conductive paths among interconnected equipment that reduces noise-induced voltages to levels that minimize improper operation. Common configurations include grids (e.g., SRGs) and planes.

telecommunications bonding backbone (TBB): A copper conductor used to connect the telecommunications main grounding busbar (TMGB) to the telecommunications grounding busbar (TGB) located on the floor farthest away.

telecommunications equipment bonding conductor (TEBC): A bonding conductor that extends from the telecommunications main grounding busbar (TMGB) or telecommunications grounding busbar (TGB) to either a rack grounding busbar or a rack bonding conductor.

telecommunications grounding busbar (TGB): A common point of connection for telecommunications system and equipment bonding to ground and located in the telecommunications rooms (TR) and equipment room (ER).

telecommunications main grounding busbar (TMGB): A busbar placed in a convenient and accessible location and bonded, by means of the bonding conductor for telecommunications, to the building service equipment (power) ground.

unit bonding conductor (UBC): A bonding conductor used to connect a rack/cabinet mounted equipment unit to the grounding structure (i.e., conductor, busbar) utilized in that rack/cabinet.

3.3 Abbreviations and acronyms

ac	alternating current
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
AWG	American wire gauge
BCT	bonding conductor for telecommunications
CBC	coupled bonding conductor
CBN	common bonding network
EDP	electrical distribution panel
EMC	electromagnetic compatibility
ENT	electrical nonmetallic tubing
ER	equipment room
ESD	electrostatic discharge
GE	grounding equalizer
IEEE	Institute of Electrical and Electronics Engineers
IT	information technology
ITS	information transport systems
Mesh-BN	mesh bonding network
NEC®	*National Electrical Code®*
NECA	National Electrical Contractors Association
NESC®	*National Electrical Safety Code®*
NFPA	National Fire Protection Association
NRTL	nationally recognized testing laboratory
OSHA	Occupational Safety & Health Administration
RBC	rack bonding conductor
SRG	signal reference grid
SRPP	system reference potential plane
SRS	signal reference structure
TBB	telecommunications bonding backbone
TBBIBC	telecommunications bonding backbone interconnecting bonding conductor (*see grounding equalizer [GE]*)
TEBC	telecommunications equipment bonding conductor
TGB	telecommunications grounding busbar
TMGB	telecommunications main grounding busbar
TR	telecommunications room
UBC	unit bonding conductor

3.4 Units of measurement

ft	foot/feet
in	inch/inches
m	meter(s)
mm	millimeter(s)

4. Regulatory

4.1 National requirements

All information in this publication is intended to conform to the *National Electrical Safety Code*® and *National Electrical Code*®.

4.2 Local code requirements

Local code requirements shall be followed. While most of the code requirements for the job should be included in the scope of work documents, always review the local code requirements with the local authority having jurisdiction (AHJ) before proceeding with the installation. This includes reviewing what code and edition is adopted, and what, if any, exceptions to the code are adopted by the governing authority (i.e., AHJ).

If no code has been adopted locally, consult with the fire marshal's office to determine which agency is responsible for that geographic area and which codes are in effect. Do not depend on installers, contractors, or company personnel in making these determinations.

Information transport systems (ITS) installation outside of the U.S. shall follow local regulatory requirements.

5. Components

5.1 Conductor

Conductors shall be copper. Bare and insulated conductors are permitted. The NEC specifies criteria for mechanical protection.

5.2 Busbar

5.2.1 Telecommunications main grounding busbar (TMGB)

The TMGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs *(see figure 2)* and shall be Listed by a nationally recognized testing laboratory (NRTL). The minimum size of the TMGB shall be 6 mm (0.25 in) thick by 100 mm (4 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/J-STD-607-A). The TMGB shall be insulated from its support attachment a minimum of 50 mm (2 in).

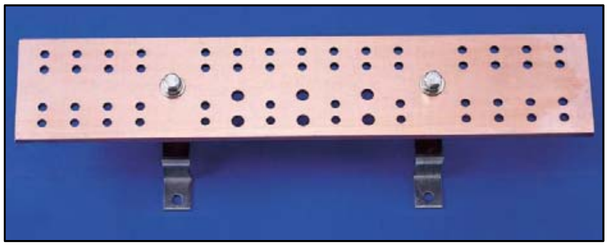

Figure 2. Example of a TMGB

5.2.2 Telecommunications grounding busbar (TGB)

The TGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs *(see figure 3)* and shall be Listed by an NRTL. The minimum size of the TGB shall be 6 mm (0.25 in) thick by 50 mm (2 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/J-STD-607-A). The TGB shall be insulated from its support attachment a minimum of 50 mm (2 in).

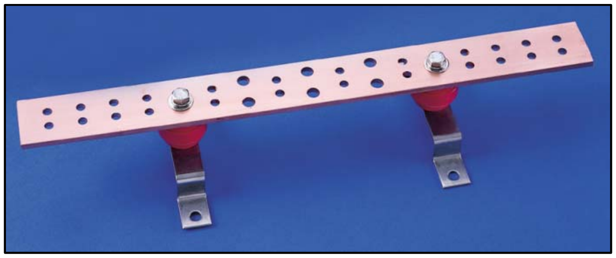

Figure 3. Example of a TGB

5.3 Bonding connector

5.3.1 Compression

Compression connectors *(see figure 4)* are devices that use a compression tool that compress into the connector, permanently forming the conductor during installation, providing an irreversible connection.

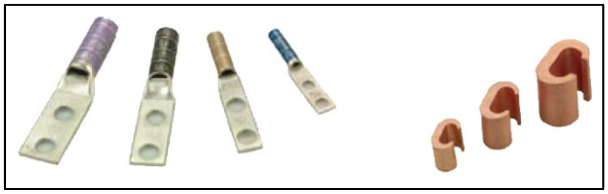

Figure 4. Example of compression connectors

5.3.2 Mechanical

Mechanical connectors *(see figure 5)* are devices that, when installed, provide a reversible connection.

Figure 5. Example of a mechanical connector

5.3.3 Exothermic

An exothermic weld connection *(see figure 6)* is a fusion of high conductivity, high copper content alloy that results in a molecular bond.

Figure 6. Example of an exothermic weld

6. Planning

6.1 General

6.1.1 Bonding to the electrical power system

The telecommunication bonding and grounding system shall be bonded to the power grounding system either at the service panel grounding busbar or the electrical grounding electrode, as described in ANSI/J-STD-607-A.

6.1.2 Primary protector

Primary protector(s) for telecommunications entrance cabling shall be bonded to the telecommunications bonding and grounding system to reduce differences in potential between telecommunications circuits and other metallic systems and components. Differences in potential create personnel hazards and can lead to catastrophic failures, especially when electrical surges and transient voltages are present.

The primary protector for each incoming telecommunications circuit shall be Listed and located as close as practicable to the point of entrance. The point of entrance should be located to minimize the length of the intersystem bonding conductor between the power system and the primary protector.

6.2 Bonding conductor

6.2.1 General

Bonding conductors shall be insulated stranded copper or flat braided copper and shall be Listed for the space in which they are intended to be placed according to the NEC® (e.g., plenum spaces, riser spaces), unless otherwise specified. When conductors are insulated, the jacket shall be green, green with a yellow stripe, or marked with green tape or a green adhesive label.

6.2.2 Size

Bonding conductors used for telecommunications should be sized using engineered calculations. In lieu of other engineered calculations, Table 1 shall be used for minimum conductor sizing.

6.2.3 Usage

6.2.3.1 Bonding conductor for telecommunications (BCT)

The BCT connects the telecommunications main grounding busbar (TMGB) to the building's electrical ground.

6.2.3.2 Telecommunications bonding backbone (TBB)

The TBB connects the TMGB to the telecommunications grounding busbars (TGBs). The TBB shall be a continuous copper conductor that should be sized no less than 6 AWG [4.1 mm (0.16 in)] to a maximum of 3/0 AWG [10.4 mm (0.41 in)]. The TBB shall be sized in accordance to *Table* 1 as a minimum (also see ANSI/J-STD-607-A).

Table 1. Conductor sizing

Linear length m(ft)	Size (AWG)
Less than 4 (13)	6
4-6 (14-20)	4
6-8 (21-26)	3
8-10 (27-33)	2
10-13 (34-41)	1
13-16 (42-52)	1/0
16-20 (53-66)	2/0
Greater than 20 (66)	3/0

NOTE: Cable shields do not satisfy the requirements for a TBB.

6.2.3.3 Grounding equalizer (GE; formerly known as the TBBIBC)

The GE connects the telecommunications grounding busbar(s) in the same-floor telecommunications rooms (TRs) on the first, top, and every third floor in a multi-story building. The GE shall be a continuous copper conductor that should be sized no less than 6 AWG [4.1 mm (0.16 in)] to a maximum of 3/0 AWG [10.4 mm (0.41 in)]. The GE shall be sized in accordance to *Table 1* as a minimum (also see ANSI/J-STD-607 A).

NOTE: Cable shields do not satisfy the requirements for a GE.

6.2.3.4 Telecommunications equipment bonding conductor (TEBC)

The TEBC connects the TMGB/TGB to the equipment racks/cabinets. There may be more than one TEBC; such as a separate TEBC per racks/cabinets lineup. The TEBC shall be a continuous copper conductor that should be sized either no less than 6 AWG [4.1 mm (0.16 in)] or sized equal to the largest size equipment grounding conductor in the alternating current (ac) branch power circuits serving the racks/cabinet lineup.

NOTE 1: Cable shields do not satisfy the requirements for a TEBC.

NOTE 2: The racks/cabinets may also be connected to the TMGB/TGB via the serving power system branch circuit equipment grounding conductor(s) being also bonded to the serv- ing electrical distribution panel (EDP) or associated metallic conduits *(see 7.4.2)*.

6.3 Busbar

6.3.1 Telecommunications main grounding busbar (TMGB)

The TMGB serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure. The TMGB should be sized in accordance with the immediate application requirements, while taking into consideration future growth. The TMGB should be located in the telecommunication entrance facility but shall be placed to minimize the length of the BCT that bonds the TMGB to the building's grounding electrode. The TMGB shall be accessible to telecommunications personnel while maintaining clearances required by applicable codes. In addition to being the central point of attachment for all components of the telecommunications grounding system, the TMGB shall serve the telecommunications equipment that is located within the area it is installed (e.g., the entrance facility), including building steel, metallic raceway, cabinets, and racks.

6.3.2 Telecommunications grounding busbar (TGB)

The TGB is the grounding connection point for telecommunications systems and equipment in the area served by a telecommunications room (TR) or equipment room (ER). The TGB shall be bonded to the power bonding and grounding system (serving that room) to ensure the two systems maintain minimal potential difference.

6.4 Bonding connections

Bonding connections are typically made by means of a compression connector, a mechanical connector, or an exothermic weld. Mechanical and compression connectors shall have only one conductor installed unless designed or Listed for more conductors. Compression and exothermically welded connections are irreversible, can withstand multiple fault currents, and will not loosen. Mechanical connections are only allowed when connecting a conductor to equipment, raceways, cable trays, water pipe, and similar appurtenances or when a compression or exothermic connection cannot be made. Connections to the TMGB/TGB shall use exothermically welded connections or two-hole lug connectors. Two-hole lug connections can be compression connectors or exothermically welded connectors.

6.5 Connections to the TMGB/TGB

6.5.1 Electrical distribution panel (EDP)

When an EDP is located in the same room as the TMGB/TGB, that EDP's equipment grounding bus or the panel board enclosure shall be bonded to the TMGB/TGB, using bonding conductors sized no less than 6 AWG [4.1 mm (0.16 in)] to a maximum 3/0 AWG [10.4 mm (0.58 in)] *(see table 1, page 8).*

6.5.2 Building steel

Where building steel is accessible and in the same room as the TMGB/TGB, the TMGB/TGB shall be bonded to building steel using a minimum 6 AWG [4.1 mm (0.16 in)] conductor. When the building steel is external to the room but readily accessible, it should be bonded to the TMGB/TGB. Building steel should be tested to verify its ground conductivity to earth.

NOTE: Modern building construction techniques will ground building steel to the main ac power entrance or another grounding source. Ensure that when working in existing buildings that the building steel is bonded to a suitable ground source (e.g., electrical power grounding electrode[s], building ground ring).

6.5.3 Conduit

In order to limit the potential difference between telecommunications conduits and telecommunications conduits and power conduits, the telecommunications conduits shall be bonded to the TMGB/TGB.

6.5.4 Telecommunications equipment bonding conductor (TEBC)

The TEBC shall be exothermically welded or connected, using either a compression style or exothermic style two-hole lug, to the connection point on the TMGB/TGB.

6.6 Bonding equipment, racks and cabinets

6.6.1 General

Grounding through the equipment ac power cord does not meet the intent of this standard. Properly bonded and grounded electrical systems are required in order to reduce power quality issues, which may affect information technology (IT) systems operation. However, grounding and bonding solely through the equipment ac power cord and its serving power circuit does not meet the intent of this standard. It is intended that the telecommunications ground path offer a supplemental and specific ground path for the equipment over and above the required ac power ground path. While the ac-powered equipment typically has a power cord that contains a ground wire, the integrity of this path to ground cannot be easily verified. Rather than relying on the ac power cord ground wire, it is desirable that equipment be grounded in a verifiable manner as described in this standard.

NOTE: Values of earth leakage should be made available by the electronic equipment manufacturers. It is recommended that the maximum designed earth leakage capability of final circuits is agreed in advance by the facility operator. This value should not be exceeded during operation or there will be a risk of earth voltages or spurious tripping of protective devices. Refer to the manufacturer's documentation for guidelines.

Electrical service power is routed in close proximity to the structural members of equipment cabinets and racks. Accordingly, priority should be given to ensure cable and wiring is approved, routed, and installed to minimize the possibility of insulation damage. As an additional measure, every structural member of a cabinet or rack shall be bonded to ground.

There are three methods to bond the equipment located in the equipment rack or cabinet to the telecommunications bonding system *(see figure 7).*
In computer rooms and ERs, racks and cabinets may be bonded to a supplementary bonding entity installed for that room. Such entities include various descriptors such as the mesh bonding network (Mesh-BN), signal

reference grid (SRG), signal reference structure (SRS), or system reference potential plane (SRPP).

NOTE: Many types of equipment do not require individual bonding conductors, and as such, do not have an attachment point for bonding conductors. Equipment that does not have attachment points for bonding conductors may be bonded either through the equipment rail or the ac power cord. Refer to the manufacturer's documentation for guidelines.

6.6.2 Example A

Example A attaches the equipment to a rack bonding conductor (RBC) that extends from the equipment rack/cabinet to the TEBC using an irreversible compression connector sized to match the conductor gauges or a grounding block Listed by a NRTL. (In a single rack or cabinet environment, there is no need for an RBC; the TEBC will serve this purpose.) The TEBC shall be bonded directly to the TMGB/TGB.

This example illustrates that there is multiple cutting and stripping of the RBC as well as the addition of multiple irreversible compression connections.

6.6.3 Example B

Example B utilizes a horizontal rack grounding busbar located at the top or bottom of the equipment rack/cabinet. Each piece of equipment in the rack/cabinet is bonded directly to the horizontal rack grounding busbar via a unit bonding conductor (UBC). The horizontal rack grounding busbar is then bonded to the TEBC via an RBC using an irreversible compression connector sized to match the conductor gauges. (In a single rack environment, there is no need for an RBC; the TEBC will serve this purpose.) The TEBC shall be bonded directly to the TMGB/TGB.

This example illustrates that UBCs may be longer and add to the complexity of cable management.

6.6.4 Example C

Example C utilizes a vertical rack grounding busbar that runs almost the entire length of the rack/cabinet and is bonded to the rack/cabinet. The equipment is then bonded to the vertical rack grounding busbar

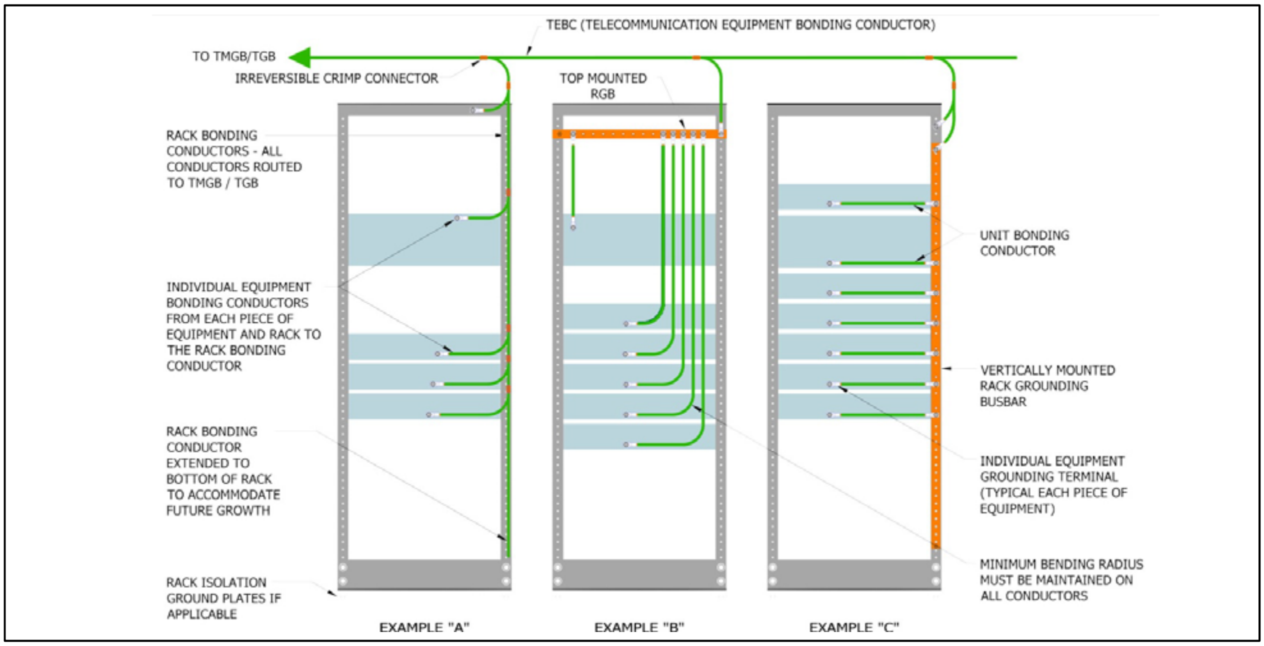

Figure 7. Example of three methods to bond equipment and racks to ground

via a very short UBC. The vertical rack grounding busbar is then bonded to the TEBC via an RBC using an irreversible compression connector sized to match the conductor gauge. (In a single rack environment, there is no need for an RBC as the TEBC will serve this purpose.) The TEBC shall be bonded directly to the TMGB/TGB.

6.6.5 Rack isolation

Where circumstances require insulating the equipment racks/cabinets from the floor (e.g., floor conduction, bolts touching rebar), rack isolation pads utilizing appropriate isolation hardware can be placed under the equipment racks/cabinets *(see figure 8)*. Where isolation pads are used, all applicable rack bonding and grounding requirements in this standard shall apply.

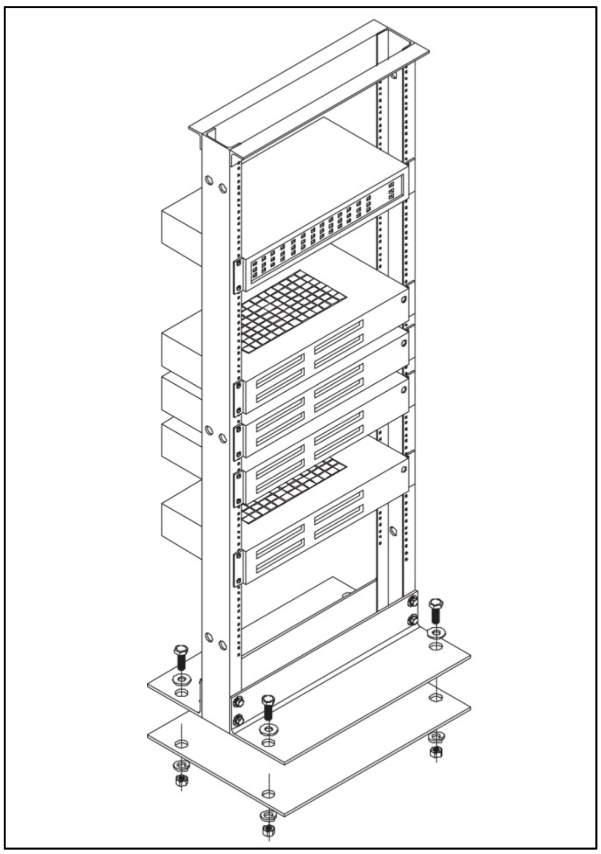

Figure 8. Example of rack isolation using a rack isolation pad

7. Installation Requirements

7.1 General

Installers should always follow the *National Electrical Code® (NEC®)*, the *National Electrical Safety Code® (NESC®)*, applicable state and local codes, manufacturer's instructions, and contract documents when installing telecommunications cabling. Only qualified persons familiar with telecommunications cabling, electrical wiring, or both should perform the work described in this publication.

7.1.1 Safety

It is recommended that all work be performed in accordance with NFPA 70E. Installation practices shall comply with local, state and Occupational Safety & Health Administration (OSHA) safety requirements.

WARNING: Connecting and removing connections to an electrical bonding and grounding system could have hazardous consequences such as arc flash and/or a possible series current path. Only "Qualified Persons" should perform these tasks.

7.1.2 Bonding to the electrical power system

The telecommunications bonding and grounding system shall be bonded to the power grounding system at either the service panel grounding busbar or the electrical grounding electrode. A qualified electrician shall make connections within an alternating current (ac) electrical panel.

7.1.3 Primary protector

The primary protector shall be bonded to the telecommunications bonding and grounding system to reduce differences in potential between telecommunications circuits and other metallic systems and components. The bonding conductor for the primary protector shall be insulated *(see subclause 6.2.1)*.

7.1.4 Equipment room (ER)

All metallic components and structures within the ER shall be bonded to the telecommunications bonding and grounding system. Equipment and power raceways in ERs shall be bonded to the serving power system.

7.1.5 Telecommunication room (TR)

All metallic components and structures within the TR shall be bonded to the telecommunications bonding and grounding system. Equipment and power raceways in TRs shall be bonded to the serving power system.

7.1.6 Backbone cables with shields, CBC, or both

Metallic indoor backbone cables, with or without a cable shield, may be configured with a coupled bonding conductor (CBC). Where provided, the cable shield and the CBC shall be bonded to the nearest telecommunications ground at each end using an insulated bonding conductor *(see subclause 6.2.1)*.

7.2 Bonding conductors

Bonding conductors exposed to physical damage shall be placed within a conduit that is securely fastened to the building structure. A 6 AWG [4.1 mm (0.16 in)] or larger conductor is permitted to be run on the surface without physical protection when it is free from exposure to physical damage.
Bonding conductors shall be:

- installed in a professional and workmanlike manner,
- no longer than required to achieve their purpose,

- installed and routed so that personnel safety is not compromised and that all equipment is serviceable,
- attached to surfaces in such a way that they do not become damaged or disconnected,
- fastened in such a way that permits associated equipment to be easily serviced, and,
- secured at no greater than 0.9 m (3 ft) intervals.

When installed within a plenum, the bonding conductors may be bare. When bare conductors are used, they shall be solidly supported on suitable standoff insulators at intervals of no more than 600 mm (24 in) unless in plenum rated electrical non metallic tubing (ENT). These conductors shall not be in contact with metallic surfaces or other conductors. These conductors shall be covered or jacketed upon exit from the plenum area and may be spliced at this point using an approved irreversible splicing method. The requirement for isolation does not apply to the supplementary bonding entity noted in section 6.6.1 that is installed under an access floor.

Where bonding conductors are placed within ferrous metal conduit that exceeds 0.9 m (3 ft) in length (a short section), the conduit shall be bonded at both ends using a connector Listed by a NRTL and suitable for the purpose. Where multiple short sections are placed in series for the conductor run, they shall also be bonded at both ends, as their collective length would exceed the 0.9 m (3 ft) criteria.

7.3 Bonding connections

Follow the manufacturer's instructions when installing the conductors into the compression connectors. The conductor shall be fully seated at this connection point. Consult the connector manufacturer for specific size and type of crimp dies.

Mechanical connections are typically made by tightening a screw. For example, a screw may be tightened when using a mechanical pipe connector on an electrical conduit. Mechanical connections are reversible and most likely will loosen over time due to expansion and contraction that normally occurs in electrical environments. Where mechanical connections are deployed, they shall be installed with an antioxidant compound between the joined surfaces and be routinely maintained (i.e., no greater than annually) for effective connection.

During the installation, exothermic welds can affect electronic equipment. When an exothermic weld is being installed in the presence of electronic equipment, a low emission exothermic weld should be used.

7.4 Telecommunications main grounding busbar/telecommunications grounding busbar TMGB/TGB

7.4.1 Installation of the TMGB/TGB

In addition to being the central point of attachment for all components of the telecommunications grounding system, the TMGB/TGB shall serve the telecommunications equipment that is located within the area it is installed (e.g., the entrance facility), including building steel, metallic raceway, ladder rack, tray, cabinets, and equipment racks.

7.4.2 Connections between a TMGB/TGB and an EDP

When an EDP is located in the same room as the TMGB/TGB, that EDP's equipment grounding bus or the panel board enclosure shall be bonded to the TMGB/TGB *(see table 1, page 8, for sizing)*. If an EDP is not available within the same room as the TMGB/TGB, provide bonds from the TMGB/TGB to all metallic conduits in the room. A qualified electrician shall make connections within an ac electrical panel.

7.5 Bonding the TBB, GE, TEBC, UBC, or RBC to the TMGB or the TGB

7.5.1 General

Connections to the TMGB/TGB shall use exothermic weld connections or two-hole lug compression connections *(see figure 9)*.

The use of two-hole lugs helps to ensure that the ground connection does not become loose due to excessive vibration or movement of the attaching

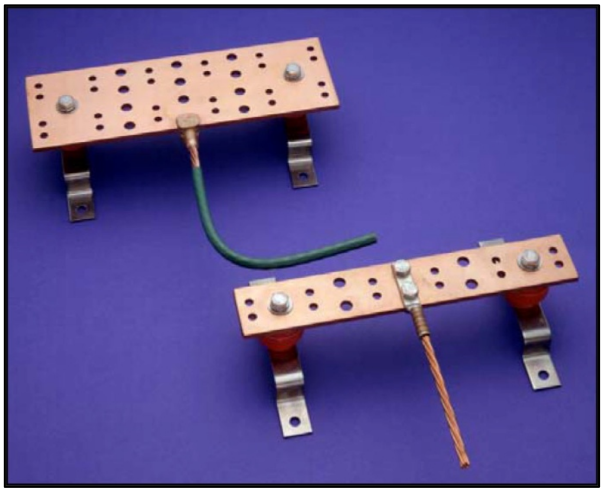

Figure 9. Example of an exothermic connection and a two-hole lug connection to a busbar

conductor. The two-hole lug shall also be the long barrel type with an inspection port *(see figure 10)*.

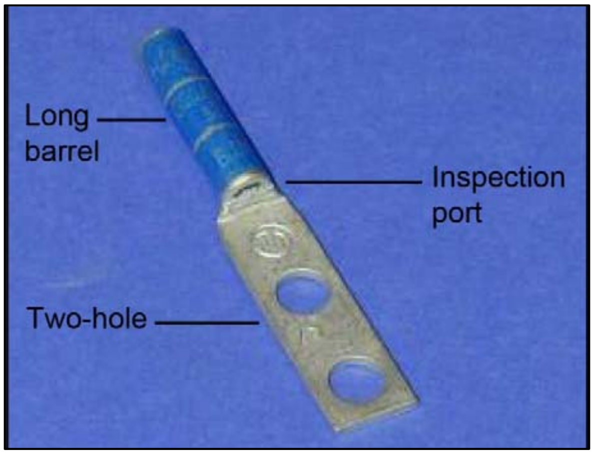

Figure 10. Example of a two-hole lug

7.5.2 Installation

7.5.2.1 Crimp connection of a two-hole lug to a bonding conductor

Select the lug size, configuration, and material applicable to the conductor size and fastening conditions. The following steps ensure a reliable connection between the two-hole lug and the bonding conductor using a crimp connection:

a) Trim the insulation back so that the bared conductor is slightly longer (recommended not to exceed 1.6 mm [0.0625 in] of the barrel) than the barrel *(see figure 11)*.

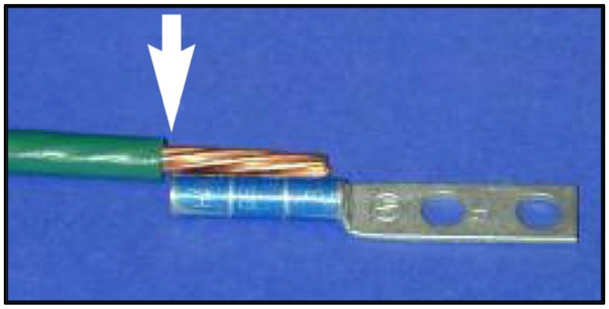

Figure 11. Example of trimmed insulation from a conductor

b) After applying an antioxidant compound on the exposed conductors, insert the conductor so that it "butts up" against the end of the barrel as viewed through the inspection port. The inspection port allows the installer to visually ensure appropriate conductor insertion *(see figure 12)*.

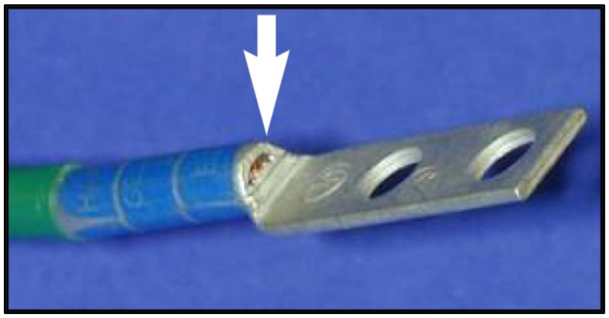

Figure 12. Example of a conductor seen through the inspection port

c) Ensure the end of the conductor remains at the end of the barrel; make the first crimp nearest the tongue end (flat end), working toward the conductor with the remaining crimps *(see figure 13)*. The lug manufacturer's instructions shall be followed for the number of crimps and their location on the barrel *(see figure 14)*.

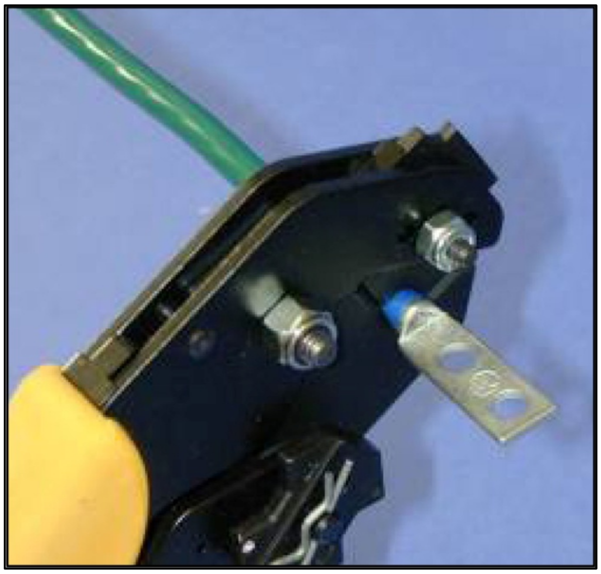

Figure 13. Example of crimping a conductor in the barrel of the lug

Figure 14. Example of a barrel with three crimps

7.5.2.2 Exothermic weld of a two-hole lug to a bonding conductor

The following steps ensure a reliable connection between the two-hole lug and the bonding conductor using an exothermic weld:

a) Select the mold and weld metal applicable to the conductor size and lug configuration.

b) Clean and torch-dry the conductor and the mold. Then insert the conductor and lug into the mold *(see figure 15)*.

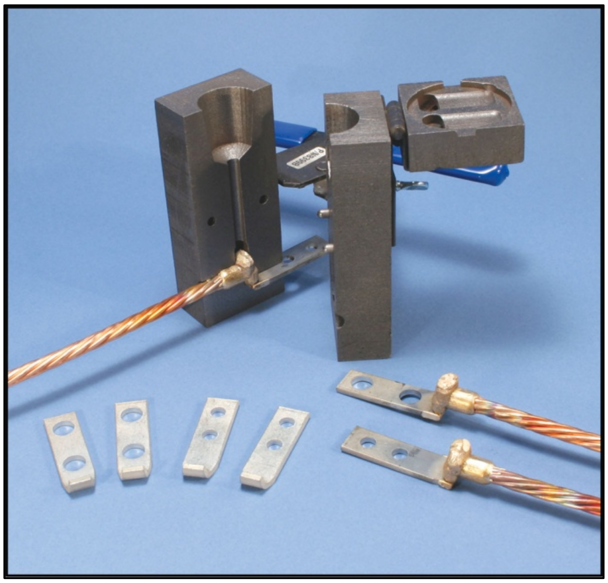

Figure 15. Example of a mold for an exothermic weld

c) Close the handle clamp, lock the mold and then insert the disk into the mold *(see figure 16)*.

Figure 16. Mold being locked and disk inserted

d) Pour the weld metal into the mold. Sprinkle starting material over the weld metal and on the lip of the mold *(see figure 17)*.

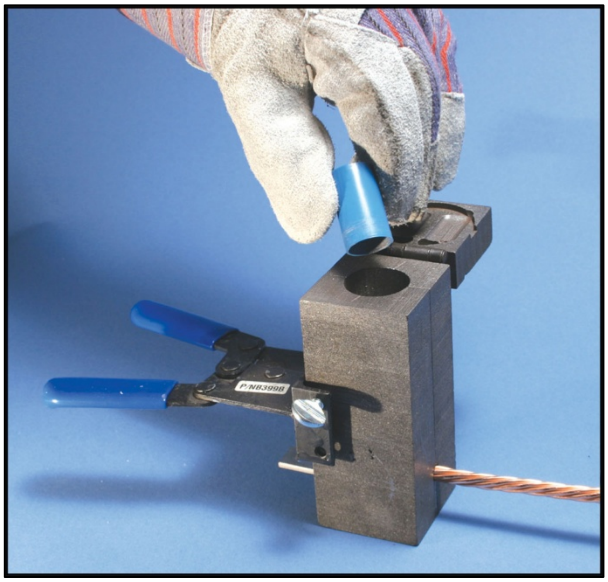

Figure 17. Pouring weld metal into a mold

e) Close the cover and ignite using a flint igniter *(see figure 18).*

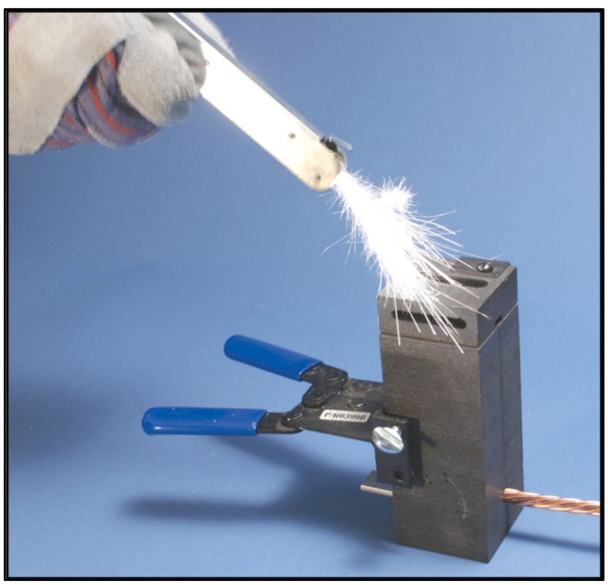

Figure 18. Igniting the accelerant

f) After the reaction is complete, wait a minimum of 15 seconds and then open the mold and remove the finished lug connection.

g) Clean any slag from the finished lug connection and remove any slag from the mold.

7.5.2.3 Connecting to a busbar

a) Surface preparation of the busbar is essential. Using an abrasive pad, remove any dirt, grease, oils, or oxidation that might be present on the busbar surface *(see figure 19).*

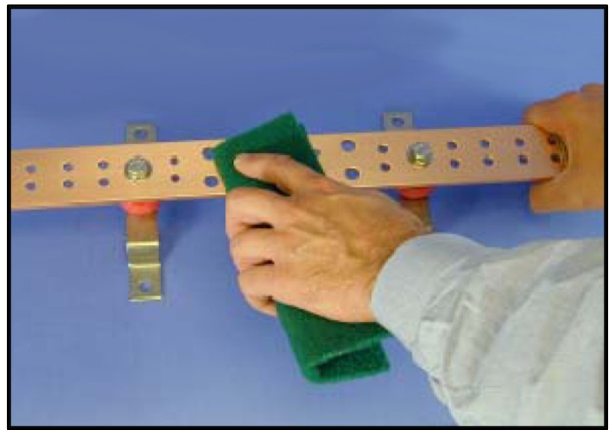

Figure 19. Removing oxidation from the grounding busbar

b) Apply a thin coating of an antioxidant compound to the connection point on the ground bar *(see figure 20).*

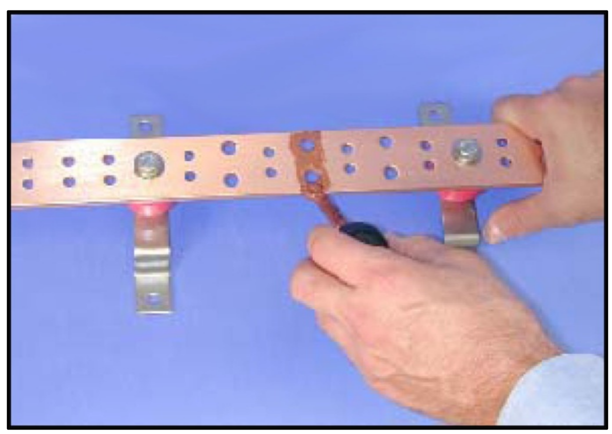

Figure 20. Applying an antioxidant to the cleaned area of the grounding busbar

c) Using stainless steel or silicon bronze hardware, tighten and torque to the value specified for the hardware material, size, and grade *(see figure 21)*.

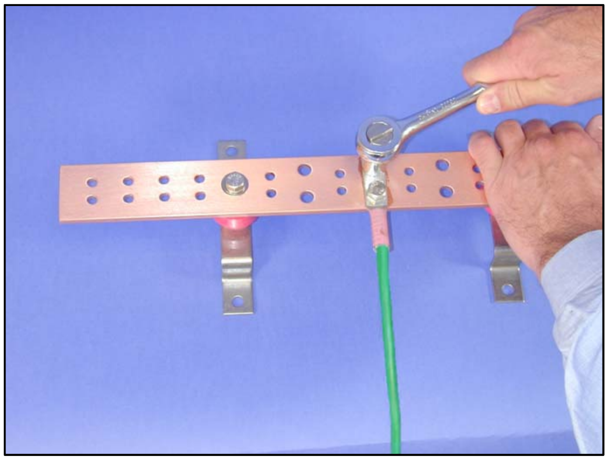

Figure 21. Attaching a lug to the grounding busbar

NOTE: Over tightening may distort the assembly. For the hardware configuration, see *figure 22*.

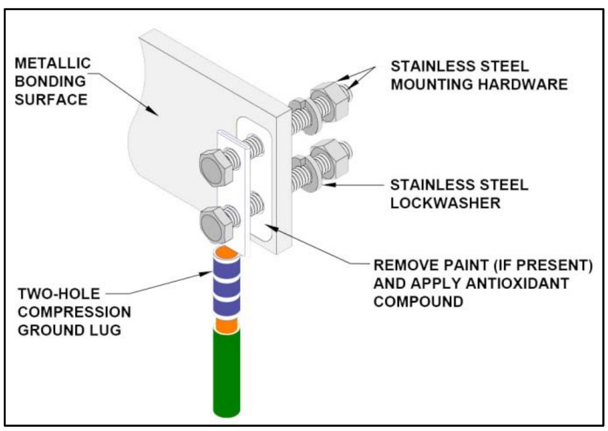

Figure 22. Lug mounting configuration

Only one lug shall be installed per a two-hole mounting on a bonding surface. Lugs shall not over- lap or use the same mounting holes on a bonding surface.

Where fastening hardware is subject to thermal cycling, the lock washer should be substituted with flat washers and a cupped spring washer (Belleville washer), with the cup against the head of the bolt *(see figure 23)*.

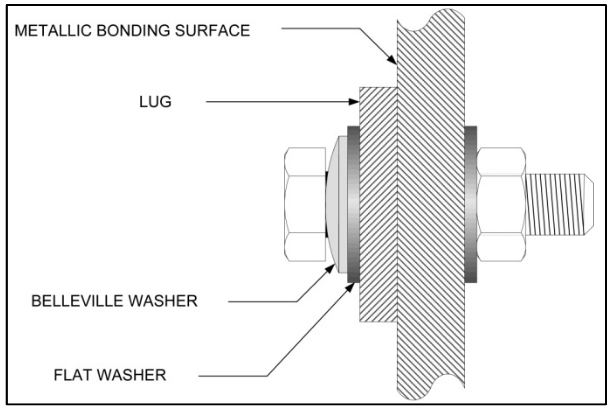

Figure 23. Illustration of the use of a Belleville washer

7.6 Routing the TEBC from the TMGB/TGB to the rack/cabinet

7.6.1 General

At points where the TEBC is routed through holes within metallic surfaces, care should be taken so that the metallic surfaces do not damage the conductor or the conductor's insulation.

Connections to the TEBC shall be made with irreversible compression connectors and with the rack bonding conductors routed toward the TMGB/TGB *(see figure 24)*.

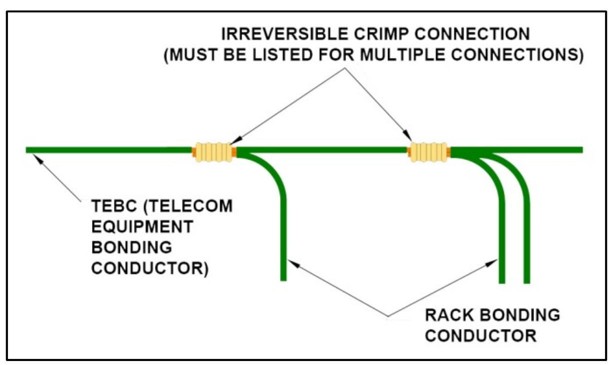

Figure 24. Example of a TEBC to rack bonding conductor connection

The TEBC's may be routed within cable trays, on the outside of ladder racks, trays supported at no greater than 0.9 m (3 ft) intervals, or along equipment platforms *(see figure 25)*. Examples of acceptable means of supporting the TEBC's include the use of lay-in

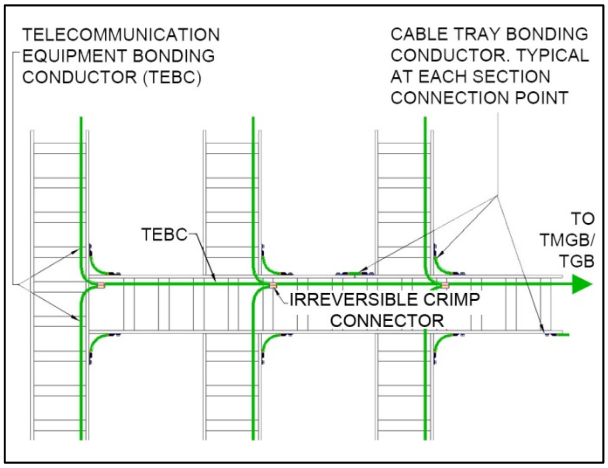

Figure 25. Example of a TEBC routed on a cable tray

lugs, cable brackets, and other brackets designed for this purpose.

An alternative method to running TEBC's overhead is to route them under the access floor. All requirements set forth for running the bonding conductors mentioned previously in this standard shall apply.

7.6.2 Bends

Maintain a minimum bending radius of 200 mm (8 in) for the TEBC. The angle of a bend shall not be less than 90 degrees *(see figure 26)*.

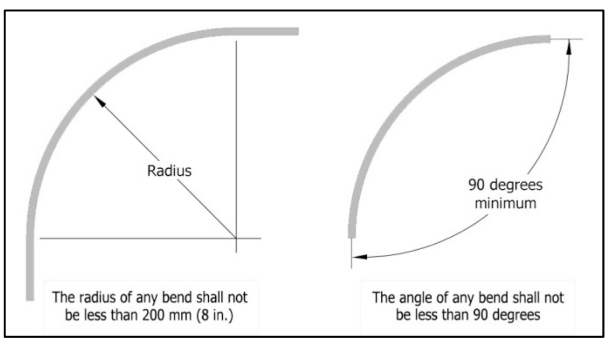

Figure 26. Illustrated bend radius of a TEBC

7.6.3 Separation

TEBC's shall be separated by a minimum of 50 mm (2 in) from conductors of other cable groups such as power or telecommunications cables. For example, TEBC's may be suspended 50 mm (2 in) under or off the side of a cable tray. TEBC's may come in contact with other cable groups if they cross at a 90 degree angle and the crossing angle can be maintained. An exception may be when conductors are grouped together to enter or exit a cabinet or enclosure. Grouping only at this point is acceptable, provided the conductors are suitably separated on either side of the opening.

TEBC's shall be separated from ferrous material by a distance of at least 50 mm (2 in) where achievable or be effectively bonded to the ferrous material.

7.7 Bonding equipment cabinets/ equipment racks to the TEBC

The TEBC shall be connected to the cabinets/equipment racks, to an RBC, or to a vertical/horizontal rack grounding busbar. Each cabinet or equipment rack shall have a suitable connection point to which the bonding conductor can be terminated. The RBC for each cabinet or equipment rack shall terminate directly to the TEBC. It is not acceptable to chain multiple racks or cabinets together with an RBC. Properly sized two-hole compression lugs Listed by a NRTL or ground terminal blocks with internal hex screw or equivalent torque characteristics shall be used at this connection point *(see figure 27)*. To prevent galvanic corrosion effects of dissimilar metals such as an aluminum equipment rack and a copper lug, use similar metallic devices or coat contact area with antioxidant compound.

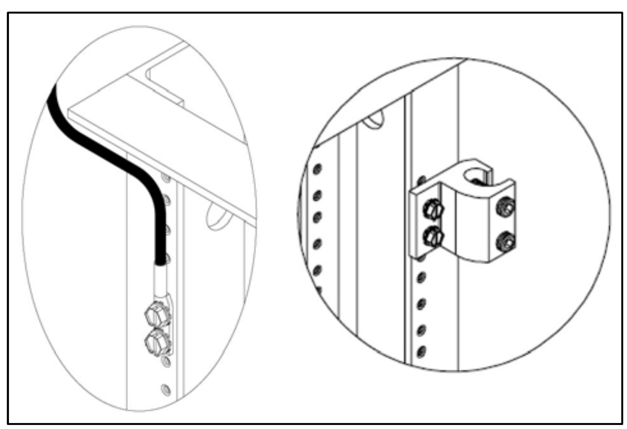

Figure 27. Illustration of a connection point to a rack from a TEBC

7.7.1 Structural bonding of equipment cabinets/equipment racks

For a welded cabinet/equipment rack, the welded construction serves as the method of bonding the structural members of the cabinet/rack together.

For a bolted cabinet/equipment rack, special consideration should be taken as noted below. Ground continuity cannot be assumed through the use of normal frame bolts used to build or stabilize equipment cabinets and racks. Bolts, nuts, and screws used for cabinet and rack assembly and support are not specifically designed for grounding purposes. In this case, paint shall be removed from all bonding contact areas. In any case, removal of the paint from all bonding contact areas is recommended. Bonding hardware (e.g., bolts, washers, nuts, screws), which are specifically designed to accomplish the integral bonding of the cabinet and rack assembly, frame, and support and has been tested to meet applicable NRTL requirements, is an acceptable bonding means.

All detachable, metallic parts of equipment cabinets (e.g., frame, door, side panel, top panel) shall be connected to the grounded cabinet frame either directly or indirectly. Direct connection Is accomplished by bonding the parts with grounding/bonding jumpers to the cabinet frame. Indirect connection is accomplished by grounding/bonding hardware such as Listed clips that penetrate both the part and the cabinet frame.

When a detachable, metallic part of an equipment cabinet is connected to ground by a grounding bonding jumper, the jumper should be a minimum 12 AWG [2.1 mm (0.083 in)] stranded, high strand count, insulated copper conductor with green or green with yellow stripe jacket. Also, the grounding bonding jumper should have an easily visible quick connect to facilitate detaching and attaching the panel or door *(see figure 28)*. Where electromagnetic compatibility (EMC) is a concern for the grounding bonding jumper, a flat braid strap with suitable parameters for EMI control may be utilized.

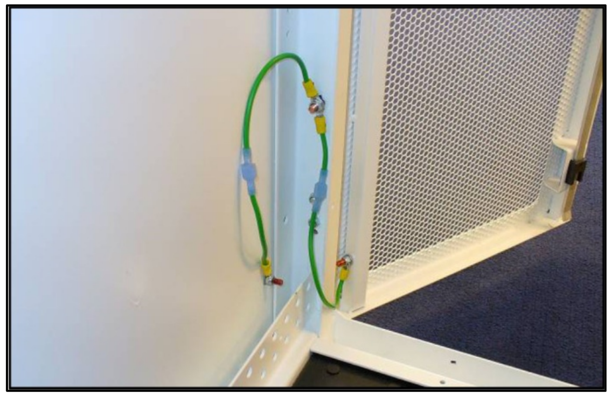

Figure 28. Illustration of a bond connection from a cabinet to the cabinet door

7.8 Bonding equipment to the rack bonding conductor or rack grounding busbars

All bonding jumpers that ground installed equipment shall be sized in accordance with the equipment manufacturer's instructions. Where instructions are not given, all bonding jumpers that ground installed equipment shall be sized to a minimum 12 AWG [2.1 mm (0.083 in)]. Follow the equipment manufacturer's instructions when bonding the equipment to the telecommunications bonding and grounding system.

All equipment chassis, frames, etc shall be bonded to an RBC or rack grounding busbar. The daisy chain method shall not be employed. The daisy chain method refers to any method of connection whereby the conductors are connected from the chassis, equipment frame or rack connection point to a second chassis, equipment frame or rack connection point and on to a third connection point, creating a series arrangement in which the removal of the second connection point interrupts the ground path from the first chassis, equipment frame or rack *(see figure 29)*.

7.9 Bonding cable runways and cable trays

7.9.1 General

In order to achieve the objectives of potential equalization in the TR, ensure that the cable runway sections are bonded together and bonded back to the

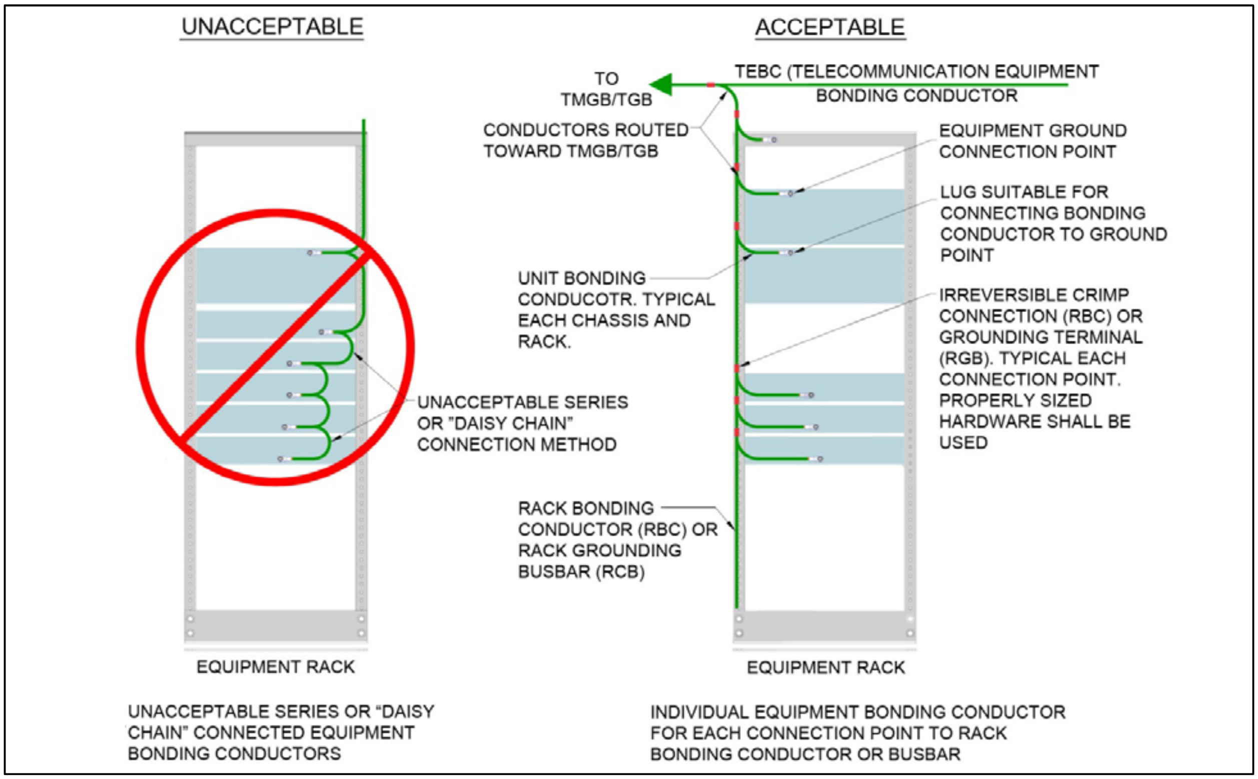

Figure 29. Illustration of acceptable and unacceptable equipment bonding

TMGB/TGB using two-hole compression lugs or ground terminal blocks *(see figure 30)*. Follow the same procedures outlined in subclause 7.5.2 when making these connections. Listed split bolts suitable for the application can be used for bonding sections of cable runways or trays.

Cable runway/tray bonding jumpers/conductors shall be installed between every splice junction of runway/ tray to ensure electrical continuity *(see figure 31)*. The bonding of the splice junctions is not required where tray sections and splice plates are identified as an equipment grounding conductor, and the original configuration of individual sections of the cable run-way or cable tray has not been modified (bent, cut, or reshaped).

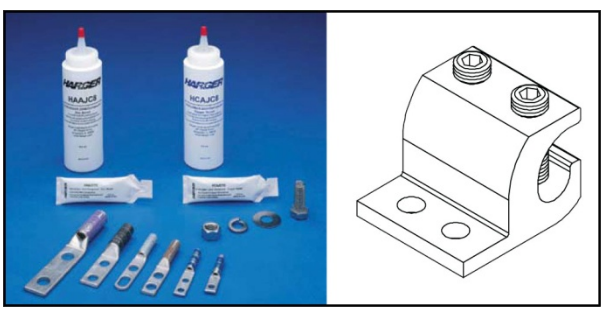

Figure 30. Example of two-hole lugs and a ground terminal block

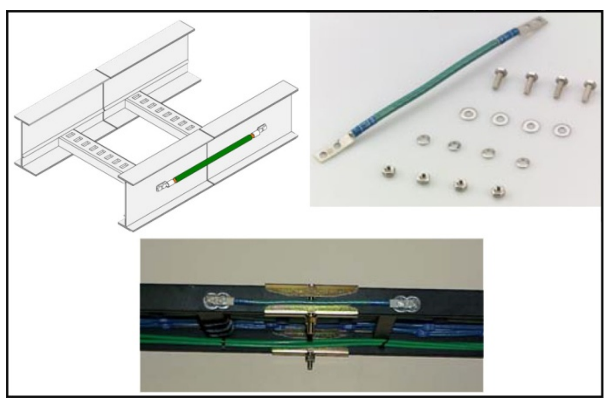

Figure 31. Example of a bonding jumper and its installation between cable tray segments

7.9.2 Installation

The following steps are used to install the cable runway bonding jumper:

a) locate the area in which the jumper is to be installed.

b) remove any paint, oxidation, etc. from the runway surface. A grinding tool is typically used to ensure that all paint and oxidation has been removed.

c) drill two holes as required to accommodate the 2-hole compression lugs.

d) apply a thin coating of antioxidant to the runway surface around the holes.

e) attach straps to the runway using stainless steel hardware sized for the lug holes.

f) tighten and torque the hardware to the value specified for the hardware material, size, and grade.

g) wipe off any excess antioxidant material.

h) repeat this step on the opposite side of the runway.

7.10 Ancillary bonding

All applicable general requirements and bonding requirements listed below shall apply when attaching UBCs to equipment and ancillary support apparatus:

- Each electronic equipment chassis shall have a separate and independent UBC connected to the chassis location that is designated by the manufacturer. Where a location is not so designated, other suitable bonding means (e.g., thread-forming mounting screws) shall be used.

- Connections to steel and galvanized steel pipes, conduit or other round member items shall be made using an electro-tin plated bronze clamp with stainless steel securing hardware Listed by a NRTL, or an aluminum connector rated for copper conductors Listed by a NRTL, each suitable for that purpose. Listed materials that could lead to galvanic corrosion shall not be used.

- Connections to structural building steel shall be made by using an exothermic weld, Listed irreversible high compression-type connection, or Listed tin-plated flange-type bonding connector that is equipped with two securing bolts. See *figure 32* for examples of a flange-type bonding connector and exothermic connection to building steel.

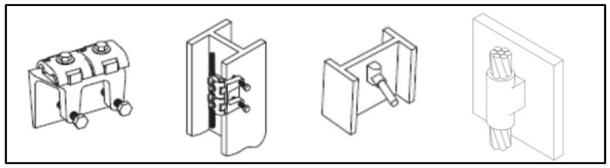

Figure 32. Examples of a flange type bonding connector and exothermic weld connection

7.11 Two-point ground/continuity testing

This procedure may help determine if there is an acceptable level of resistance between any point in the telecommunications bonding and grounding system and the building's electrical grounding electrode system. The test is performed using an earth ground resistance tester that is configured for a continuity test otherwise known as a two-point test or a "dead earth" test.

The earth ground resistance tester *(see figure 33)* generates a specific ac test current; this current is less susceptible to the influences of stray currents on the grounding system. This makes the ground resistance tester a more accurate testing device than a standard volt-ohm-milliammeter.

The test is typically performed by connecting one meter lead to the building's nearest building's electrical

Figure 33. Example of an earth ground resistance tester

grounding electrode and a specific point on the telecommunications bonding and grounding system such as the TMGB. The same test can also verify continuity between any two points of the telecommunications bonding and grounding system such as between the TMBG and the TGB.

The recommended maximum value for resistance between any point in the telecommunications bonding and grounding system and the building's electrical grounding electrode system is 100 milliohms.

Due to the possibilities of ground faults traveling through the telecommunications bonding and grounding system, care should be taken when performing this test; the equipment manufacturer should be contacted for detailed instrument setup and safety precautions.

7.12 Inspection

Visual inspections shall be conducted regularly and whenever alterations or damage occurs, to reveal problems such as loose connections, corrosion, physical damage, and system modifications.

(This annex is not a part of the standard)

Annex A: Bibliography and references (informative)

This annex is informative only and is not part of this standard.

This annex contains information on the documents that are related to this document. Many of the documents are in print and are distributed and maintained by national or international standards organizations. These documents can be obtained through contact with the associated standards body or designated representatives. The applicable electrical code in the United States is the *National Electrical Code® (NEC®)*.

ANSI/NECA/BICSI 568 2006, *Installing Commercial Building Telecommunications Cabling*;

ANSI/TIA 758 A 2004, *Customer-owned Outside Plant Telecommunications Infrastructure Standard*;

ASTM E814-02, *Standard Test Method for Fire Tests of Through-Penetration Fire Stops*;

ATIS T1.313-2003, *Electrical Protection for Telecommunications Central Offices and Similar Type Facilities*;

ATIS T1.331-1999, *Description of Above-Baseline Physical Threats to Telecommunications Links*;

ATIS T1.333-2001, *Grounding and Bonding of Telecommunications Equipment*;

IEEE STD 1100-2005, *Recommended Practice for Powering and Grounding Electronic Equipment*;

Motorola R56-2005, *Standards and Guidelines for Communication Sites*;

NFPA 780-2004, *Standard for the Installation of Lightning Protection Systems*;

TIA 569 B 2004, *Commercial Building Standard for Telecommunications Pathways and Spaces*.

The organizations listed below can be contacted to obtain reference information.

American National Standards Institute® (ANSI®)
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www.osha.gov

Telecommunications Industry Association (TIA)
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(703) 907-7700
www.tiaonline.org

Underwriters Laboratories, Inc. (UL)
333 Pfingsten Road
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(847) 272-8800
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Current *National Electrical Installation Standards*™ published by NECA:

NECA 1-2010, *Standard for Good Workmanship in Electrical Construction* (ANSI)

NECA 90-2009, *Recommended Practice for Commissioning Building Electrical Systems* (ANSI)

NECA 100-2006, *Symbols for Electrical Construction Drawings* (ANSI)

NECA 101-2006, *Standard for Installing Steel Conduits (Rigid, IMC, EMT)* (ANSI)

NECA 102-2004, *Standard for Installing Aluminum Rigid Metal Conduit* (ANSI)

NECA/AA 104-2006, *Recommended Practice for Installing Aluminum Building Wire and Cable* (ANSI)

NECA/NEMA 105-2007, *Recommended Practice for Installing Metal Cable Tray Systems* (ANSI)

NECA 111-2003, *Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC)* (ANSI)

NECA/NACMA 120-2006, *Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC)* (ANSI)

NECA 130-2010, *Standard for Installing and Maintaining Wiring Devices* (ANSI)

NECA 169-2010, *Standard for Installing and Maintaining Arc-Fault Circuit Interrupters (AFCIs) and Ground-Fault Circuit Interrupters (GFCIs)* (ANSI)

NECA 200-2010, *Recommended Practice for Installing and Maintaining Temporary Electric Power at Construction Sites* (ANSI)

NECA 202-2006, *Standard for Installing and Maintaining Industrial Heat Tracing Systems* (ANSI)

NECA 230-2010, *Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers* (ANSI)

NECA/FOA 301-2009, *Standard for Installing and Testing Fiber Optic Cables* (ANSI)

NECA 303-2005, *Standard for Installing Closed-Circuit Television (CCTV) Systems* (ANSI)

NECA 305-2010, *Standard for Fire Alarm System Job Practices* (ANSI)

NECA 331-2009, *Standard for Building and Service Entrance Grounding and Bonding*

NECA 400-2007, *Standard for Installing and Maintaining Switchboards* (ANSI)

NECA 402-2007, *Recommended Practice for Installing and Maintaining Motor Control Centers* (ANSI)

NECA/EGSA 404-2007, *Standard for Installing Generator Sets* (ANSI)

NECA 406-2003, *Standard for Installing Residential Generator Sets* (ANSI)

NECA 407-2009, *Standard for Installing and Maintaining Panelboards* (ANSI)

NECA 408-2009, *Standard for Installing and Maintaining Busways* (ANSI)

NECA 409-2009, *Standard for Installing and Maintaining Dry-Type Transformers* (ANSI)

NECA 410-2005, *Standard for Installing and Maintaining Liquid-Filled Transformers* (ANSI)

NECA 411-2006, *Standard for Installing and Maintaining Uninterruptible Power Supplies (UPS)* (ANSI)

NECA 420-2007, *Standard for Fuse Applications* (ANSI)

NECA 430-2006, *Standard for Installing Medium-Voltage Metal-Clad Switchgear* (ANSI)

NECA/IESNA 500-2006, *Standard for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 501-2006, *Standard for Installing Exterior Lighting Systems* (ANSI)

NECA/IESNA 502-2006, *Standard for Installing Industrial Lighting Systems* (ANSI)

NECA 503-2005, *Standard for Installing Fiber Optic Lighting Systems*

NECA/BICSI 568-2006, *Standard for Installing Commercial Building Telecommunications Cabling* (ANSI)

NECA/MACSCB 600-2003, *Recommended Practice for Installing and Maintaining Medium-Voltage Cable* (ANSI)

NECA/NEMA 605-2005, *Recommended Practice for Installing Underground Nonmetallic Utility Duct* (ANSI)

NECA/BICSI 607-2011, *Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings*

NECA 700-2010, *Standard for Installing Overcurrent Protection to Achieve Selective Coordination* (ANSI)