Corning Optical Communications
4200 Corning Place
Charlotte, North Carolina 28216

800 743-2671
f 828 901-5533
www.corning.com/opcomm

Applications
Engineering Note

Indoor Fiber Optic Bonding & Grounding

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This Applications Engineering Note (AE Note) discusses conventional bonding and grounding practices for conductive fiber optic cable and hardware installations within the scope of the National Electrical Code (NEC). This AE Note does not address outside plant fiber optic installations or applications outside the scope of NEC 2014 Article 90.2*.

Relevant Standards

In addition to the National Electrical Code, various industry standards promote safe and effective bonding and grounding practices in commercial buildings. These standards include, but are not limited to the following published documents:

- **ANSI/TIA-568-C.0**: "Generic Telecommunications Cabling for Customer Premises"
- **ANSI/TIA/EIA-J-STD-607**: "Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications"
- **ANSI/TIA/EIA-942**: "Telecommunications Infrastructure Standard for Data Centers"
- **GR-63-CORE**: "NEBS™ Requirements: Physical Protection"
- **GR-1089-CORE**: "Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment"
- **GR-449-CORE**: "Generic Requirements and Design Considerations for Fiber Distributing Frames"
- **IEEE Std 142**: "IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems"
- **IEEE Std 1100™:** "IEEE Recommended Practice for Powering and Grounding Electronic Equipment"
- **BICSI® Telecommunications Methods Manual (TDM):** Chapter 17: "Grounding, Bonding, and Electrical Protection"

Corning Optical Communications' (COC) recommends consulting these specifications for a complete and thorough understanding of the topic of bonding and grounding of telecommunications systems. This AE Note addresses only bonding and grounding practices for fiber optic components in the context of the overall bonding and grounding network in commercial buildings. This AE Note is not intended to supersede any of the aforementioned standards and codes, but to apply specific interpretation and clarification about fiber optic hardware and cable.

*Installations not covered by the NEC include communications equipment under the exclusive control of communications utilities (telephone, CATV, satellite, etc.) located outdoors or in building spaces used exclusively for such installations.

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The following terms & definitions are consistent with the 2014 NEC and relevant standards:

- **bonded:** connected to establish electrical continuity and conductivity.
- **bonding:** 1) connecting to establish electrical continuity and conductivity. 2) The electrical interconnecting of conductive parts, designed to maintain a common electrical potential. 3) The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the ampacity to conduct safely any current likely to be imposed.
- **bonding jumper:** a reliable conductor to ensure the required electrical conductivity between metal parts to be electrically connected.
- **device:** a unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function.
- **equipment:** a general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, and electrical installation.
- **ground:** 1) the earth. 2) a conducting connection, whether intentional or incidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.
- **grounded(grounding):** 1) connected to earth or to some extended conducting body that serves instead of the earth, whether the connection is intentional or accidental. 2) connected (connecting) to ground or to a conductive body that extends the ground connection, aka "earthing".
- **grounded conductor:** a system or circuit conductor that is intentionally grounded.
- **grounding conductor:** a conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.
- **grounding conductor, equipment (EGC):** the conductive path(s) that provides a ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.
- **grounding electrode:** a conducting object through which a direct connection to earth is established.
- **grounding electrode conductor:** 1) the conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment, or at the source of a separately derived system. 2) a conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.
- **service:** the conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

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Bonding and Grounding Overview:

Bonding and grounding is required for the safe and effective dissipation of unwanted electrical current that may arise in a telecommunications system. Bonding and grounding promotes personal safety, reduces fire hazards, equipment damage and service interruptions. Normally, dielectric optical fiber cable is not capable of transferring electrical current. However, when optical fiber cable contains metallic components such as steel armor or strength members, it is necessary to ground and bond the fiber optic cable to reduce radiated and conducted electromagnetic emissions, as well as to dissipate electrostatic charges that would otherwise build-up on facility structures, cables and equipment. Although telecommunications cabling generally does not communicate electrical power, it is necessary to protect systems and equipment from voltage and current transients. These include internal faults on the facility electrical system, and external disturbances and faults induced by lightning and events that may enter the network from the public utility or electrical grid.

Grounding and Bonding Network

Both public and private premises should establish a uniform grounding and bonding infrastructure to provide for the reliable operation of telecommunications equipment and systems that rely on the electronic transport of information. The NEC is primarily oriented with practical safeguarding of persons and property from hazards arising from the use of electricity but does stipulate requirements for both optical fiber cable and communications systems towards this end. Although the NEC serves as the basis for most authorities having jurisdiction in the U.S., different markets and environments have also relied on various standards for guidance on establishing a complete grounding and bonding system within the overall telecommunications network. Private network enterprises and local area networks (LANs) have traditionally relied on ANSI/TIA-568-C.0 and ANSI/TIA/EIA-J-STD-607. Data centers have begun to rely upon ANSI/TIA/EIA-942. Traditional public carrier networks and RBOCs have historically looked to the Telcordia GR documents for proper bonding and grounding specifications (GR-63-CORE, GR-1089-CORE and GR-449-CORE). IEEE and BISCI recommendations have spanned across all of these markets.

The bonding network or infrastructure typically originates at the service equipment (power) ground and extends throughout the building. In accordance with ANSI/TIA/EIA-J-STD-607, it includes the telecommunications main grounding busbar (TMGB) and associated bonding conductors. It may also include a dedicated telecommunications bonding backbone (TBB), grounding equalizer (GE), and a telecommunications grounding busbar (TGB). The bonding network is also associated with both the building's grounding electrode system and the building structural components, as well, such as the building steel itself, and water pipes, as well as the various telecommunications and power subsystem components, such as cable racks, vertical and horizontal equalizer conductors, bonding conductors, and electrical metallic raceways. When all of these components are bonded together, it is commonly called the Common Bonding Network (CBN).

In summary, the bonding network typically is comprised of three distinct interconnected, functional subsystems:

- NEC-specified electrical safety grounding subsystems.
- Telecommications (including data and signaling circuits) grounding subsystems.

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- Lightning and surge protection subsystems.

These functional grounding subsystems are all eventually solidly (electrically) interconnected (bonded) to a common earth electrode system at the power utility service entrance. The Intersystem Bonding Termination is typically the device that connects the communications system(s) grounding conductor(s) and bonding conductor(s) at the service equipment or at the disconnecting means for buildings or structures supplied by an electrical current-carrying feeder or branch circuit. It is the “bonding conductor for telecommunications” (J-STD-607-A) that effectively bonds the telecommunications subsystem (at the TMGB) to the service equipment power ground.

Bonding and Grounding Fiber Optic Cable

Conductive fiber optic cable containing metallic components or strength members capable of transmitting stray current must be grounded when entering or terminating on the outside of buildings in compliance with 770.100 of the NEC (2014). Alternatively, an insulating joint or equivalent device must interrupt metallic members. The grounding or interruption should occur as close as feasible to the point of entrance, which is where the cable "emerges from an external wall, concrete floor slab, rigid metal conduit (RMC), or from intermediate metal conduit (IMC)". In these requirements, it is important to differentiate the terms “conductive” from “composite” with regards to optical fiber cables. “Composite” cables are classified as electrical cables and subject to NEC requirements for those types of electrical conductors.

Conductive fiber optic cable per NEC 770.100 must be grounded through a bonding or grounding electrode conductor. NEC 770.100 (A) provides the requirements for the bonding conductor, but most fiber optic cable manufacturers provide a U.L. listed 6 AWG copper strand and clamp (per Article 250.70). Although the NEC does allow a minimum size of 14 AWG (minimum) for the size of the grounding conductor, 6 AWG is preferred to allow for both grounding and bonding purposes in compliance with ANSI/TIA/EIA-J-STD-607 and the NEC. The NEC also requires that the bonding conductor be run to the building’s grounding electrode “in as straight a line as practicable”, which suggests that the fiber optic cable’s metallic components be bonded directly to the grounding electrode. This is also consistent with the NEC's requirement for "continuity" (Article 200.2), which states, "the continuity of a grounded conductor shall not depend on a connection to a metallic enclosure, raceway, or cable armor." The bonding conductor or grounding electrode needs to be “as short as practicable” (generally, less than 20 ft. in length). The bond attachment to the grounding electrode can either occur at the Intersystem Bonding Termination (if present) or depending on whether the building does or does not feature other grounding means, it can occur at other accessible locations per NEC Article 770.100 (B).

In practical implementations, conductive fiber optic cable will be bonded to the TMGB or the TGB (i.e. Central Office Ground Busbar, or COG Busbar) with a dedicated bonding conductor. Although the telecommunications grounding and bonding infrastructure may include a TBB, (which serves to interconnect all TGBs with the TMGB) the main purpose of the TBB is to reduce or equalize potential differences between telecommunications systems and multiple TGBs and the TMGB, and is not intended to serve as the only conductor providing a ground fault current return path. Hence, fiber optic cables are often connected to dedicated bond paths back to the TGB or TMGB. ANSI/TIA-568-C.1 requires that ANSI/TIA-568-C.0 be followed to properly bond and ground installed cables. ANSI/TIA-568-C.0 in turn requires that the telecommunications grounding and bonding system shall conform to local

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codes and ANSI-J-STD-607-A requirements. Specifically, J-STD-607 requires that backbone cables incorporating metallic armor or strength members be bonded [directly] to the TMGB or TGB.

Bonding and Grounding Fiber Optic Hardware:

Article 770 of the NEC does not specifically address the bonding and grounding of fiber optic hardware, including fiber optic distribution frames and racks, and rack-mountable and wall-mountable enclosures and housings (i.e. “patch panels”). Moreover, ANSI/TIA-568-C.3 (Optical Fiber Cabling Components Standard) contains no requirements for grounding and bonding provisions in “Housing for cable terminations” (section 6.4). However, this does not preclude or prevent fiber optic hardware from being bonded and grounded in conformance with NEC Articles 250 (“Grounding and Bonding”), 770 (“Optical Fiber Cables and Raceways”), 800 (“Communication Circuits”), and 830 (“Network-Powered Broadband Communications Systems”). Depending on the local **authority having jurisdiction (AHJ**), some fiber optic hardware enclosures could be considered as normally non-current-carrying electrically conductive materials that are likely to become energized, and therefore subject to the requirements of NEC Article 250.4, General Requirements for Grounding and Bonding.

If deemed necessary by the AHJ, indoor fiber optic hardware can be bonded and grounded through the attachment of a 6 AWG copper or equivalent bonding jumper in accordance with Article 770.100 of the NEC. Some, but not all fiber optic hardware provides means for attaching a bonding strap or conductor in compliance with NEC Article 250.70, which provides methods of "grounding and bonding conductor connection(s) to electrodes". In general, Article 250 of the NEC is concerned with the grounding and bonding requirements of electrical installations that include electrical equipment, enclosures and raceways. Both Article 250 and Article 314 (“Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures”) do not specifically address fiber optic hardware with regards to bonding and grounding practices. When the applicability of these articles is in question or challenged, the local AHJ should be consulted for final interpretation.

In many central offices (COs), distributing frames and protector frames must be grounded as part of the CBN per Telcordia GR-1089-CORE. Furthermore, each frame, cabinet, or similar metallic communication equipment enclosure or supporting assembly must provide a means for attaching a bonding conductor to the grounding system. This is consistent with NEC Article 250.96 ("Bonding Other Enclosures") which requires "metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings, and other metal non-current-carrying parts that are to serve as equipment grounding conductors to be bonded where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them." Telcordia GR-449-CORE stipulates that the frame bond to ground be made with at least a 6 AWG copper conductor using a 2-hole connector. In addition, fiber distribution frame (FDF) bays must provide bonding and grounding terminals for all metallic components, including those found in fiber optic cables. Fiber optic housings (i.e. patch panels) often directly bond via thread-forming type unit mounting screws to the frame. In addition, per NEC 250.96, "any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings designed so as to make such removal unnecessary."

When a steel frame is bonded to the grounding infrastructure, it effectively will be part of the grounding path, which is justified because the cross-sectional area of the frame uprights is

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much larger than that of a #6 AWG copper wire. The net effect is that a standard 7-foot frame has approximately the same electrical resistance as an 8-foot, #6 AWG copper wire. Such practices may or may not be applicable in the enterprise LAN or Data Center, or when aluminum equipment frames are used. Consult with the manufacturer of the specific fiber optic frame or housing for specific bonding and grounding practices in these instances, as traditional central office practices and standards may not be applicable. For more information contact Product Technical Support at 800-743-2671.

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References:

1) ANSI/TIA-568-C.0: “Generic Telecommunications Cabling for Customer Premises"
2) ANSI/TIA/EIA-J-STD-607: “Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications”
3) ANSI/TIA/EIA-942: “Telecommunications Infrastructure Standard for Data Centers”
4) GR-63-CORE: “NEBS™ Requirements: Physical Protection”
5) GR-1089-CORE: “Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment”
6) GR-449-CORE: “Generic Requirements and Design Considerations for Fiber Distributing Frames”
7) IEEE Std 142: “IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems”
8) IEEE Std 1100™: “IEEE Recommended Practice for Powering and Grounding Electronic Equipment”
9) BICSI® Telecommunications Methods Manual (TDM): Chapter 17: “Grounding, Bonding, and Electrical Protection”
10) ATT-TP-76416-001: Grounding and Bonding for Network Facilities – Design Fundamentals

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