STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

At a session of the Public Service Commission held in the City of Albany on December 10, 2008

COMMISSIONERS PRESENT:

Garry A. Brown, Chairman
Patricia L. Acampora
Maureen F. Harris
Robert E. Curry, Jr.

CASE 08-V-0835 - In the Matter of Verizon New York Inc.'s Network Review Plan.

ORDER CONCERNING THE GROUNDING OF FIOS INSTALLATIONS

(Issued and Effective January 14, 2009)

BY THE COMMISSION:

INTRODUCTION

Verizon New York Inc. (Verizon or the company) is building a state-of-the-art, all fiber network, known as FiOS, over which it intends to provide advanced voice, data and video services. In this Order we consider the applicability of the National Electric Code (NEC or the Code) to those and the broader issue of the safety of Verizon's installations regardless of the Code. We find that because there are significant ambiguities in the Code it is not clear that it applies to the provision of service over a fiber optic system such as Verizon's FiOS. We determine that given the testing that has been performed on Verizon's equipment there is an insufficient basis on which to conclude that the ONT is an appropriate path to ground. Because the demonstration on safety is in some respects incomplete and in other ways not robust, we will require a simple and inexpensive grounding block be added to installations going forward unless Verizon can provide a better demonstration that the grounding paths within its

installations are appropriate. We also determine that at this time existing installations will, for the most part, not be required to conform to the new procedure. The cost of remediations is not well developed on the record before us, and we hesitate to order such action for those ONTs that have withstood the Curtis Strauss testing (discussed below) without either additional testing or data that show that full remediation of all ONTs is justified. On the other hand, those installations, also described below, that have demonstrated a vulnerability to having the grounding circuit open (i.e. fail) when subjected to the currents employed in the tests shall be remediated when Verizon has another reason (such as maintenance or service) to visit the premise, unless Verizon is able to demonstrate why it should not be required to do so.

BACKGROUND

Verizon says that passive optical networks such as FiOS do not rely on electrical power transmitted through outside plant facilities and that the optical fiber does not conduct electricity. It claims that an all-fiber network significantly reduces the risks associated with delivering service over electrically conductive coaxial cable, which is the technology used by conventional cable companies.

FiOS is provided through a fiber optic cable that, in some installations, enters the house and terminates at an Optical Network Terminal (ONT) – a device that contains electronics that separate voice, data, and video, and forwards signals to the appropriate device[1]. A television and set-top box are often connected to the ONT by conductive, coaxial cable. The ONT has a three prong electric power plug and a separate grounding lug.

[1] See the diagrams in Attachment 1.

Instances where the ONT is mounted inside the house are referred to as “inside installations.” The location of the ONT is important, as discussed below, because there is non-conductive fiber leading to the ONT but conductive coaxial cable leaving it. Outside ONTs thus have some coaxial cable outside of the building, giving rise to an issue about the applicability of the National Electric Code.

After Verizon's filing of its Network Review Plan on July 15 an issue arose concerning the applicability of the grounding and bonding requirements of the National Electric Code relating to a subset of FiOS installations, i.e., installations where coaxial cable does not have an external appearance, that is, where the fiber optic cable attaches to the building and enters the premises and terminates at Verizon's inside installed ONT. Interim grounding commitments were made in Verizon's August 15 supplement to its Network Review Plan to utilize traditional Code compliant grounding methods for inside installations unless they are "impractical or unsafe" in which case Verizon would use the alternative TII 442 grounding module. The TII 442 grounds the ONT and attached coaxial cable inside the premise by using typical three-prong household plugs, as opposed to a separate direct path to the main grounding electrode. The issue subsequently expanded to include a closer examination of the grounding pathway within the ONT because Verizon uses the ONT to facilitate grounding of the attached coaxial cable. Thus at issue here are all ONTs (inside and outside) and the wiring for the TII 442 grounding module (from the ONT to the household plug) which is only used in inside installations.

Grounding and bonding[2] reduces the risk of electric shock. The Commission has recognized the importance of grounding and bonding of telephone and cable television services:

> Telecommunications facilities are designed to be properly grounded and bonded to protect facilities and personnel in the event of an electrical surge, lightning strike or an electrical power fault. [3]

The coaxial cable connecting the ONT to the set top box by the television may conduct electricity; the issue is how the cable should be grounded and bonded. For inside installations, Verizon claims all that is required is plugging the ONT into a properly grounded outlet, or, in instances where such an outlet is beyond a certain distance from the ONT, into a TII 442 grounding module.

APPLICABILITY OF THE NATIONAL ELECTRIC CODE

The Commission has incorporated the National Electric Code (NEC or Code) by reference in its regulations, so there is a

[2] "Grounding" refers to connecting the non-current carrying, accessible parts of electrical circuits to ground (earth) as protection from hazards such as electrical voltages, static charges, voltage spikes, or inadequate insulation. ”Bonding” refers to the connection of various ground circuits to a common grounding electrode system to avoid voltage potentials between them. Relevant provisions of the National Electric Code are provided in an attachment to this order.

[3] Case 04-M-0159, Examination of the Safety of Electric Transmission and Distribution Systems – Implications of Stray Voltage Issues as They Relate to Telephone and Cable Companies, Order (issued October 3, 2005) p. 3.

threshold issue of whether the Code requires grounding and bonding.[4]

Argument Supporting Applicability

Staff has viewed the Code broadly as protecting coaxial cable used to interconnect electronic equipment from introducing electrical hazards. Article 820 of the National Electric Code "covers coaxial cable distribution of radio frequency signals typically employed in community antenna television (CATV) systems" and the Code Handbook, an aide to interpretation of the code, makes clear that the scope of Article 820 includes coaxial cable used in the provision of cable telephone service: "the installation of coaxial cable for the distribution of radio frequency (RF) signals associated with closed-circuit television, cable television, and security television cameras. This article also covers interior coaxial cable for radio and television receiving equipment". We note as well Article 820.2, which provides that "coaxial cable containing a shield shall be grounded . . . ."

Verizon contends that grounding is designed solely to safeguard against external hazards. The NEC 2008 Handbook explains that there are two basic reasons for grounding:

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[4] 16 NYCRR 896.2 provides that

> Construction of cable television systems shall comply with all relevant safety codes including electric or other public utility codes for joint use of pole lines or underground facilities. Other local construction codes and municipal and state laws and ordinances may also apply to the construction and maintenance of cable television systems. Particular attention is called to the appropriate sections of the National Electric Code as published by the National Fire Protection Association concerning the grounding and bonding of subscriber drop cables at building entry points as referenced in §10.3 of this Title.

> 1. To limit the voltages caused by lightning or by accidental contact of the supply conductors with conductors of higher voltage
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> 2. To stabilize the voltage under normal operating conditions (which maintains the voltage at one level relative to ground, so that any equipment connected to the system will be subject only to that potential difference).[5]

Staff disagrees with Verizon's suggestion that there is no risk of lightning or power line contact for inside installations. Although the risk of surges from lightning or power line contact in the FiOS architecture is less than the conventional cable system, Staff notes that the coaxial cable connected to the ONT has a metallic shield which could be exposed to induced currents as a result of a nearby lightning strike, a surge affecting power lines which arcs to the metallic components of the cable or its connectors, or current resulting from a fault in equipment attached to the coaxial cable. Staff also recognizes that these risks are likely remote and that existing protective devices like circuit breakers can sometimes address certain of these risks.

Verizon's basic argument is that while the Code applies to conventional coax-based cable systems as yet there is no Article of the Code that was developed specifically with FTTP-type architecture in mind. It also claims that FiOS is safe without the conventional grounding and bonding approach proposed by Staff. It says it is not aware of any instances in which it has been determined that harm to either person or property was caused by an improperly grounded ONT. Verizon says that each of the ONTs used by Verizon is "listed" by a nationally recognized testing laboratory and that they are safe.

[5] NEC 2008 Handbook, NFPA 70: National Electric Code, Article 250, p. 200.

It says that because the only facility entering a house in inside installations is made up of optical fiber that does not conduct electricity there is no risk of a current surge entering the building from a lightning strike or power line contact. It quotes a letter from Underwriters Laboratory to Staff to the effect of "[t]he requirements for bonding the grounding conductor to the grounding electrode system appear to address hazards originating external to the dwelling such as lightning and induced transient conditions that would enter the dwelling via conducted elements."[6]

Verizon says that ONTs are grounded and the grounding requirement is satisfied by connecting the coaxial cable through the ONT to the equipment grounding conductor via the grounding pin of the electrical receptacle in the building. Verizon claims that Staff's opposition to its method arises from a belief that there is a need to establish a grounding path for current surges originating in a television set and the need to dissipate current surges resulting from a lightning strike on or near a home that energizes conductors inside the home. Verizon says there is no requirement in the NEC for this approach and that expecting the ONT to provide a grounding path is neither an effective nor an appropriate solution to the problems Staff sees.[7] It says that no matter what type of grounding arrangement is used between the ONT and the grounding electrode, the coaxial cable connecting the television to the ONT is an ineffective grounding path. Verizon states that in order to determine whether safe management of a "hot TV" is satisfied by using the ONT and TII 442, it commissioned a testing laboratory to perform a series of tests and that the test results, described in some

[6] Verizon's Comments, p. 13, quoting letter to Peter McGowan from Mr. Donald J. Talka, Senior Vice President and Chief Engineer, Underwriters Laboratories (September 9, 2008).

[7] Verizon's Comments, p. 15 and Verizon Reply, p. 4.

detail in its comments, demonstrated the potentially high impedance of the coaxial cable and its susceptibility to heating under fault conditions, thus pinpointing the cable, and not the ONT ground as the potential failure point.[8]

Turning to an analysis of sections of the code, Verizon notes first that §250.114 exempts double-insulated, listed, information technology equipment from grounding requirements. It asserts that its ONT falls within the requirements of this section:

> Under any of the conditions described in §250.114(1) through (4), exposed noncurrent carrying metal parts of cord and plug connected equipment likely to become energized shall be connected to the equipment grounding conductor.
>
> Exception: Listed tools, listed appliances, and listed equipment covered in §250.114(2) through (4) shall not be required to be connected to an equipment grounding conductor where protected by a system of double insulation or its equivalent.[9]

It says that "listed equipment" includes listed information technology equipment such as ONTs – citing §250.114(3)(b) - - and that since the ONT is listed it falls within the exception.

Verizon claims that other aspects of the code are similarly inapplicable. It claims that §770.100 deals only with "grounding methods" and that that section is applicable only where grounding is otherwise required and, in any event, only to "metallic members of optical fiber cables entering buildings." Article 800 is inapplicable in Verizon's view because it applies to communication circuits and equipment.[10] While the code defines "communication circuit" as "[t]he circuit that extends

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[8] In the so-called Curtis Straus tests the coaxial cable that was used in the tests did not fail as Verizon suggests.

[9] Verizon's Comments, p. 19.

[10] Verizon's Comments, p. 20 citing §800.1.

voice, audio, video, data, interactive services, telegraph (except radio) outside wiring for fire alarm and burglar alarm from the communications utility to the customer's communications equipment up to and including terminal equipment such as a telephone, fax machine, or answering machine" Verizon cites its expert's opinion that the term circuit can only refer to a conductive, current carrying facility, and, in any event, Verizon states that §800.93 applies grounding requirements only to "metallic sheath members" of "communications cables entering the building or terminating on the outside of the building" and that Verizon's fiber optic cable has no metal sheath but is rather sheathed in a nonconductive substance called Kevlar.

Article 820, Verizon goes on, "covers coaxial cable distribution of radio frequency signals typically employed in community antennae television (CATV) systems."[11] It says that the reference to CATV clearly applies to the traditional type of cable system in which coaxial cable enters the building, not to a fiber to the premises system. It says that §820.93 imposes grounding requirements only for coaxial cables entering buildings or attached to buildings and that Article 830 applies only to network powered broadband communication systems. It concludes that there is no basis for requiring Verizon to bond inside or outside ONTs to a grounding electrode anymore than such a requirement exists for the wide array of other electronic equipment and appliances in a consumer's home.

Discussion

Article 820.1 provides "this article covers coaxial cable distribution of radio frequency signals typically employed in community antennae television (CATV) systems."[12] The threshold issue, then, is the extent to which Verizon's fiber architecture is so different from "typical" installations that

[11] Verizon's Comments, p. 21 citing §820.1.

[12] National Electric Code §820.1 (emphasis supplied).

they need not conform to Article 820, which in turn requires consideration of (1) the nature of the FiOS installation and, (2) the effect of the scope clause.

Verizon's FiOS service architecture is different from that of a traditional cable network. FiOS delivers services from Verizon's serving office to the customer's premises over fiber-optic cable protected with a Kevlar sheath. Neither the fiber-optic cable (which is glass) nor the Kevlar (a plastic) conduct electricity.[13] The conventional architecture used by cable companies, on the other hand, delivers service into a customer's home using coaxial cable. And unlike the fiber-optic cable used in connection with FiOS, coaxial cable does conduct electricity, and thus can provide a path into and within the customer's premises for unwanted and potentially hazardous currents originating from outside the customer's premises. Moreover, unlike FiOS, the coaxial cable drop used in a conventional cable company's distribution plant is exposed to lightning strikes and to accidental contact with the power supply lines that are frequently located only a few feet above it.

As noted above, at the customer's premises, Verizon's fiber-optic cable is terminated at an Optical Network Terminal (ONT). The circuitry in the ONT separates out the signals on the fiber-optic cable, performs protocol conversions, and sends the resulting voice, data, and video streams out to television set-top boxes, computers, and other equipment in the customer's home over interior coaxial cable or other types of conducting media. In outside ONT installations the ONT is mounted outside

[13] Where the fiber-optic drop to a customer's building is buried underground, Verizon utilizes fiber-optic cable containing conductive "tracer wire" that can be located using metal-detection equipment. Verizon cuts off and caps the tracer wire at a point before the cable enters the building. Thus, the tracer wire will not provide an electrically conductive path into a customer's premise as required by Article 770.

of the customer's building. In such cases, the coaxial cable that emerges from the ONT is routed along and through the wall of the building into the customer's premises. Typically the outside coaxial cable found in FiOS installations are the relatively short lengths of cable running from the ONT to the point of entry into the building, or between entry and exit points.

There seems to be little question that the FiOS installation is indeed different than a "typical" cable TV installation, but the issue remains as to whether the scope clause quoted above should be construed as limiting application of the article to only the "typical" systems using mostly coaxial cable. This is a close question for outside installations and either interpretation is plausible.

Next, we consider the more narrow arguments concerning the construction of section 820. Verizon seems to have the better of the argument when it asserts that the Code doesn't require the cable to be grounded for inside ONT installations. Perhaps the strongest argument for requiring grounding would be the sentence in the 820.100 that provides that "the shield of the coaxial cable shall be grounded as specified in 820.100(a) through (d)."[14]

There are at least two problems with this argument. The first is that it seems reasonable, as Verizon suggests, to assume that the intent here was to ground traditional coaxial cable that entered the house, not simply the coaxial cable that is within the house. Second, the sentence is in a section titled "Grounding Methods," and if we were to give effect to the title of the section, we would look for an affirmative grounding requirement elsewhere. That is, while the particular sentence

[14] An argument further supported by 820.103 which says equipment and enclosures shall be grounded by virtue of their connection to the coaxial shield.

says that the cable "shall be grounded" it is reasonable, given the title of the section in which the sentence appears, to construe that requirement as only providing for the method of grounding, that is "as specified in 820.100(a) through (d)" of installations that must otherwise be grounded. [15] Turning to the preceding section of the code which provides the grounding requirement – 820.93 provides that cables shall be grounded in at least two instances: either when entering the building or terminating outside of the building. Those instances are not applicable for inside installations. Thus, when read together the requirement of 820.100 is reasonably construed as going to only the method of grounding, not whether an installation should be grounded or not.

Additionally, while 820.93 applies to "coaxial cables entering buildings or attached to buildings," the ground requirements of that section apply only to cable "entering buildings," or cable "terminating outside of the building," instances that don't apply for inside installations.

Verizon's comments acknowledge that the outside configuration creates a potential – perhaps small – risk that the coaxial cable outside of a home could introduce a current surge into the home, either as the result of a lightning strike or through accidental contact with an electrical power supply line. Verizon's experts appear to concede that the NEC requires

[15] Article 820.100 may not be solely a list of grounding methods. Article 250 specifically addresses Grounding and Bonding, and Article 250.94 addresses bonding of systems. A "fine print note" to that section advises to "See 800.100, 810.21, and 820.100 for bonding and grounding requirements for communications circuits, radio and television equipment, and CATV circuits." This note is not sufficiently authoritative to override our conclusion that section 820.100 does not require grounding of inside coaxial cable.

that outside installations be grounded in accordance with the requirements of the Code.[16]

In outside installations a coaxial cable is attached to the building and has an external appearance, so there is a stronger argument that the Code applies, and a reading of the plain meaning of 820.93 would support that conclusion.[17] Reading that section in context, however, reveals several ambiguities. The most significant question is the extent to which it matters that Verizon's system is composed largely of nonconductive fiber, as discussed above.

We also note that while Verizon has claimed that it is not aware of any harm to persons or property from FiOS installations, staff is examining several incidents brought to its attention by end users that involve property damage. In three incidents, Verizon rearranged the ground wiring to resolve the complaint, and, in two incidents Verizon replaced faulty ONT equipment. At one location the ONT was replaced seven times and it was ultimately determined that voltage existed on a segment of coaxial cable where a TV was claimed to have been damaged and service was lost intermittently. Verizon compensated that customer for two months of lost service and another customer for damaged equipment following a lightning strike. Tellabs model 612 ONTs, discussed below, were installed in each of the incident locations. While it is difficult to conclusively pinpoint the cause of the damage and loss of service in these instances to improper grounding or defective ONTs after the

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[16] Declaration of Michael F. Stringfellow, ¶16, and Exhibit 3 to Verizon Comments (August 11, 2008 letter from Dan McMenamin and Associates, Inc.).

[17] Section 820.93 requires that "coaxial cables entering buildings or attached to buildings shall comply with 820.93(A) or (B)." 820.93(A) and (B) both require that the outer conductive shield of the cable shall be grounded.

fact, the nature of the damage and the methods employed by Verizon to resolve three of the four FiOS consumer complaints suggest that those factors cannot be ruled out as contributing factors.

Accordingly, a reasonable interpretation of the NEC is that Article 820 does not apply to inside installations. The logic of not applying the code to inside installations militates in favor of extending the logic to outside installations, because the risk of moving the ONT one or two feet from inside to outside does not appear to be a material difference warranting a different conclusion. Therefore, instead of basing any decision solely on the applicability of the Code we will analyze the testing results and evaluate FiOS safety in that light.

WHETHER VERIZON'S GROUNDING APPROACHES ARE ACCEPTABLE

Putting aside the arguments as to the applicability of the Code previously addressed, the broader issue is whether Verizon's grounding methods provide an acceptable level of protection for potential electrical hazards. This exercise involves a balancing of the likelihood of occurrence of the potential risk presented (and potential for damage) with the level of protection (suitability of design, durability, consequences of failure) provided and the cost/benefit trade offs associated with altering the balance. We consider first Verizon's proposed use of the TII 442 grounding module and then the broader issue of the grounding path within the ONTs.

The TII 442

The TII 442 grounding module is designed to ground installations where easy access to conventional grounding approaches is impractical, as, for example, in apartment buildings where the ONT may be a great distance from an appropriate traditional ground point. Verizon's Plan provided that

> For Inside Installations Verizon will utilize one of the approved Staff methods [essentially, the National Electric Code] unless it would be impractical or unsafe to do so, in which case it will utilize – on an interim basis – the TII-442 Grounding Module with ten-gauge wire, as presented by Verizon to Staff on August 13, 2008. . . . Verizon will work expeditiously and cooperatively with Staff to secure an additional confirmation, from an appropriate independent forum or organization, that use of the TII-442 Grounding Module is safe and appropriate for Inside Installations. If such a confirmation is obtained, Verizon will use that approach as an option for all Inside Installations. If confirmation is not obtained, Verizon will expeditiously remediate the TII-442 installations to replace them with a grounding method~~s~~ approved by Staff.[18]
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> In addition, if Verizon subsequently believes that there is an additional, appropriate solution to this grounding issue, it will raise it with Staff and Verizon and Staff will work expeditiously and cooperatively to secure confirmation from an appropriate independent forum or organization for any such additional solution.

Verizon's Plan included an expert opinion letter from Dan McMenamin and Associates Inc. attesting to the safety and appropriateness of the use of the TII-442 Grounding Module to ground ONT Inside Installations. UL's Senior Vice President and Chief Engineer indicated to staff that use of the equipment grounding conductor of a properly wired general use receptacle would be "acceptable" to ground the ONT and its related coaxial cable[19].

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[18] Network Review Plan, Supplement pp. 3-4 (footnote omitted).

[19] Letter to Peter McGowan from Donald J. Talka, Underwriters Laboratories, Inc. (September 9, 2008).

Inside installations have no coaxial cable (conductive material) attached to the outside of a building. The connection Verizon's network uses is fiber optic cable rather than coaxial cable, which lessens the risk of voltages caused by lightning or accidental contact with power supplies. Verizon's use of three prong household electrical receptacles as the grounding path provides a measure of protection, but a level that is vulnerable to conditions beyond the company's control (i.e., the homeowner may remove the TII 442 module) and the grounding and bonding path may not be as robust (low impedance) as the traditional direct ground (i.e., the alternative approach relies on household wiring within the walls that cannot be directly observed). The TII 442 is designed to be screwed into a wall receptacle and therefore has a measure of stability. Verizon technicians are trained to test the receptacle prior to installation to ensure it has an active ground upon installation. Moreover, the TII 442 approach uses a #10AWG gauge (which is more robust than grounds in typical three prong cords) grounding wire to connect the ONT to the receptacle. Finally, the Curtis-Straus testing, described below, demonstrated that the TII 442 would enable a range of voltages above low levels to trip the circuit breaker and thus resolve potential hazards.

In light of the unique features of the TII 442 and its demonstrated ability to resolve potential hazards and in view of the reduced likelihood of potential electrical hazards associated with inside installations, we conclude that the alternative TII 442 approach is an acceptable grounding method. However, in terms of achieving a safe and appropriate ground, absent a good reason not to use the more robust direct ground, Verizon will be required to continue to adhere to its commitment to use the TII 442 only where it would be impractical or unsafe to use the conventional direct ground. We expect that approach,

where practical, should not add any material cost to installations. Where use of the direct ground approach would add material costs to inside installations, we will allow use of the TII 442.

ONT Ground Path

Verizon utilizes the grounding circuit within the ONT to establish a conductive pathway between the coaxial cable shield and the grounding lug on the ONT, which in turn gets connected to a grounding circuit. As Verizon began to assert informally that the Code did not strictly apply to even outside installations, and when Verizon's Reply Comments indicated that it is not "appropriate, safe, or consistent with listing standards or Code requirements to utilize an ONT as a way to provide a path to ground electrode for current surges originating in television sets or other household appliances or equipment,"[20] staff began to examine more closely Verizon's ability to demonstrate that this portion of the grounding path complied with the Code or was otherwise suitable for its intended purpose. Verizon provided test results which have not yet demonstrated this to our satisfaction. Moreover, the latest round of Curtis-Straus[21] test results indicate that the grounding pathway within at least one of the ONT models failed (i.e., the circuit opened) when subjected to a short circuit test from a 20 amps/120 volt source of electricity.

Verizon's assertion that the ONT is listed and that there is less risk of current entering the building because the fiber is not conductive, while true, does not resolve our concern. The coaxial cable from the ONT to the set top box and other equipment, is conductive and may pose a safety risk.

[20] Verizon Reply Comments, p. 4.

[21] Curtis-Straus is a Nationally Recognized Testing Laboratory (NRTL).

Recognizing that the record on this issue is for the most part Verizon comments and declarations and opinions by its experts which have not been subject to any formal challenge (the proceeding was initially focused on the Network Review Plan), we reviewed the issue to satisfy ourselves that there is a reasonable basis to conclude that the alternative grounding approach constitutes “safe, adequate and reliable service” within the meaning of the Public Service Law. We conclude that the grounding path within the ONT likely does not satisfy the NEC (Article 820), and based on our review of the listing reports and other test results (discussed below) we are not yet satisfied that Verizon's alternative grounding method provides a level of protection that is roughly equivalent to the protection offered by the traditional cable systems. However, because the risks associated with FiOS are less than the conventional cable system (for example, the drop is not conductive) the lack of equivalence does render Verizon’s installations unsafe. Nevertheless, because a simple and apparently inexpensive improvement can be used to achieve the roughly equivalent standard, we find that the improvement should be implemented by Verizon on new installations.

Test Results

Background

Testing of ONTs was conducted relative to established standards as with any electric equipment. Standards and standard-setting bodies generally conform to the requirements of the International Electrotechnical Commission (IEC) and the American National Standards Institute (ANSI). Electrical devices are further subject to additional standards to ensure their suitability and safety. The principal standard-setting body for such devices in North America is the Underwriters Laboratories (UL) and its standards are referred to as UL Standards.

The NEC does not extend to installations "under the exclusive control of communications facilities" (NEC, Article 90.2 [B]) such as equipment on utility poles or in central offices. The National Equipment-Building Standard (NEBS) maintained by Telcordia (formerly Bellcore) is a generic industry requirement generally employed by local and inter-exchange carriers to ensure equipment they deploy in their networks meets a common standard.

In brief, the NEC sets the standards and acceptable practices for electrical safety, UL regulations set standards more specifically for electrical devices and equipment, and NEBS establishes separate industry standards, called Generic Requirements, for network installations of telecommunications equipment by exchange carriers. These various standards overlap and cross-reference one another.[22] A common expectation in both the UL and NEBS standards is compliance with the code overall.

Manufacturers who intend to construct a product must design and manufacture the product to comply with the applicable portions of the code and the appropriate UL standard. If the device is to be used by local or inter-exchange carriers it is further advisable that it receive NEBS certification as well.

The device is then submitted to a "nationally-recognized testing laboratory" (NRTL) for testing to confirm it meets the appropriate standard. A device that passes NRTL testing relative to a UL Standard is given a UL "mark" which indicates it is now "listed" under a certain UL standard and considered suitable and safe for its intended use.[23]

Verizon agreed as part of it Network Review Plan to adhere to the "grounding methods" set forth by staff for FiOS

[22] See, for example, UL 60950-1, 1.1.1, and Telcordia GR-1089, 1.7.

[23] For example, a swimming pool pump must meet UL Standard 1081 and an electric lawn mower must comply with UL Standard 1447.

installations.[24] However, in Verizon's later filed comments it argued that ground "terminals installed in units intended for indoor use are primarily intended as a signal reference ground and not as an electrical safety ground".[25] Verizon also submitted testing performed for it by a NRTL (Curtis-Straus) of a ground fault condition (the "hot" TV scenario) to examine how it might impact the TII 442, ONT and attached coaxial cable. The purpose of the testing is described in Exhibit 4 of Verizon's Comments as "designed to assess the integrity of the ONT grounding scheme under a remote ground fault condition."[26]

The purpose of the staff grounding and bonding methods is to ensure fiber optic, communications, and coaxial cables at a customer's premises are each properly grounded and bonded as a matter of general safety, or code compliance as applicable. Coaxial cable shields and their connectors are exposed directly to human contact and they are conductive of electrical energy. The coaxial shield can then be the source of exposures to electrical energy of very low through high current and voltage levels caused by induced and conducted faults from various sources.

The range of voltages and currents possible specifically from faults are often limited by the circuit breaker protection associated with the source of the electricity serving the device which has faulted. Faults can range from

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[24] Network Review Plan Supplement, Para 4. The staff's grounding methods are set forth in its Letter of August 5, 2008 to the company and mirror the methods set forth by the National Electrical Code with one exception discussed above (i.e., T11-442). Those methods cover installations involving an external appearance of the "conductive" coaxial cable (an "outside" installation), and to follow the same methods for all other installations ("inside" installations) unless "unsafe or impractical".

[25] Verizon's Comments, Stringfellow Affidavit, Para. 18.

[26] Comments, Exhibit 4, Motorola.

short circuits of a magnitude that result in extremely high electrical currents and which instantly trip a circuit breaker, to those which would only cause a small current flow but which could result in an elevated voltage if left ungrounded. Electrical charges conducted or induced onto the coaxial shield from such conditions do not always result in electrical currents high enough to cause the circuit breaker to trip. Low or mid-range electrical faults are typically sourced through the 15 or 20 ampere circuit breaker in a home but can conduct electrical currents indefinitely without tripping the breaker. Voltages of this kind may originate from electrically "leaky" devices attached directly to the coaxial cable (for example TVs, VCRs, DVRs, set-top boxes, cable modems, and the like). Further, coaxial cable may be energized by accidental contact with power cables (commonly by a staple or nail driven in proximity to both cables and which pierces both), or wiring problems within the premise (such as reversed polarity outlets).[27] In these instances, a grounded coaxial cable shield will generally allow the induced voltage to effectively dissipate the induced current and voltage mitigating the hazard.

Verizon's Plan and our November 3, 2008 Order commit Verizon to ground and bond in accordance with the staff

[27] At times Verizon has described the coaxial cable as weak and the likely place where such fault currents might produce damage. However, as recent Staten Island shock incident indicate, and Verizon's methods and procedures warn, hazardous voltages may be present on interior coaxial cables which can present themselves as shock hazards without damage to the coaxial cable. For instance, staff investigated an incident on Staten Island where approximately 30 volts was found on a coaxial cable which caused a shock to a Verizon installer. Also, in response to a consumer claim of TV damage and repeated loss of service, Verizon found voltage on a coaxial cable segment inside a home that resulted in repeated ONT replacement. Verizon's procedures require technicians to conduct voltage tests on coaxial cables before working on the system. These incidents and procedures indicate that the potential issue is not just theoretical.

grounding methods, which are methods that generally mirror the NEC. All installations under the Plan are currently performed and evaluated relative to those methods.[28] However, in all circumstances Verizon is ultimately relying on the grounding terminals in the ONT itself to complete the ground and bond path. Verizon's comments, however, say the "ONT should not be utilized as a grounding path for set-top boxes, televisions, computers, or other attached equipment."[29] Verizon, in transmitting further test results also suggests "it is not appropriate, safe, or consistent with listing standards or Code requirements to utilize an ONT as a way to provide a path to a grounding electrode for fault current surges originating in television sets or other household appliances or equipment."[30]

Yet, under the Verizon Plan, the ONT is being utilized as a potential grounding path for the coaxial cables. If the ONT is not a suitable platform for such grounding, the question arises as to how it can be relied upon for this task.

These concerns were heightened with the filing of additional test results (Verizon Letter, October 3, 2008) demonstrating a particular model of ONT failed the ground fault test previously applied to other ONTs. The laboratory conducting the test concluded in this case the "the shield of the coax was still 'live' with 120 Volts AC which of course constitutes a shock hazard."[31]

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[28] An interim exception to that mirroring is for inside installations (TII 442) was recognized where adherence to the methods described in the code for grounding and bonding is deemed "impractical or unsafe"; in those instances Verizon uses a "grounding module" as a last priority. As discussed above staff recommends accepting that exception.

[29] Verizon's Comments, p. 15.

[30] Verizon's Letter of October 3, 2008, p. 1.

[31] Curtis-Straus Report SI1234-1, p. 3.

In summary, Verizon committed to follow staff grounding methods under its Plan. Those methods are based on the methods applicable under the code. While Article 820 of the code is arguably not applicable to this new architecture, we find (and Verizon has agreed) that coaxial cable should be grounded. Verizon's position regarding the suitability of the ONT for grounding and bonding of fiber optic cable, communications cable, and coaxial cable can be summarized as follows:

- ONTs were not intended to ground other equipment
- The grounding lug within some ONTs is intended to provide a signal ground, not a safety ground
- ONTs are not a safe ground path under some conditions

Against this backdrop, we now review the test results that Verizon has offered to demonstrate the suitability of the ONT as a ground path.

Underwriters Laboratories Standards

In an effort to determine whether the listing Verizon's manufacturers obtained for various ONTs might actually support their use for grounding and bonding as safe and appropriate, staff asked Verizon to provide details on the UL 60950-1 standard applicable to ONTs and to provide the supporting NRTL test results to demonstrate how they were tested. Staff also invited Verizon to file any other applicable standard and to explain why that standard was consistent with UL 60905-1 and thus a suitable substitute. Verizon then submitted additional results and documents as confidential and protected material. It also filed various test results for NEBS testing and a NEBS generic requirement (GR-1089). However, no explanation of the suitability of the NEBS alternative was provided as requested.

Twenty-eight different ONT models are currently deployed in New York and all were listed as compliant with UL 60950-1. Closer review of the standard and the test results revealed that the NRTLs do not always test each model relative to every component of the standard. They use discretion to determine which portions of the standard they viewed as applicable and which are not.

UL 60950-1 is composed of seven sections or "clauses." Clause 2 is entitled "Protection From Hazards," and it contains sub-section 2.6.3.4 "Resistance of Earthing Conductors." Staff reviewed this section carefully and tentatively concluded that devices which were tested and passed this standard might then be considered reliable for grounding and bonding in accordance with the staff grounding methods. Of the 28 ONT models, 13 models were compliant with this portion of the standard.

Verizon, however, subsequently pointed out that under UL 60950-1, Clause 2 testing is limited to the currents which could be passed into the ONT by the power supply unit of the ONT. As some of the ONTs are powered by relatively low direct current (dc) and outside mounted models typically perform the alternating-to-direct current transformation in a power supply unit external to the ONT, this would mean such ONTs need only be tested for very low currents.

UL 60950-1, Clause 7 is entitled "Connections to Cable Distribution Systems".[32] This section sets standards for equipment which is attached to a cable distribution system. However, none of the ONTs were evaluated relative to this standard.

Staff then considered whether another rational standard might apply to ensure the integrity of the grounding and bonding path within the ONTs. After review of traditional

[32] However, Clause 7 also assumes "that the cable shield will be earthed. . ." (Note 5).

grounding and bonding devices used for coaxial cables, staff found such devices are typically listed under another UL Standard, UL 467 Grounding and Bonding Equipment. The purpose of UL 467 is to set a standard for:

> a) ground clamps, bonding devices, grounding bushings, water-meter shunts, grounding electrodes, and the like used in a grounding system; [and]
>
> c) equipment for making electrical connections between
>
> i) the grounding conductors used in telecommunications systems such as telephone, radio, CATV, network power broadband, and the like; and
>
> ii) grounding electrodes[33]

Testing under the UL 467 Standard requires that a grounding and bonding device "not crack, break, or melt" when subject to a specified current in what is termed a "Short Time Current Test" (UL 467, 7.5.1). After carrying the current the device is to be re-tested to ensure it maintains continuity post-test (UL 467, 9.5.8-9). Under the staff grounding methods (i.e., the code), the minimum size ground conductor that is appropriate for grounding of coaxial cable equipment is 14 gauge (copper AWG). The current specified for 14 gauge conductor is 300 amps for 4 seconds.[34] Verizon reports that none of the ONTs had been considered subject to the UL 467 standard or tested relative to that standard.

Telcordia Standards

Verizon indicated to Staff that NEBS (Telcordia GR-1089) requires that devices also pass lightning tests. Of the

[33] ulstandardsinfonet.ul.com/scopes

[34] Under its Plan, Verizon typically employs 10 gauge ground conductors which would require testing at a current of 750 amps for 4 seconds.

28 models deployed in New York, all were subjected to some form of NEBS testing.

Testing under NEBS focuses on the ability of the "equipment under test" (EUT) and particularly the "ports" on the equipment to survive the test.[35] Thus, NEBS tests applicable to coaxial cable appear to focus on the coaxial cable ports on the device which are categorized as Type 4 ports. Lightning is not generally considered applicable to Type 4 ports and thus such tests do not appear to have been consistently performed. Type 4 ports are subject to the "Intrabuilding Surge Tests". The results of those tests indicate nine ONT models passed such testing.

Curtis Straus Standards

Verizon also submitted testing it had performed by a NRTL (Curtis Straus) of a ground fault condition (the "hot" TV scenario). The purpose of the testing is to examine the impact of short-circuited device, such as a TV or set top box, on the ONT and attached coaxial cable, both with and without use of the TII 442 module. The tests "were designed to assess the integrity of the ONT grounding scheme under a remote ground fault condition"[36]. The laboratory conducting these tests described the testing objective to demonstrate "the resolution of hazardous voltages and stray currents in a typical installation".[37]

The results of the test were described as follows:

> In short, the testing demonstrated that even under the hot-TV scenario, connection of an ONT to a grounded electrical outlet provided safe grounding, whether the connection between the ONT and the AC current supply was made directly through the three-pronged

[35] GR-1089, Section 4.6.

[36] Verizon's Comments, Exhibit 4

[37] Curtis Straus Report SI1234-1, p. 4

> plug on the ONT's built-in power cord, or through a TII-442 Grounding Module.[38]
>
> While the use of any networked device, including the earthing of coaxial cable, as means for protecting un-grounded devices is not a recommended practice (*See* UL 60950-1 § 2.6.5.8) the results of this test indicate the Motorola ONT is capable of handling the fault current that could arise.[39]

There are several reasons why the Curtis Straus testing is unpersuasive. As discussed previously, the range of voltages for current faults which may be present on coaxial cable include those too low to trip the breaker, or energy levels so high and of such short duration, such as lightning or power surges, that the breaker would not be expected to prevent them in any event. The testing performed by Curtis Straus was of a limited circumstance, the "hot TV" scenario, and was essentially a test of the circuit breaker's ability to perform its function under ideal conditions. Since it did not apply to a full range of currents and voltages, Curtis Straus testing is not particularly useful as a demonstration of the adequacy of the company's grounding scheme.

Discussion

We analyzed the testing provided by Verizon to ascertain whether the ONT, in spite of Verizon's concerns, may actually be appropriate for use as a ground and bond conductor for equipment, such as coaxial cables, which might be attached to it. The tests, we find, are not conclusive.

The standards and supporting tests reviewed appear limited to the equipment itself; that is they didn't test ground

[38] Verizon's Comments, p. 18.

[39] Verizon's Comments, Exhibit 4.

path for suitability for use as ground path. Moreover, the Tellabs 612 model failed the Curtis-Straus tests as previously discussed. This raises special concerns regarding the adequacy and safety of the Tellabs 612 model.

CONCLUSION

Because there are significant ambiguities in the National Electric Code it is not clear it applies to the provision of service over a fiber optic system, especially one which interconnects with coaxial cable wiring at the customers' premises. Instead of relying exclusively on the Code, we evaluated the results of ONT tests undertaken both prior to and as a result of this proceeding, to determine, on a preliminary basis, the suitability of using the ONT as a portion of the ground path. We determine that given the testing that has been performed on Verizon's equipment there is an insufficient basis on which to conclude that the ONT is an appropriate path to ground. To allow us to develop a sufficient basis to make a final conclusion, we urge Verizon to obtain an independent expert determination by making arrangements with its ONT manufacturers to approach nationally recognized testing laboratories (e.g., UL) for listings beyond what has already been obtained, with the clear understanding that the ONT will be used to ground coaxial cable in the configurations that Verizon is utilizing. Verizon should indicate within 30 days of the order in this case whether it intends to pursue this approach. Alternatively, Verizon could commit to begin immediately to implement a minor modification to its installation procedures on a prospective basis (installing a simple grounding block to bypass the grounding path in the ONT). The minor modification is warranted because the benefits of enhanced safety from potential electrical hazards appear to outweigh the apparent cost of making such modifications. If Verizon commits to

demonstrating that the nationally recognized testing laboratories will assess the ONT as an appropriate path to ground it should implement the grounding block modification (noted above) pending the results from the nationally recognized testing laboratories. In the event Verizon fails to commit to these proposed actions within 30 days, it is directed to demonstrate, within 30 days, why we should not order these actions.

The Tellabs models raise special concerns because some models did not perform well in the Curtis-Straus short circuit testing. In those tests the ground path in the ONT opened under nearly all the testing scenarios. In addition, the UL 60950 test results show that testing pursuant to Clause 2.6.3.4 (Resistance of Earthing Conductors) was not performed because it was deemed not applicable. While NEBS tests were conducted on many of the Tellabs models, the Company has not demonstrated why this test is a suitable demonstration of the grounding path's robustness, especially in light of the Curtis-Straus test. The exact scope of the problem, and the risk to customers, however, are presently unknown.

Thus, pending clarification, the company should install the simple grounding block on all Tellabs models[40] (other than the 612A model) that have already been deployed whenever it is required to make a premises visit for maintenance or remediation purposes. In the event Verizon fails to commit to this remediation program within 15 days, it is directed to demonstrate, within fifteen days, why we should not order it. Further, the company shall report monthly to the Director of the

[40] It appears that only three of numerous Tellabs models were subjected to the Curtis Straus test. Thus, while the 612A model passed the test, it is not clear whether the untested models should be assumed to be vulnerable given the other unsuccessful tests. The remediation effort should extend to all Tellabs models unless Verizon can demonstrate that the untested models have passed the Curtis Straus test.

Office of Telecommunications, any instances of damage or other reported problems associated with any of its ONT installations, and test the grounding path for continuity in existing ONTs when conducting routine maintenance or inspections at a premises.

Finally, we find the alternative TII 442 approach is an acceptable grounding method for inside installations. Verizon is required to continue to adhere to its commitment to use the TII 442 only where it would be impractical or unsafe to use the conventional direct ground. We expect the approach, where practical, should not add any material cost to installations. Where use of the direct ground approach would add material costs to inside installations, we allow use of the TII 442.

The Commission orders:

1. Verizon New York Inc. shall indicate, within 30 days of the date of this Order, whether it will (1) seek the assurances discussed above from nationally-recognized testing laboratories, and, pending the results of those tests, whether it will implement the grounding block modification as discussed in the text of this Order, or (2) whether it will implement the grounding block modification prospectively, or why it should not be directed to do so. Verizon shall serve the active parties list with its filing and parties may comment on Verizon's filing within 15 days of the date of service, subject to adjustment by the Secretary.

2. Verizon New York Inc. shall remediate the Tellabs installations discussed in the foregoing Order by applying the grounding block whenever the company has a reason to make a premises visit, or demonstrate within 15 days of issuance of this Order why it should not be required to do so. Verizon shall serve the active parties list with its filing and parties

may comment on Verizon's filing within 5 days of the date of service, subject to adjustment by the Secretary.

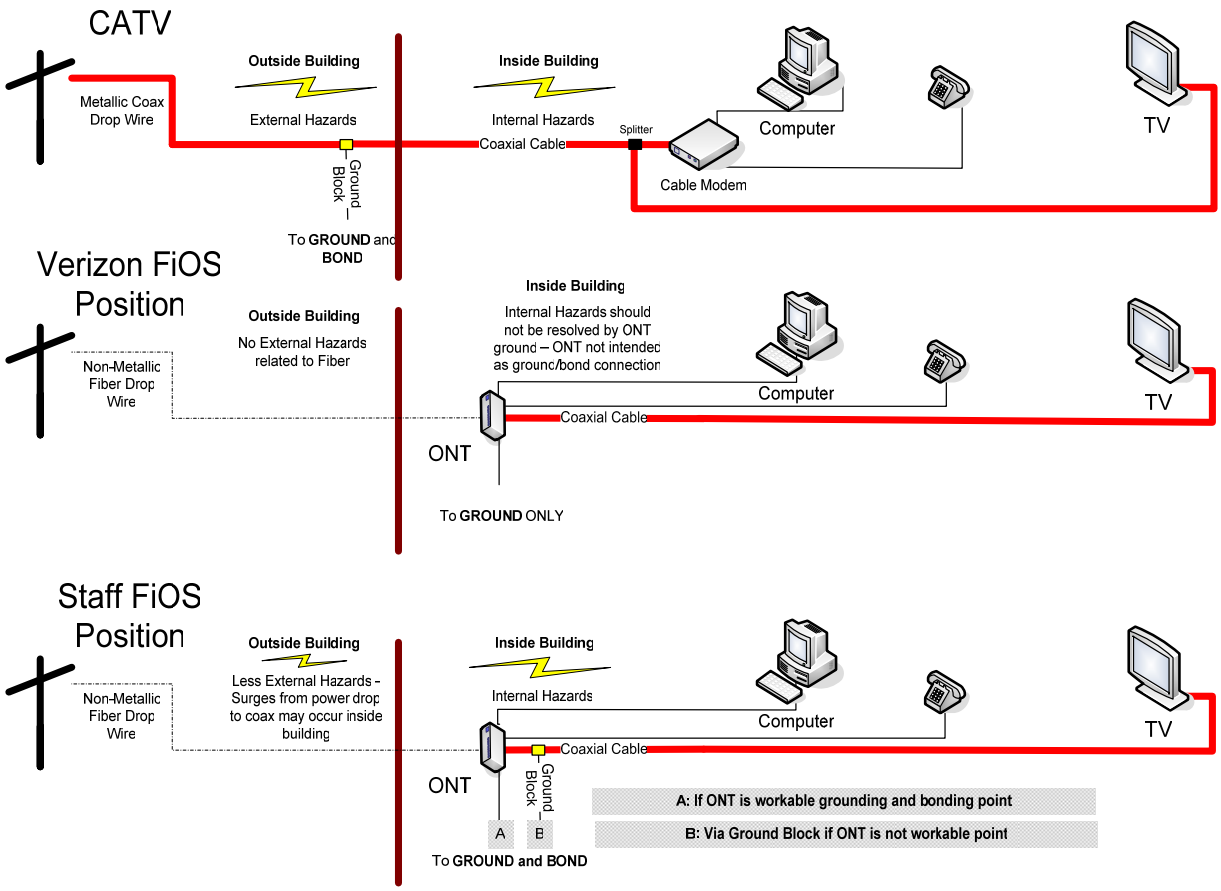
3. Verizon New York Inc. shall report to and as specified by the Director of the Office of Telecommunications, any incidents of property damage resulting from an ONT, as well returns to any manufacturer, each listed by manufacturer and model and any shock incidents reported by customers or Verizon employees.

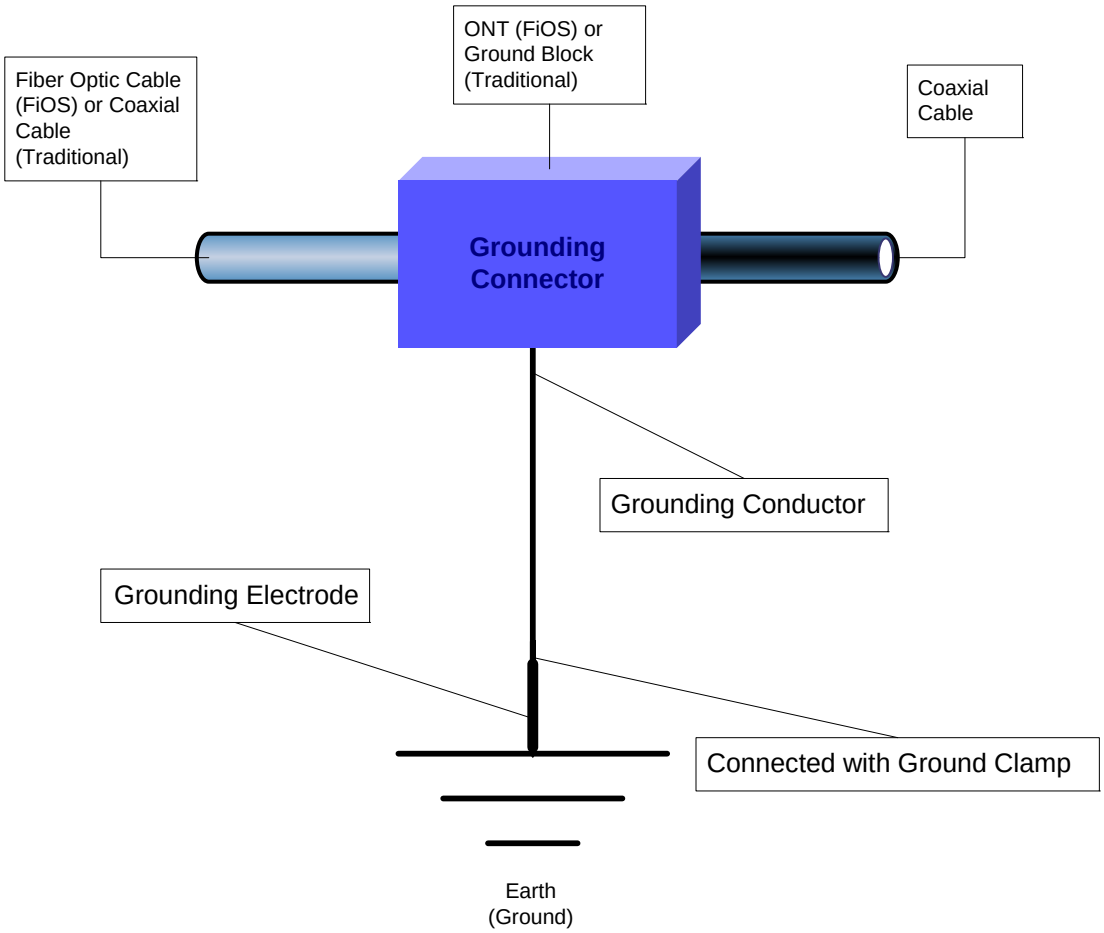
4. This proceeding is continued.

By the Commission,

(SIGNED) JACLYN A. BRILLING
Secretary

Attachment 1
Diagram of Grounding and Bonding Issues – Inside Installations




ONT (FiOS) or Ground Block (Traditional)
Fiber Optic Cable (FiOS) or Coaxial Cable (Traditional)
Coaxial Cable
Grounding Connector
Grounding Conductor
Grounding Electrode
Connected with Ground Clamp
Earth (Ground)

Attachment 2

National Electric Code
Definitions of Grounding and Bonding

250.4 General Requirements for Grounding and Bonding
The following general requirements identify what grounding and bonding of electrical systems are required to accomplish. The prescriptive methods contained in Article 250 shall be followed to comply with the performance requirements of this section.
(A) Grounded Systems.
(1) Electrical System Grounding. Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.
(2) Grounding of Electrical Equipment. Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials.
(3) Bonding of Electrical Equipment. Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.
(4) Bonding of Electrically Conductive Materials and Other Equipment. Normally non-current-carrying electrically conductive materials that are likely to become energized shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.
(5) Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

250.70 Methods of Grounding and Bonding Conductor Connection to Electrodes
The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means. Connections based on solder shall not be used.