

ELECTRICAL PROTECTION OF THE SUBSCRIBER OUTSIDE PLANT

Proprietary Information

Not for use or disclosure outside SBC Local Exchange Carriers except under written agreement

Electrical Protection of the Subscriber Outside Plant

Contents	Page
Work Print Symbols Pertaining to Electrical Protection.....	8
Glossary of Terms.....	9
1. INTRODUCTION.....	13
The Purposes of Electrical Protection.....	13
Determining Exposure to Extraneous Potentials	13
Exposure to Lightning.....	14
Exposure to Power	14
Power Contacts.....	14
Power Induction.....	14
Ground Potential Rise	14
Exposed and Unexposed Plant.....	15
Aerial and Buried Plant.....	15
Underground Plant	16
Submarine Cable and Cable on Bridges and Overpasses.....	16
Achieving Optimum Protection.....	16
Consider All Exposures	16
Insist on Good Construction	16
Specify Protection on Work Prints	17
Special Situations	18
2. CENTRAL OFFICE PROTECTION.....	20
Protection Measures	20
Bonding and Grounding	20
Alternative Arrangements for Bonding and Grounding Optical Fiber Cables	21
Grounding of Shield Only in the CEF	21
Bonding and Grounding of Metallic Components at the Interconnection Equipment.....	21
Protector Units and Heat Coils	22
Fuse Cable and Fuse Links.....	23
Paired Conductor Cables	23

Contents	Page
Optical Fiber Cables	24
Special Situations	25
3. PAIRED CONDUCTOR CABLE, WIRE AND OPTICAL FIBER CABLE PROTECTION.....	31
Paired Conductor Cable and Wire Protection.....	31
Aerial Plant Protection Measures	31
General Measures for All Exposed Aerial Plant	31
Additional Measures for Aerial Plant Exposed to Lightning.....	31
PIC Cable	32
Pulp Cable	32
Rural or Urban Wire.....	32
Additional Measures for Aerial Plant Exposed to Power	33
Cable Plant.....	33
Single Pair Rural Wire	33
Branches, Extensions and Crossings.....	33
Joint-Use with Unigrounded Wye Power Systems and with Delta Power Systems	33
Exposed Guys	34
Buried Plant Protection Measures.....	43
Buried Plant Exposed to Lightning	43
Buried Plant Exposed to Power.....	43
Joint Buried Plant with One Foot Separation.....	43
Joint Random Buried Plant.....	43
Bonding Requirements – Less Than Three Foot Separation	45
Bonding Requirements – More Than Three Foot Separation	45
Cable Buried in the Same Right-of- Way with Aerial Power....	46
Bonding Methods.....	46
Armor Protected Cable.....	49
Underground Plant Protection Measures	49
General Measures for All Underground Plant.....	49
Aerial-Underground Junctions	49

Contents	Page
Optical Fiber Cable Protection.....	50
Aerial Optical Fiber Cable Protection Measures	50
General Measures for All Exposed Aerial Optical Fiber Cable Plant	50
Additional Measures for Aerial Optical Fiber Cable Exposed to Lightning	50
Additional Measures for Aerial Optical Fiber Cable Exposed to Power	50
Buried Optical Fiber Cable Protection Measures	51
General Measures for All Exposed Buried Optical Fiber Cable Plant	51
Additional Measures for Buried Optical Fiber Cable Exposed to Lightning	51
Additional Measures for Buried Optical Fiber Cable Exposed to Power	52
Paired Conductor Cable or Buried Service Wire Placed With All-Dielectric Optical Fiber Cable	52
Armor Protected Optical Fiber Cable – Aerial or Buried.....	52
Underground Optical Fiber Cable Protection Measures.....	52
Special Situations.....	53
4. CUSTOMER LOCATION PROTECTION.....	54
Protection Measures	54
General Measures for All Customer Locations Served by Exposed Conductors	54
Fuse Requirements.....	54
Protector Requirements	56
Fuseless Protectors	56
Central Office Type Connectors.....	57
Approved Protector Grounds	57
Bonding and Grounding in Buildings Served by Exposed Cable	59
Bonding and Grounding in Buildings Served by Drop or Buried Service Wires	59
Bonding and Grounding in High Rise and Low Wide Commercial Industrial Buildings	63

Contents	Page
General Protection Measures for PBX and Other Customer Premises Switching Equipment.....	65
Special Situations	65
References	66

List of Figures

Figure	Title	Page
Figure 1-1	Determining Exposure Status	19
Figure 2-1	Underground CO Entrance with Exposed 26-Gauge Entrance Cable and 24-Gauge Connector Stubs. No Fuse Cable Required	26
Figure 2-2	Aerial CO Entrance with Exposed 24-Gauge Entrance Cable and 22-Gauge Connector Stubs, No Fuse Cable Required.....	26
Figure 2-3A	Underground CO Entrance with Exposed 22-Gauge Entrance Cable, 24-Gauge Fuse Cable Installed at Aerial-Underground Junction, 22-Gauge Connector Stubs Required	27
Figure 2-3B	Underground CO Entrance with Exposed 22-Gauge Entrance Cable, 24-Gauge Fuse Cable Installed in Manhole Nearest CO, 22-Gauge Connector Stubs Required	27
Figure 2-4	Underground CO Entrance of Exposed Optical Fiber Cable. Fuse Link Installed in Metallic Pairs in Manhole Nearest CO Entrance.....	28
Figure 2-5	Underground CO Entrance with 24-Gauge Entrance Cable Incorporating an Insulating Joint	28
Figure 2-6	KS-14595 Capacitor Requirements for CEFs with Insulating Joints, (BEFs with insulating joints should be treated in a similar fashion.).....	29
Figure 2-7	Bonding and Grounding of Optical Fiber Cable at Interconnect Equipment.....	30
Figure 3-1A	Aerial Plant Exposed to Lightning, Cable protectors Installed at Each Terminal.....	35
Figure 3-1B	Aerial Plant Exposed to Lightning, Full Count Protection at Junction with Unexposed Cable.....	35
Figure 3-2	Aerial Cable in Joint Use with MGN Power Operating at Less Than 11.6 kV to Ground, (20 kV Phase-to-Phase)	36
Figure 3-3	Crossing with, and Branch from, Aerial Cable in Joint Use with MGN Power Operating at More Than 11.6 kV to Ground, (20 kV Phase-to-Phase).....	36
Figure 3-4	Protection of Aerial Cable	37
Figure 3-5	Protection of Aerial Wire	38
Figure 3-6	Joint Buried Cable with Less Than a Three Foot Separation from Power Conductors, Power and Telephone Have Separate Above Ground Fixtures	47
Figure 3-7	Protection of Buried Paired Conductor Cable	48

Figure	Title	Page
Figure 3-8	Aerial Optical Fiber Cable (with Metallic Sheath Components and Strength Members) in Joint Use with MGN Power	51
Figure 4-1	Selecting an Approved Ground, (Does not include mobile homes)	58
Figure 4-2	Exposed Building Entrance Paired Conductor Cable with Nonmetallic Closure Installed Ahead of Protectors.....	60
Figure 4-3A	Exposed Building Entrance Paired Conductor Cable with Protector More Than 50 Feet from Cable Entrance Point.....	61
Figure 4-3B	Exposed Building Entrance Paired Conductor Cable with Protector not More Than 50 Feet from Cable Entrance Point.....	61
Figure 4-3C	Exposed Building Entrance Optical Fiber Cable with Protector for Metallic pairs not More Than 50 Feet from Cable Entrance Point.....	62
Figure 4-3D	Exposed Building Entrance Cable – Building Entrance at Point of Emergence from Metal Conduit	62
Figure 4-4	Bonding and Grounding of Exposed Building Entrance Cable ...	63

List of Tables

Table	Title	Page
Table 2-1	Technical References Covering Protector Units for Central Office Connectors Conforming to GR-2916.....	23
Table 2-2	Fuse Cable Requirements	24
Table 2-3	Fuse Link Requirements – Optical Fiber Cable	25
Table 3-1	Protection Requirements for Aerial Cable Plant in Joint Use with Power Where an MGN is Available	39
Table 3-2	Protection Requirements for Aerial Cable Plant in Joint Use with Uni-Grounded Wye and Delta Power in Areas Where Bonding to Neutrals is Not Allowed	40
Table 3-3	Protection Requirements for Aerial Wire Plant in Joint Use with MGN Power	41
Table 3-4	Protection Requirements for Branches and Extensions from, and Crossings with, Cable in Joint Use with MGN Power Operating at More Than 15 kV to Ground (26 kV Phase-to-Phase)	42
Table 4-1	Fusible Link Requirements	56
Table 4-2	Ground Wire Capacity	57

Work Print Symbols Pertaining To Electrical Protection



Joint Use Pole - Power 12 KV Or Less



Electric Company Pole - Power 12 KV Or Less (Phase-To-Phase)



Joint Use Pole - Power More Than 12 KV (Phase-To-Phase)



Electric Company Pole - Power More Than 12 KV (Phase-To-Phase)



Bond Between Separate Strands*



Ground



Bond To Existing MGN Power Vertical Ground Wire



MGN Wire For Bonding Telephone Plant To MGN Power, Telephone Company To Make Bonding Connection To Telephone Plant And Leave Coil Of Wire For Power Company To Run Up Pole And Connect Neutral Of MGN



Bond To MGN At Power Transformer Or Pedestal



Ground To Power Service Entrance Grounding System At Station, Connection May Be Made To Service Entrance Conduit Or Power Service Ground Wire*



Ground To Power Ground Rod



Ground To Telephone Ground Rod



Ground To Cold Water Pipe



Cable Or Wire Terminal Equipped For Cable Protection



Cable Terminal Equipped For Station Protection



Station Protector



Auxilliary Protector Housing, May Contain Cable Or Open Wire Protectors



Bond Optical Fiber Cable Metallic Sheath Components And Strength Members To Support Strand.*

* These Symbols do not appear in other practices. It is unlikely, however, that they would be misunderstood by personnel who are accustomed to reading work prints, since they are based on already widely used symbols. Nevertheless, make certain that the meaning of these symbols are clear to those using your prints.

Glossary of Terms

Approved floor ground: A grounding medium on a floor of a high-rise building suitable for connection to the grounding terminal in the riser closet.

Approved ground: An acceptable medium for grounding the building entrance protector, entrance cable metallic sheath components, metallic strength member or a coupled bonding conductor.

Arrester: A protection device used on power lines to limit the line-to-ground surge voltage caused by lightning. The arrester simultaneously interrupts "power follow", i.e., the discharge of normal power.

Bond(ing): The permanent joining of metallic parts to form an electrically conductive path, which will assure electrical continuity and the capacity to conduct any current likely to be imposed. Bonding provides equalization of potential between separate connections to ground.

Building entrance facility (BEF): A space provided at the customer's location for termination of distribution cable. Station protectors are often located in the building entrance facility, and cable metallic sheath components are grounded there.

Cable entrance facility (CEF): A space at the central office where cables enter from the outside plant network. Electrical protection measures here protect the CO from the outside plant environment.

Carbon blocks: A pair of carbon electrodes that provide an air discharge gap of a specified dimension.

Concentric neutral power cable: A power cable with neutral and ground conductors which are wrapped around the outside of an insulated phase conductor. The neutral conductors may be either bare or covered by a semi-conducting outer jacket for direct buried applications.

Cone-of-protection: Tall grounded structures, such as towers, buildings, and antenna masts provide a discharge point for lightning strokes, thus providing a degree of protection for lower structures nearby. This concept is referred to as the cone-of-protection principle. A tall structure shields lower structures located within an imaginary cone constructed using the apex of the taller structure and a finite base radius. Almost perfect protection is provided to those structures whose highest points fall within a 1:1 cone (where the radius of the base equals the height of the mast). A large degree of protection is also provided to structures within a 2:1 cone. Experience has shown that the 2:1 ratio provides a favorable balance between effectiveness and cost for most engineering purposes. Two masts of equal height that are located at a distance of about four times the height of the masts will provide a degree of protection afforded by a 1:1 ratio cone. Therefore, an array of two or more masts will effectively shield a larger area than the combined area for the same number of isolated masts.

Coupled bonding conductor (CBC): A conductor used to extend the approved ground in the building entrance facility (BEF) to certain types of ac-powered terminal equipment. It is closely coupled to the pairs feeding the equipment so that mutual coupling or transformer action between the CBC and the cable pairs minimizes lightning-introduced surge voltages between the equipment and its local ground. The CBC consists of a continuous cable shield, a tie-wrapped conductor, or a combination of the two.

Delta power system: An ungrounded, three phase, primary power system.

Earth resistivity: The dc resistance of the soil on a per-unit basis. The commonly used unit of measure is the meter-ohm, which refers to the resistance measured between opposite faces of a cubic meter of soil. It is the reciprocal of earth conductivity, which is expressed in mhos per meter.

BSP 918-216-100MP
ISSUE A, July 2003

Exposed facilities: Any outside plant facilities subject to the effects of lightning, or to power contacts, power induction, or differences in ground potential exceeding 300 Vrms to ground.

Extraneous potential (current): Any voltage (or current) imposed on telephone plant that is not intentionally supplied from the central office or from telephone equipment.

Fuse: A protection device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Fuse cable: A length of protective cable, having 24 or 26 gauge copper conductors, that is inserted between the exposed plant and the cable, wiring, or apparatus that it protects. The fuse cable is intended to fuse open in the presence of extraneous power currents; it does not, however, protect against lightning currents or sneak currents.

Fusible link: A conductor, usually block wire, that serves the same purpose on wire plant as fuse cable on cable plant.

Gas tube protector: A voltage-limiting protection device containing gas tube protector units. The gas tube consists of a spark gap or gaps that discharge in a gas atmosphere within a sealed envelope.

Ground (earth): A conducting connection, whether intentional or accidental, between an electric circuit or equipment and the earth or some conducting body that serves in place of the earth.

Grounding electrode: A conductor, usually a rod, pipe, or plate (or group of such conductors) in direct contact with the earth for the purpose of providing a connection to the earth.

Ground electrode system: A bonded-together assembly of all of the following available electrodes at the customer's location: an acceptable metal water system, effectively grounded metal building frame, concrete-encased electrode and a ground ring. (Required by the National Electrical Code as first choice for power service ground.)

Ground mat: An extensive system of bare conductors, buried below the surface of the earth. The ground mat is intended to provide a very low resistance connection to earth and to equalize potentials within the area covered, thus providing protection from dangerous voltages.

Ground potential rise (GPR): A voltage difference between grounding electrodes caused by conduction of earth return currents. A ground potential rise occurs most often when power fault current is conducted to ground. However, when lightning currents are conducted to ground at a station protector, cable pairs may be subject to a ground potential rise.

Ground riser: A No. 6 AWG copper wire connected to ground and run as a coupled wire with a riser cable where the riser cable does not have a continuous metallic shield.

Grounding terminal: A suitable bar, bus, terminal strip, lug, or binding post to which grounding and bonding conductors can be connected.

Heat coil: A protection device that grounds or opens a conductor when overheated by excessive current due to power contact or induction. It is used as protection against sneak currents.

High-rise building: Any building over three stories high and constructed of reinforced concrete or structural steel.

Induction (electric): Voltage-controlled currents induced in a telephone line by capacitive and/or inductive coupling from the electric field of a nearby power line.

Induction (magnetic): Currents induced in a telephone line by inductive coupling from the magnetic field of a nearby power line.

Insulating joint: A splice in a cable sheath made so that continuity of the sheath, shield, metallic strength member and moisture barrier is deliberately interrupted to prevent the flow of electrolytic currents (dc) that may cause corrosion.

Joint random separation: The practice of burying telephone cable or service wire in the same trench with power conductors, making no attempt to maintain a specific separation between the two systems.

Low-wide building: A low structure covering a large area. Low-wide buildings are typified by the large shopping mall, factory, or warehouse.

Metallic sheath components: Metal members contained in the sheath of a telecommunications cable such as a shield, moisture barrier, or possibly a strength member of an optical fiber cable.

Metallic strength member: A metal component of optical fiber cable used to provide tensile strength to the cable. It may be located centrally, or placed circumferentially within the cable.

Multigrounded neutral (MGN) power system: A power system in which the neutral conductor is continuously present along with the phase conductors and is grounded at least four times per mile.

Network interface: The location on all connecting entities' premises at which any network channel service or tariff offering is properly terminated in terms of design, installation and maintenance parameters and a physical interface is provided for connection to the network.

Optical fiber cable: A communications cable containing optical fibers as the primary transmission medium. The cable may also contain metallic components such as strength members, protective shield and metallic pairs. Strength members may also be non-metallic.

Paired conductor cable: A communications cable containing paired metallic conductors as the transmission medium. The cable usually contains a metallic shield.

Primary power: Power operating at more than 300 volts (rms) to ground.

Protector: A device consisting of one or more protector units and a mounting assembly for limiting abnormal voltages on communications circuits.

Protector (cable): A protector which limits the voltage between the conductors and shield of a cable. Cable protection at the PIC-pulp junction may use station gas tubes.

Protector (open wire): A protector used to limit power voltages between open wire conductors and ground on joint use lines. Open wire protectors are usually provided with 20-mil gap spacing between electrodes.

Protector (station or central office): A protector which limits the voltage between telephone conductors and ground. Station and central office protectors are equipped with 3-mil (white) carbon blocks, gas tubes or solid state elements.

BSP 918-216-100MP
ISSUE A, July 2003

Protector grounding conductor: A wire that is run from the protector grounding lug to an approved ground via the shortest and straightest route.

Protector unit: A protection device containing carbon blocks or a gas tube in combination with shorting devices. It may also contain a heat coil. The protector unit screws or plugs into a protector, protected terminal, connecting block, or central office connector.

Riser cable: A cable that is run vertically in a high-rise building to provide pairs to various floors.

Riser closet: A space provided on a floor of a high-rise building for terminating pairs which leave the riser cable to feed that floor.

Satellite closet: The last space within a building that is under control of the network telephone company where pairs are brought out to feed customer premises equipment.

Secondary power: Power operating at less than 300 volts rms to ground (typically, 120/240 or 277/480 volts).

Semiconducting jacketed power conductor: A power cable with a conductive outer covering of carbon-black impregnated polyethylene. Such cables are typically of concentric neutral construction and are intended for direct buried application. The conductive jacket protects the concentric neutral conductors while fulfilling code requirements for a grounded conductor in continuous contact with the earth in joint random installations.

Single point ground (SPG) terminal: A terminal sometimes provided with PBX and key telephone systems equipment which is the only acceptable point for connecting the equipment to the external protector grounding system.

Station fuse: A fuse (usually 7 amperes) that is used in place of fuse cable or a fusible link. It does not satisfy the requirements for a sneak current fuse.

Thunderstorm day: Any day during which thunder is heard at a specific observation point. Such observations confirm the presence of lightning but do not provide information on the number of strokes to earth.

Unigrounded wye power system: A power system in which only one point – usually the midpoint of a supply transformer bank is grounded. In this type of power system, the neutral conductor may or may not be carried along with the phase conductors. If the neutral is present, it is not grounded along the line.

Water pipe area: An area, usually urban or suburban, having an extensive metallic underground water system and where the power services at buildings are normally grounded to the water pipe system.

1. INTRODUCTION

THE PURPOSES OF ELECTRICAL PROTECTION

Preventing shock hazards to those who use the telephone system and to those involved with its construction, operation, and maintenance is the primary aim of electrical protection. Electrical protection refers to the methods and devices used to control or reduce voltages and currents imposed on telephone plant from sources other than central office and terminal equipment. If unchecked, these extraneous voltages and currents may cause:

- Injury to personnel and customers
- Damage to customer's property
- Excessive damage to aerial, buried, or underground plant, or to station or central office equipment
- Disruption of service.

Optimum protection of plant and equipment involves striking a balance between the initial cost of the protection measures, the cost of maintenance, the value of uninterrupted service and the cost of system repairs. Electrical protection should be considered early in the development and planning of plant facilities, because most protection measures cost more to introduce at a later time. Where service continuity is the dominant factor, there is no alternative other than to initially provide a high level of protection.

DETERMINING EXPOSURE TO EXTRANEIOUS POTENTIALS

Depending on its environment, outside plant may be subject to the following sources of extraneous potentials, either singly or in combination:

- Lightning
- Power contacts
- Power induction
- Ground potential rise.

The terms exposed and unexposed are used to classify the plant with respect to its vulnerability to these sources of voltage and current . Outside plant that is subject to electrical disturbances from any of these sources is classified as exposed. Plant not subject to their effects is classified as unexposed. A station or central office is exposed or unexposed according to the classification of the outside plant (including lines, drops, terminals, cable, wire, and strand) which serves it.

BSP 918-216-100MP ISSUE A, July 2003

The exposure classification of outside plant is a function not only of the outside plant environment, but also of the physical characteristics of the plant. For example, a conventional shielded, paired conductor cable subject to the electrical disturbances detailed above would be classified as exposed. An all dielectric optical fiber cable placed in the same environment would be classified as unexposed because the optical fiber cable contains no metallic sheath components, metallic strength members or metallic pairs.

Exposure to Lightning

Lightning is a common source of hazardous extraneous potentials. Plant is classified as exposed to lightning except when located:

- In an area where the soil resistivity is approximately 100 meter-ohms or less and the incidence of thunderstorm days does not exceed an average of five (5) per year. However, plant and stations located above the average altitude of the surrounding terrain or associated with structures such as fire towers, radio stations, etc., must be classified as exposed to lightning regardless of soil resistivity and thunderstorm incidence.
- In metropolitan areas where buildings are close together and sufficiently high (relative to the telephone plant) to provide cone-of-protection shielding. Multistory buildings and other tall structures intercept the lightning strokes and divert them from the telephone plant. In these areas, surge currents are dispersed over public water systems and/or other extensive buried metallic networks.
- In buried or underground interbuilding cable runs not exceeding 140 feet with a continuous shield grounded at both ends.

Exposure to Power

Power contacts – Since power companies and telephone companies serve the same customers, their outside plant facilities are necessarily located close together. Telephone and power outside plant facilities may share joint-use poles with power, may be directly buried with power in a common trench, or may share a common right of way. Telephone plant exposed to possible contact with energized power lines operating at more than 300 volts rms to ground is classified as exposed. All primary power systems operate at more than 300 volts rms, while most secondary power operates at voltages less than 300 volts rms to ground.

Power induction – Disturbances from power induction can occur whenever telephone and power lines run parallel. Plant subject to power induction of more than 300 volts rms to ground is classified as exposed. Although lower voltages may exist as a result of unbalanced power line operation, induced voltages exceeding 300 volts rms are most likely to be caused by power line faults. The existence of steady state low voltage induction, however, may indicate that plant should be classified as exposed, because voltages in excess of 300 volts rms may be induced by a fault in a power line phase conductor. The Inductive Coordination and Electrical Protection (ICEP) engineer should be consulted whenever the exposure status of the plant is uncertain.

Ground potential rise (GPR) – Plant subject to a ground potential rise of more than 300 volts rms to ground is classified as exposed. The danger from a ground potential rise is greatest in the vicinity of a power generating station, substation or high voltage tower. A ground potential rise can develop between the power station ground and remote grounds when a fault occurs anywhere in the power system network, and the condition may persist until the fault is cleared. Subscriber stations located within the influence of the power station ground mat are the most vulnerable to a ground potential rise;

special protection measures should be provided (see BSP 876-310-100MP). A ground potential rise greater than 300 volts rms can also occur at subscriber stations remote from a power station during a power fault. This situation usually develops when the power neutral at the subscriber station is not grounded to a low-resistance ground, or is not part of a multigrounded neutral (MGN) power system. The ICEP engineer should be consulted if there is a question about the protection status of such areas.

In recent years, the rising demand for power has resulted in higher voltages on existing power lines and the construction of additional transmission lines, power stations and substations. These factors have contributed to increased incidence of power exposures. Power contacts, power induction, and ground potential rise are individual threats to telephone plant, but the protection measures used for one source of power disturbance are generally effective against all three. Because of this commonality, in a discussion of electrical protection, plant that is exposed to power is plant that is subject to disturbance from any one or more of these sources.

EXPOSED AND UNEXPOSED PLANT

The decision whether a particular outside plant facility should be classified as exposed or unexposed often involves judgement. The physical characteristics of the outside plant cable need to be considered for example, does the cable contain metallic components such as a strength member, metallic shield or metallic pairs. Furthermore, the source(s) and severity of the exposure must be considered, since both play a part in determining the protection measures to be specified. Previous experience in a particular geographic area is often the best guide. For instance, in some locations alpeh sheath cable may be satisfactory in conventional paired-conductor cable aerial plant that is exposed to lightning. However, in areas where excessive trouble rates from lightning have been experienced, it may be necessary to substitute PAP or PSAP sheath cable.

Often, a segment of the outside plant network may itself be unexposed to lightning and power; yet, by virtue of exposed branches or extensions connecting with that segment, it too should be classified as exposed. For example, underground plant is not directly exposed to power contacts, but individual circuits in the cable can be exposed to power or lightning if they are extended into an exposed environment by aerial or buried construction. As a result, it is possible for an underground conventional paired conductor cable to have both exposed and unexposed complements. If the administration of the pair complement cannot be assured, the entire cable should be classified as exposed. In determining the exposure status of cables, the effects of future rearrangements on the exposure status should also be given careful consideration.

The exposure status of specific types of plant to lightning and power disturbances is discussed below. Figure 1-1 outlines the steps involved in determining exposure status.

Aerial and Buried Plant

Aerial and buried plant is almost always exposed to lightning. It can be classified as unexposed only if it is located in a geographic area where low incidence of thunderstorms and low ground resistivity virtually preclude the threat of exposure, if it is located in an urban area and benefits from a cone-of-protection, or if it contains no metallic components or pairs, such as all-dielectric optical fiber cable. In practice, however, aerial and buried construction is seldom used in metropolitan areas.

BSP 918-216-100MP ISSUE A, July 2003

Aerial plant is generally considered to be exposed to power whether power is present or not, since there is no assurance that power will not be built at a later time. The only exception is aerial plant confined entirely within a block where it is not exposed to power conductors operating at more than 300 volts rms to ground. The term "block", as used here, means a square or portion of a city, town, or village enclosed by streets. Any alleys so enclosed are part of the block, but the streets themselves are not.

Joint buried plant is considered unexposed to power contacts if a separation of at least 12 inches of tamped earth is maintained between the cables of the power and telephone systems. However, buried plant that parallels power conductors over long distances and plant that would be affected by power line faults (even faults on aerial extensions), is subject to power induction and ground potential rise and is classified as exposed.

Underground Plant

In metropolitan areas, underground plant is usually not exposed to lightning because of the shielding effects of surrounding buildings and buried metallic pipe systems. Underground plant is exposed to lightning in rural and suburban areas unless the plant is located where low incidence of thunderstorms and low ground resistivity virtually preclude the threat of exposure. Underground construction methods by design eliminate the possibility of power contacts, but regardless of location, underground plant may be exposed to power induction and ground potential rise.

Submarine Cable and Cable on Bridges and Overpasses

For the purposes of electrical protection, cable in conduit on bridges and overpasses is treated as underground cable, and cable mounted on bridge supports is treated as aerial cable. Submarine cable is regarded as buried cable.

ACHIEVING OPTIMUM PROTECTION

Consider All Exposures

Protection considerations for a specific cable installation should include all the exposures encountered, whatever the source, and the protection measures should be coordinated to reduce the effects of these exposures. Lightning protection, for example, is primarily a voltage-limiting task requiring bonding and grounding of metallic sheath components and metallic strength members, and the application of protectors to metallic pairs at specified locations. Power protection includes current-limiting that requires a fusible link in addition to the application of protectors and bonding and grounding. Fusible links, however, are not effective for lightning protection or sneak current protection and are not a substitute for protectors.

Insist on Good Construction

Good construction, including adequate mechanical strength and proper spacing between power and telephone facilities is the first line of defense against power contacts. (Clearance rules for telephone facilities with respect to power, roads, and railroads are given in the 918 and 620 Divisions of the Practices). Even with proper construction, power contacts can and do occur; this necessitates a coordinated protection plan. Such a plan should provide paths to ground on the telephone plant sufficient to prevent excessive voltage rise, and to conduct enough power line fault current to ground either to rapidly operate fuses or breakers on the faulted power line or to cause line conductors to fuse open at the fault point.

Low impedance paths to ground are an effective aid for both lightning and power protection and are achieved by the following:

- Establishing and maintaining continuity of metallic cable components (shield, strength member, vapor barrier) in cables
- Bonding metallic sheath components and strength members of cables to metallic support strands as required
- Bonding the metallic sheath components, strength members and strands of separate cables together
- Bonds to MGN or grounding to telephone company provide ground rods when an MGN is not available
- Proper grounding at buildings and central offices.

These measures are accomplished primarily by proper performance of work operations in splices and terminals in accordance with the appropriate sections of the plant series Practices.

Specify Protection on Work Prints

It is the Outside Plant Engineer's responsibility to provide complete and accurate information on all work prints so that optimum electrical protection of the plant is achieved. This information should specify:

- The operating voltages of power lines in joint use with telephone plant, or of nearby power lines that may influence the construction of the plant.
- Location of bonds between telephone and power facilities
- Location of bonds between metallic sheath components and strength members of optical fiber cable and the support strand
- Location of bonds between separate cable strands at crossover poles or branches
- Location and type of protectors and protected cable terminals
- Location and type of fuse cable
- Details on protector and cable grounding in buildings
- Location of driven grounds that may be necessary for the grounding of aerial plant
- Location of insulating joints in cables and the types of capacitors to be bridged across them.

The Outside Plant Engineer should become familiar with the work print symbols pertaining to electrical protection shown on Page 8.

SPECIAL SITUATIONS

Protection procedures for outside plant located in other types of hostile environments are detailed in the appropriate Practices and are not covered in this practice. In particular, the reader is referred to the 877 Division which deals with Corrosion; the 873 Division on control of inductive disturbances from power lines and radio stations; and BSP 876-310-100MP which concerns the protection of communications facilities serving locations subject to high ground potential rise for example, electric power stations, substations and PCS and cellular antennas located at or near high voltage towers.

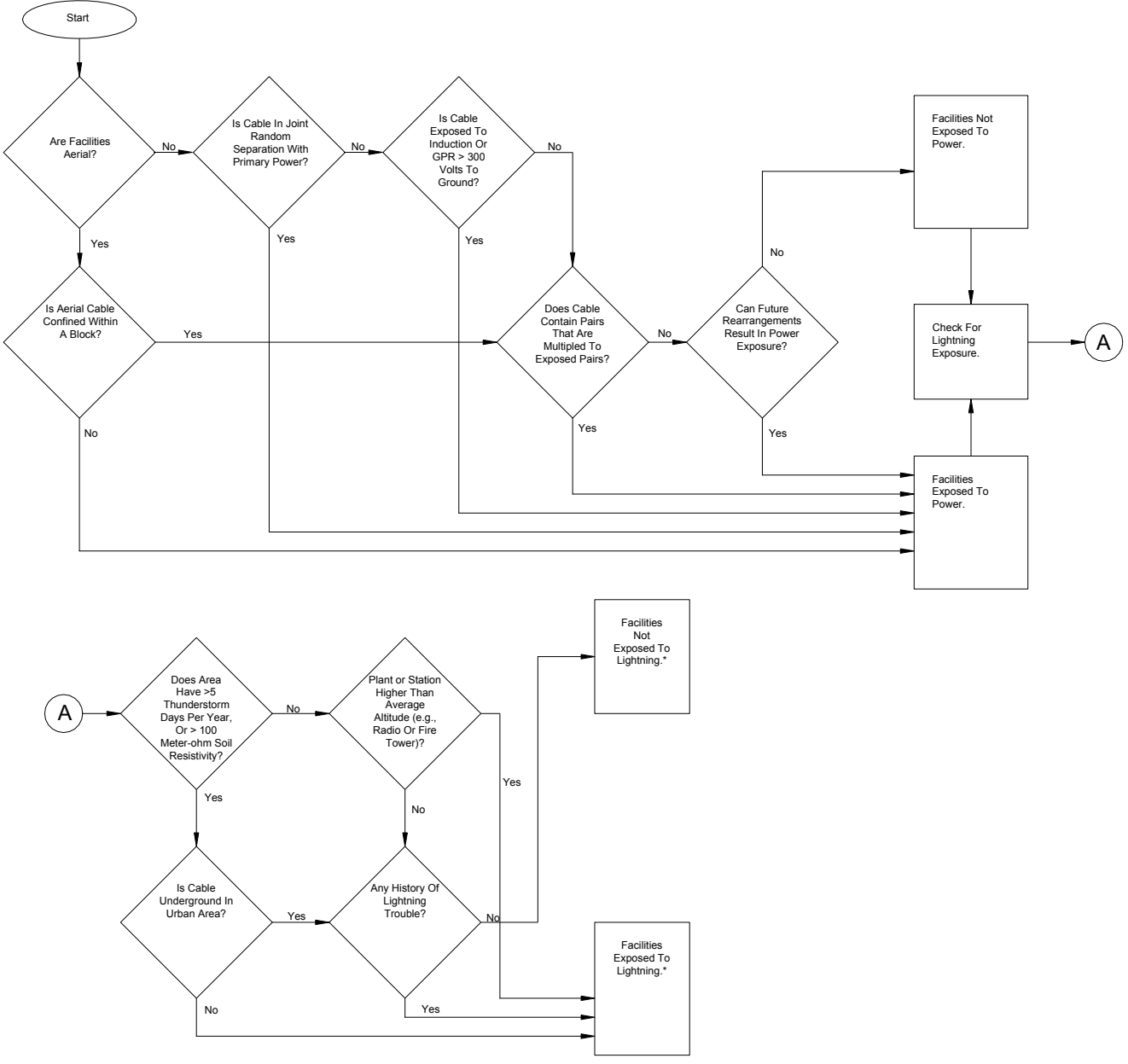


Figure 1-1 – Determining Exposure Status

2. CENTRAL OFFICE PROTECTION

All entering exposed telecommunications cables that contain metallic components such as a metallic shield, a metallic strength member, metallic pairs or a vapor barrier, require some form of electrical protection at the central office. The electrical protection includes bonding and grounding of cable metallic sheath components and metallic strength members, and the application of protectors to metallic pairs, along with fuse links and heat coils, where required. Air pressure pipe that is exposed and is metallic or contains a metallic vapor barrier also requires bonding and grounding. Where the cable complement consists of both exposed and unexposed cables, it is advisable to provide protective devices on metallic pairs on both the exposed and unexposed cables for ease of administration and the possibility of future rearrangements. Cables containing no metal components, such as all dielectric optical fiber cables without metallic pairs, are considered unexposed and will require no electrical protection at the central office.

PROTECTION MEASURES

Bonding and Grounding

The central office principle ground point is the location where all grounding conductors are connected to the Central Office's earth electrode system. The major emphasis of bonding and grounding is to maintain potential equalization between the equipment ground, power ground, metallic cable sheath components, cable metallic strength members, MDF ground, and the central office principle ground point. The metallic sheath components and metallic strength members of all cables entering the central office must be connected to the central office ground. Two different arrangements are used, depending on whether or not insulating joints are installed at the central office. Insulating joints may be required in certain areas where corrosion of cable is a problem. Insulating joints do not provide effective protection against hazardous voltages and are not intended for that purpose.

In a central office without insulating joints, bond the metallic sheath components and strength members of all entrance cables with No. 6 AWG copper wire or bonding ribbon to the No. 1/0 AWG copper wire which is run from the Cable Entrance Facility (CEF) to the central office ground. This includes the metallic shield of paired conductor cables and the metallic sheath components and strength members of optical fiber cables. The routing of the No. 1/0 AWG to the central office ground should be as direct and straight as possible and kept away from central office equipment that might be affected by current surges in this conductor. Figures 2-1, 2-2, 2-3A, 2-3B and 2-4 show central office entrance cables without insulating joints.

Figure 2-5 shows an entrance cable with an insulating joint. Where insulating joints are used:

- The metallic sheath components and strength members of all entering cables (paired conductor and optical fiber) must be bonded together with No. 6 AWG copper wire or bonding ribbon on the outside plant side of the insulating joint. The cables, together with all associated metal (such as capacitors, pressure pipes, and bonding wire or ribbon), must be isolated from all grounded objects (such as building steel, equipment and racks) on the outside plant side of the insulating joint.
- The insulating joint must be located as near as possible to the point of entrance to the central office. Insulating joints must be bridged with capacitors as specified in Figure 2-6.

- On the central office side of the insulating joint, bond the metallic sheath components and strength members of all cables with No. 6 AWG copper wire or bonding ribbon to the No. 1/0 AWG copper wire that is run to the central office ground. The preferred method is to bring the No. 1/0 AWG wire into the CEF and connect each cable to it with No. 6 AWG wire or bonding ribbon.

Alternative Arrangements For Bonding and Grounding Optical Fiber Cables

There may be operational or economic penalties associated with bonding and grounding of optical fiber cable metallic sheath components and strength members in the CEF. For example, access to the metallic sheath components and strength members may require a fiber splice, increasing both the installation cost and transmission loss. Bonding and grounding of metallic sheath components and strength members at the interconnection equipment would overcome these liabilities, but would allow lightning and power fault currents to be carried past the CEF and into the central office. Although bonding and grounding of all metallic sheath components and strength members at the CEF is recommended, the following bonding and grounding alternatives offer adequate protection.

Grounding of Shield Only in the CEF

If the outermost metallic component of an entering optical fiber cable is a full circumferential shield, only this shield need be bonded to the central office ground at the CEF. Other metallic components internal to the circumferential shield need not be bonded at the CEF, but if electrically continuous, should be bonded together and grounded at the interconnection equipment. Extensions of outside plant optical fiber cable into the central office should conform to the fire protection requirements described in BR 781-810-855. Where insulating joints are used at the central office, this method shall not be used as it will short circuit the insulating joint.

Bonding and Grounding of Metallic Components at the Interconnection Equipment

Bonding and grounding may be done only at the interconnection equipment when there are compelling reasons for not bonding and grounding all metallic components, or at least grounding a full circumferential shield in the CEF. The pathway within the central office through which the outside plant optical fiber cable is routed should conform to the fire protection requirements described in BR 781-810-855.

All metallic sheath components and strength members, as well as the interconnection equipment itself, must be bonded and grounded to the central office building ground system. A No. 6 AWG copper wire or equivalent should be used; if there is more than one cable, the No. 6 AWG wires should be joined to a No. 1/0 AWG copper conductor connected to the central office building ground system. The routing of this conductor should be as direct and straight as possible. It should be kept away from central office equipment that might be affected by current surges carried by the conductor. The bonding and grounding of a single optical fiber cable containing a shield and central metallic strength member is illustrated in Figure 2-7. Where insulating joints are used in the central office, the metallic components must be separated from the central office building system ground through a capacitor as shown in Figure 2-7.

Protector Units and Heat Coils

Protector units limit the voltage difference between conductors and ground by providing a small gap that will break down almost instantaneously and ground the circuits when the operating voltage of the protector unit is reached. Protector units are required on all exposed cable pairs entering the central office. This includes tip and ring conductors contained in conventional paired conductor cables and in optical fiber cables. It also applies to conductors contained in a cable or wire installed along with buried optical fiber cable to serve as order wire pairs and to locate all dielectric optical fiber cable.

Protector units may be equipped with either carbon blocks, gas tubes, hybrid or solid state elements. Certain electronic switching offices require special gas tube protector units. At central offices where protector or equipment maintenance has been excessive, specialized protectors may be required. Consult with the ICEP engineer.

If an extraneous voltage less than the operating voltage of the protector unit is impressed on a telephone circuit, the terminal equipment may provide the only path to ground for the resulting current. Such currents (sneak currents) are usually small in magnitude but may, if allowed to continue, overheat the equipment and constitute a fire hazard.

The heat coil is designed to divert these currents to ground or opens the circuit before dangerous overheating occurs. Heat coils are required on:

- Exposed pairs in step-by-step and crossbar offices
- T1 carrier, and certain analog and digital carrier circuits as specified by the manufacturer that are exposed to power, regardless of office type
- Other specific equipment as stipulated in applicable Practices and equipment installation requirements
- Exposed pairs serving digital switches as specified by the manufacturer.

Heat coils are not required on:

- Exposed pairs in electronic offices as specified by the manufacturer (unless exposed T-carrier, subscriber loop carrier or subscriber loop multiplexer circuits are involved).
- T2, N, ON and earlier carrier systems. The terminating equipment has sufficient impedance to ground so that it will not dangerously overheat when sneak currents are present.

Except for T1 carrier, heat coils are not usually required on toll circuits. However, where toll circuits are not terminated on the frame in well defined groups, so that they cannot be readily distinguished from conductors requiring heat coils, it is advisable to provide heat coils on all circuits.

In general, the maintenance of mixed protector complements on the central office protector frame is not recommended as it is difficult to administer. Where heat coils are required, they should be employed throughout.

Three basic types of central office protector units are available:

- Those providing voltage protection only (equipped with either carbon blocks or gas tubes).
- Those providing both sneak current and voltage protection (equipped with heat coils and either carbon blocks or gas tubes).
- Those providing “continuity only” which have no protective function and are intended for use on unexposed circuits. Continuity only devices are necessary to complete the circuit path between the central office wiring and the outside plant cable pairs. These devices are also known as “5 type protectors, dummies or steelies”.

All three types of protector units are accommodated by a Central Office Distributing and Protector Frame Connector that meets the generic requirements of GR-2916, Distributing Frame Protected Connector. The appropriate protector units for use in connectors conforming to GR-2916 are listed in Table 2-1.

Table 2-1. Technical References Covering Protector Units for Central Office Connectors Conforming to GR-2916

PROTECTOR UNIT			
CARBON	GAS TUBE	SPECIAL PURPOSE GAS TUBE NO. 5 ESS	HYBRID
TR-TSY-000300	SR-5165	TR-TSY-000072	SR-5165

Fuse Cable and Fuse Links

When outside plant cable facilities are exposed to power, either fuse cable or a fuse link is required in addition to the protector unit applied at the central office. Fuse cable or a fuse link consists of fine gauge conductors installed between the outside plant power exposure and the central office. In the event of prolonged current flow, such as might accompany a power contact, the fuse cable or fuse link will burn open preventing overheating of central office cabling and protector units.

Paired Conductor Cables

No fuse cable is necessary if the entrance cable has 24 or 26 gauge copper conductors and the central office connector stub (tip cable) is at least two gauges coarser than the entrance cable. In this case, the entrance cable pairs themselves serve as the fuse cable or fuse link. Figures 2-1 and 2-2 illustrate this arrangement.

When the entrance cable is not 24 or 26 gauge, fuse cables having 24 or 26 gauge conductors must be used along with connector stubs (tip cables) that are at least two gauges coarser than the fuse cable. Fuse cables are usually installed at the junction of the underground cable and all exposed aerial and buried extensions and branches (see Figure 2-3A). As an alternative, they may be installed in the central office manhole (see Figure 2-3B). For transmission reasons, it is desirable to keep the length of the fuse cables as short as possible, but a minimum length of two feet is required.

Fuse cable requirements are given in Table 2-2 which shows the relationship between the gauge sizes of the entrance cable, the fuse cable and the connector stubs.

Table 2-2. Fuse Cable Requirements

ENTRANCE CABLE	FUSE CABLE	CONNECTOR STUB
19 or 22 ga	24 ga	22 ga
19 or 22 ga	26 ga	24 or 22 ga
24 ga	None	22 ga
24 ga	26 ga	24 ga
26 ga	None	24 or 22 ga

Note: Any intervening conductors between the entrance cable and the connector stubs must be the same gauge as the connector stubs.

Optical Fiber Cables

A fuse link is required in metallic pairs contained in an optical fiber cable that is exposed to power and enters the central office. The preferred locations for the fuse link are the distribution plant on the central office side of the power exposure, the CEF, and the central office manhole (as shown in Figure 2-4).

These locations minimize the length of pairs within the building that may be energized by unwanted power voltages after a fuse link or fuse cable opens.

Optical fiber cable metallic pairs may be terminated on a tip cable leading to the main distribution frame (MDF) and may themselves serve as the fuse link provided:

- They are no coarser than 24 gauge
- They are at least two gauges finer than the tip cable pairs
- The optical fiber cable within the CEF must contain a full circumferential metallic shield, or be placed in a metallic conduit, or be placed in a plastic conduit as described in BR 781-810-855.

The optical fiber cable metallic pair to tip cable splice may be made within the optical fiber cable splice closure in the CEF.

Alternatively, it may be desirable to stub the metallic pairs out of the optical splice closure to an MDF tip cable splice. This stub may serve as the fuse link provided its pairs are contained under a metallic shield and are at least two gauges finer than either the tip cable pairs or the optical fiber cable metallic pairs, whichever are finer.

If there is no CEF splice in the optical fiber cable, a dedicated connector with an integral stub cable may be placed on the interconnection equipment. The integral stub may serve as the fuse link provided the stub pairs are contained under a metallic shield, are no coarser than 24 gauge, and are at least two gauges smaller than the optical fiber cable metallic pairs. Splices of optical fiber cable metallic pairs to stub cable pairs must be contained in a fire retardant splice case. Fuse link requirements are given in Table 2-3.

Table 2-3. Fuse Link Requirements – Optical Fiber Cable

OPTICAL FIBER CABLE METALLIC PAIRS	FUSE LINK	TIP CABLE OR TERMINATING WIRE
22 ga	24 or 26 ga	22 ga
24 ga	26 ga	22 ga
22 ga	26 ga	24 ga
24 ga	26 ga	24 ga

When using a stub cable in the CEF or a dedicated connector with integral stub it should be established that the optical fiber cable will not be damaged by heating effects of currents in the optical fiber cable metallic pairs that can be conducted by the fuse link. It should also be established that the optical fiber cable coordinates with the fuse link. If not, the optical fiber cable within the CEF or building must have a full circumferential metallic shield, be placed in metallic conduit, or be placed in plastic conduit as described in BR 781-810-855. If the optical fiber cable metallic pairs themselves are used as the fuse link, extensive repair of the optical fiber cable may be required if fusing occurs and the metallic pair function is to be restored. Fusing of metallic pairs may also possibly damage the optical fibers.

SPECIAL SITUATIONS

Under certain conditions, extra steps must be taken to ensure the electrical protection of outside plant serving a central office. These procedures are described in the following Practices:

- Central office located near high voltage transmission line right of way, BSP 876-200-100, Issue 5 October 1983.
- Central office located within the influence of the ground potential rise at a power station or power substation, BSP 876-200-100, Issue 5, October 1983 and BSP 876-310-100MP.
- Central office serving a power station or substation, BSP 876-310-100MP.
- Central office combined with a microwave relay or radio station, BSP 876-210-100, Issue 4, November 1973.

BSP 918-216-100MP
ISSUE A, July 2003

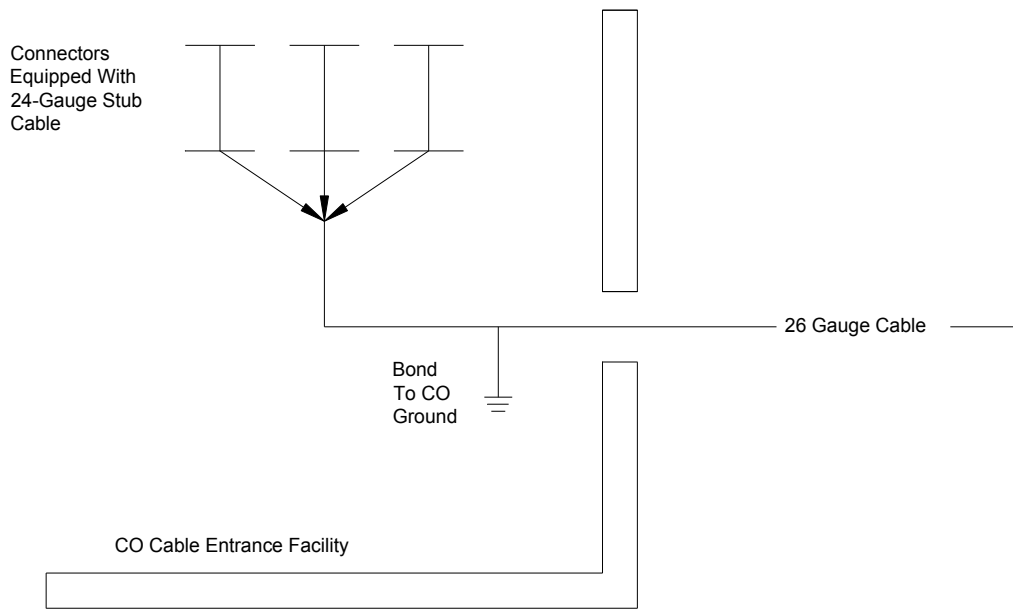


Figure 2-1 – Underground CO Entrance With Exposed 26-Gauge Entrance Cable and 24-Gauge Connector Stubs, No Fuse Cable Required

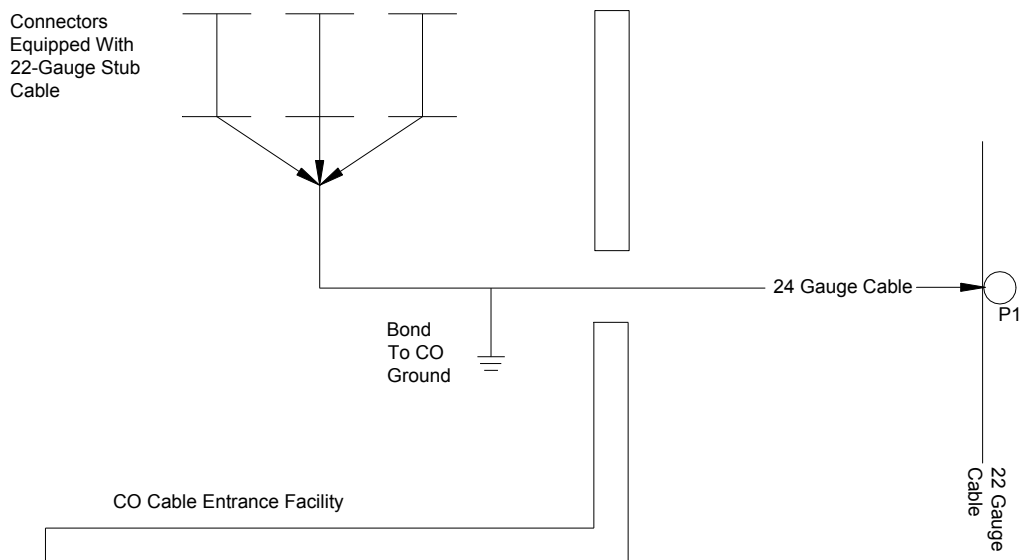


Figure 2-2 – Aerial CO Entrance with Exposed 24-Gauge Entrance Cable and 22-Gauge Connector Stubs

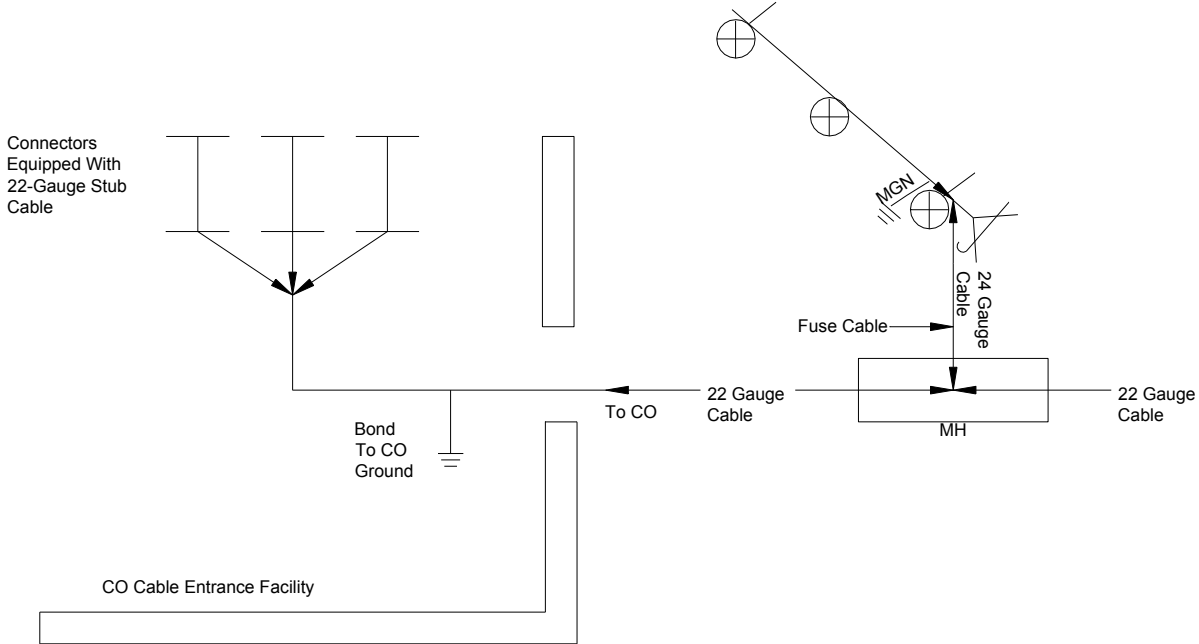


Figure 2-3A – Underground CO Entrance with Exposed 22-Gauge Entrance Cable, 24-Gauge Fuse Cable Installed at Aerial - Underground Junction, 22-Gauge Connector Stubs Required at CO

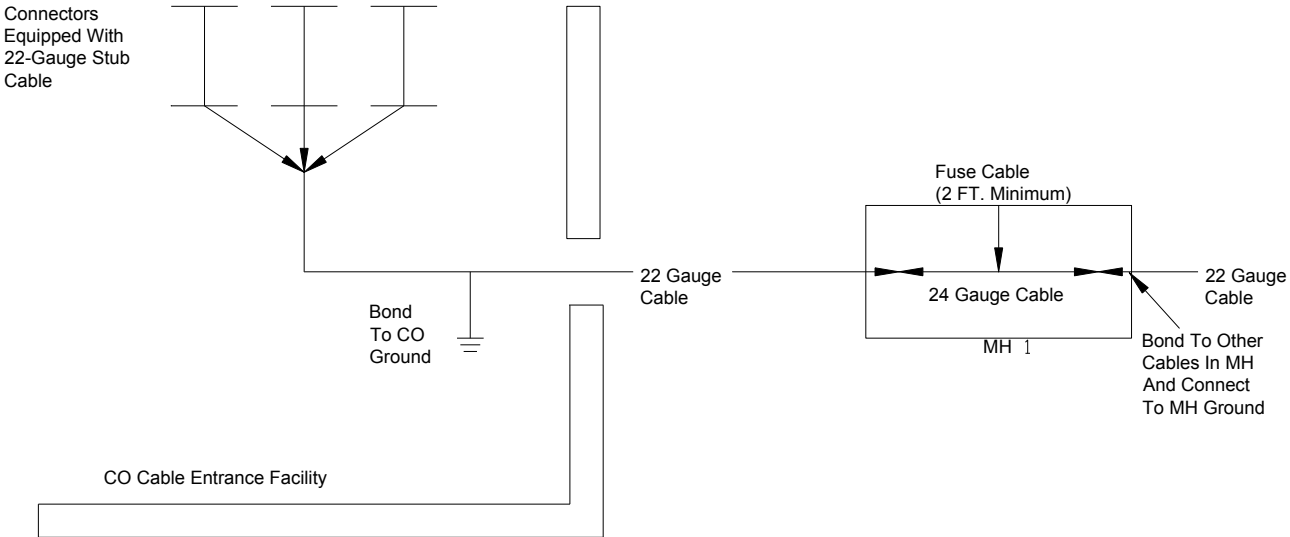


Figure 2-3B – Underground CO Entrance with Exposed 22-Gauge Entrance Cable, 24-Gauge Fuse Cable Installed in Manhole Nearest CO, 22-Gauge Connector Stubs Required at CO

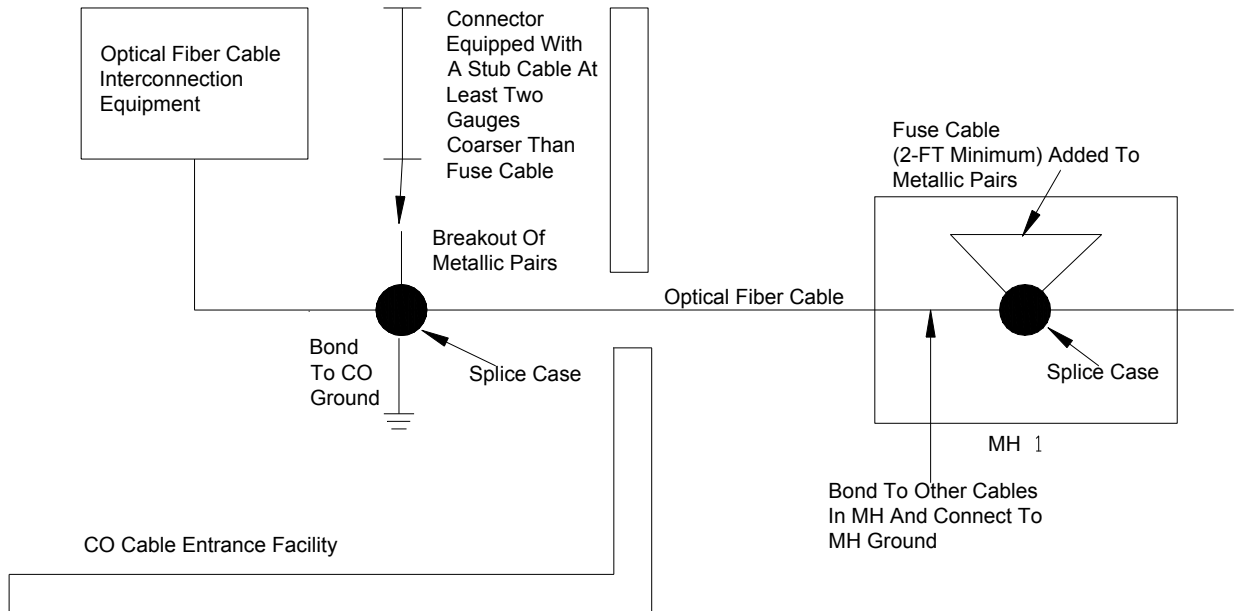


Figure 2-4 – Underground CO Entrance of Exposed Optical Fiber Cable, Fuse Link Installed in Metallic Pairs in Manhole Nearest CO Entrance

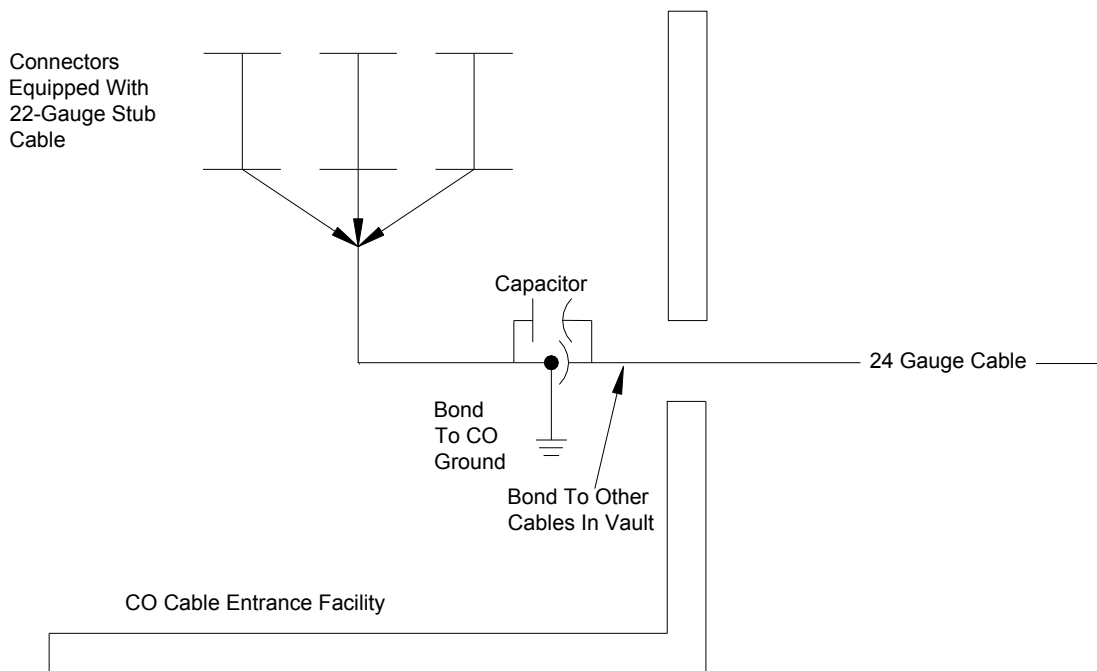


Figure 2-5 – Underground CO Entrance with 24-Gauge Entrance Cable Incorporating an Insulating Joint

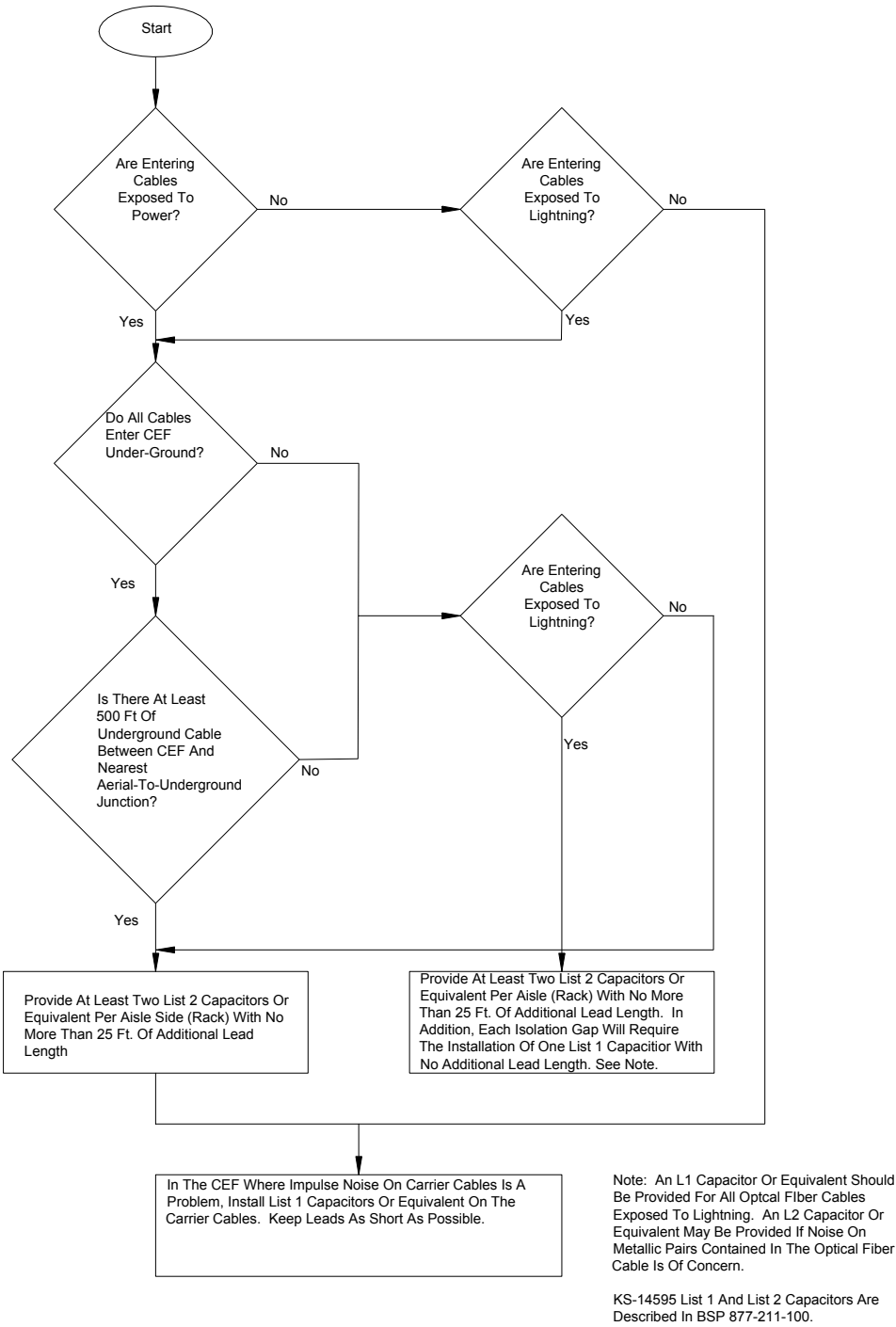


Figure 2-6 – KS-14595 Capacitor or Equivalent Requirements for CEFs with Insulating Joints (BEFs with insulating joints should be treated in a similar manner.)

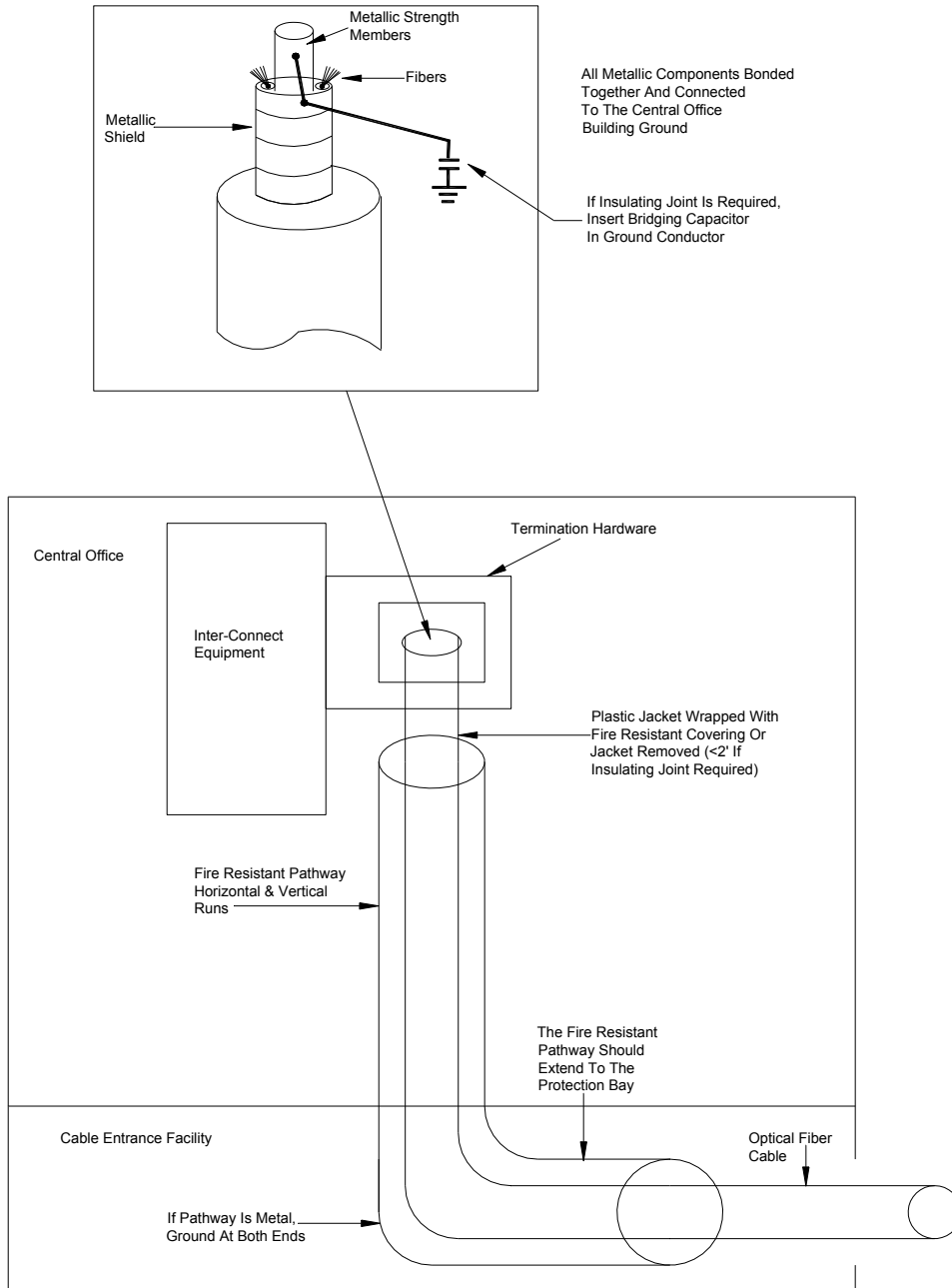


Figure 2-7 – Bonding and Grounding of Optical Fiber Cable at Interconnect Equipment

3. PAIRED CONDUCTOR CABLE, WIRE, AND OPTICAL FIBER CABLE PROTECTION

Protection recommendations in this section apply to paired conductor cable (paired copper or aluminum conductor core), wire, and optical fiber cable outside plant facilities. Although protection considerations for paired conductor cable and optical fiber cable are similar, sufficient differences exist to warrant addressing the protection of the two cable types separately.

A. PAIRED CONDUCTOR CABLE AND WIRE PROTECTION

These protection recommendations for paired conductor cable and wire plant apply under most exposure conditions. Excessive electrical core and sheath trouble rates caused by a severe electrical environment may indicate that additional protection measures are necessary, such as more frequent bonding or the installation of additional protective devices.

AERIAL PLANT PROTECTION MEASURES

General Measures for All Exposed Aerial Plant

Apply the following protection measures to all exposed aerial plant, regardless of the source of exposure:

- Establish and maintain shield continuity in the cable and in terminals and splices.
- Bond the cable shield to the strand at least once every 1/4 mile. This is usually accomplished by properly installed closures and terminals that provide the bond as part of their design. Where the distance between closures and terminals exceeds 1/4 mile, or where additional bonds are required, additional closures, splice cases, or bond clamps may be installed to provide the bond.
- Bond together the strands of separate cables and wires at least once every 1/4 mile. This is accomplished automatically if both strands are mounted on the same throughbolt. In addition, bond the strands of separate cables or wires at each crossover and at each branch.
- SBC 627-020-005 summarizes the methods used to bond and ground telephone hardware in aerial plant.
- Bonding and grounding of aerial plant is important as there is a risk of power contact, possibility of personnel contacting grounded objects (e.g., separate strands) at different potentials, and a risk of physical accidents such as dropped tools and falls due to minor shocks.

Additional Measures for Aerial Plant Exposed to Lightning

Apply the following additional protection measures to aerial plant that is exposed to lightning:

BSP 918-216-100MP
ISSUE A, July 2003

PIC Cable

- PAP and PASP sheaths are recommended for use in areas where excessive lightning-caused trouble rates have been experienced with alpth cable.
- Where excessive lightning-caused trouble rates have been experienced, ground the cable shield and strand at 1/4 mile intervals. The ground may consist of a bond to the vertical down lead of an MGN system or to a driven ground.
- A bond must not be made to the vertical down lead of a power system lightning arrester unless the vertical down lead also is connected to the neutral of an MGN system.
- Use cable protectors in terminals at aerial drop or wire branches (see Figure 3-1A).
- Where the subscriber station is elevated relative to other structures in the immediate vicinity (such as fire towers, radio stations, and airport control towers).
- Where specified by the ICEP engineer. (See Figure 3-1B.)

Pulp Cable

PASP sheath is recommended in areas where excessive lightning caused trouble rates have been experienced with stalpeth cable.

- Ground the cable shield and strand at 1/4 mile intervals. The ground may consist of a bond to the vertical down lead of an MGN system or to a driven ground.
- A bond must not be made to the vertical down lead of a power system lightning arrester unless the vertical down lead also is connected to the neutral of an MGN system.
- Use cable protectors in terminals at aerial drop or wire branches:
- Where the subscriber station is elevated relative to other structures in the immediate vicinity (such as fire towers, radio stations, and airport control towers).
- Where specified by the ICEP engineer.
- Where there has been a history of lightning-caused troubles on a pulp insulated feeder and the lightning may be entering the cable through particular PIC distribution cables, use full count protection at the PIC to Pulp junctions (see Figure 3-1B). Protection at the PIC to Pulp junction may be accomplished by using gas tubes that are suitable for station protection. These gas tubes will offer a service life that is approximately six times longer than a 6-mil carbon block (formerly used for PIC to Pulp junction protection), and their lower voltage breakdown characteristic more closely coordinates with the dielectric capabilities of pulp insulated cable, resulting in improved protection. (See BR 876-405-100, Issue 2.)

Rural or urban wire

Use gas tubes that are suitable for station protection at drop wire branches serving highly exposed stations (such as radio stations and fire towers).

Additional Measures for Aerial Plant Exposed to Power

Cable Plant - In addition to the general protection measures for all exposed aerial plant, apply the protection measures for aerial plant in joint use with MGN and non-MGN power given in Tables 3-1 and 3-2 respectfully. For joint use with power that operates at more than 2.9 kV to ground, the current carrying capability (I^2t) of the cable strand must be verified, unless the power is provided with overcurrent protection having the characteristics of a 200T or smaller size fuse. In many cases the power will have this type of overcurrent protection, but confirmation should be obtained from the power company. When the power overcurrent protection does not meet this requirement, the ICEP engineer should be consulted to determine that the cable strand has adequate I^2t .

Protection against power contact exposure is accomplished by placing fusible links in the outside plant in addition to the protectors placed at the central office and customer network interface. A typical arrangement is the use of fuse (fine gauge) cable at the aerial to underground junction, as illustrated in Figures 3-1A, 3-1B and 3-2 to separate aerial cable exposed to power from otherwise unexposed underground cable. The fuse cable will usually fuse open before the coarser gauge conductors of the underground cable and permits maintaining complements of exposed and unexposed pairs in the same underground cable. Fuse cable cannot be used to protect a connecting cable from lightning as lightning surges occur too rapidly to operate the fuse cable.

Single Pair Rural Wire - A two (2) foot fuse link of D or E block wire (or equivalent) is required at the junction of single pair rural wire with:

- Aerial drop wire
- Buried service wire
- A terminal spliced to pulp cable.

Protectors (such as 118-type) are required for single pair rural wire exposed to power as shown in Table 3-3. The requirement for fuse links and protectors should be specified on the work order by the outside plant engineer.

Branches, Extensions, and Crossings - Special protection is required for branches and extensions from, and crossings with, cable that is in joint use with MGN power operating at more than 15 kV to ground (26 kV phase to phase). Refer to Table 3-4 for this information; see Figure 3-3.

Joint Use with Unigrounded Wye Power Systems and with Delta Power Systems - Avoid joint use with unigrounded wye power systems operating at more than 2.9 kV to ground unless there is a suitable grounding medium available. This can be the MGN or grounded secondary neutral of a lower voltage system on the same pole line, the MGN or grounded secondary neutral of an adjacent system or telephone company provided ground rods.

Joint use with delta power systems that operate at more than 2.9 kV to ground (5 kV phase-to-phase) is not recommended. Single phase-to-ground faults may persist for substantial lengths of time and may not be detected. Multiphase faults to ground are difficult to clear and can cause extensive plant damage. Where joint use with delta power systems cannot be avoided, consult the ICEP engineer.

BSP 918-216-100MP
ISSUE A, July 2003

Exposed Guys - A guy is exposed to power if:

- It is attached to a pole supporting open power conductors or spacer cable, regardless of their operating voltage.
- It crosses such power conductors.
- It is within ten horizontal feet, and any vertical distance, of such power conductors.
- It is attached to the same pole as an exposed guy.
- It is attached to a pole carrying an isolated cable that is not effectively grounded (e.g., a length of aerial cable inserted in an open wire line).

Exposed guys must be grounded, except for the following cases where they must be insulated:

- Where electrolytic corrosion of anchors is a problem
- Where exposed to dc powered transportation facilities
- Where placed within a power station zone of influence
- Where adequate grounds cannot be obtained.
- Are located within the State of California (CPUC General Order 95 requires exposed guys to be insulated.)

Adequate grounding for guys is obtained by connecting to any of the following:

- Suspension strand of a well grounded cable
- Anchor rods used in common with an MGN power guy
- Vertical down lead of an MGN power system.

Figures 3-4 and 3-5 can be used to help determine the protection requirements for aerial cable and wire.

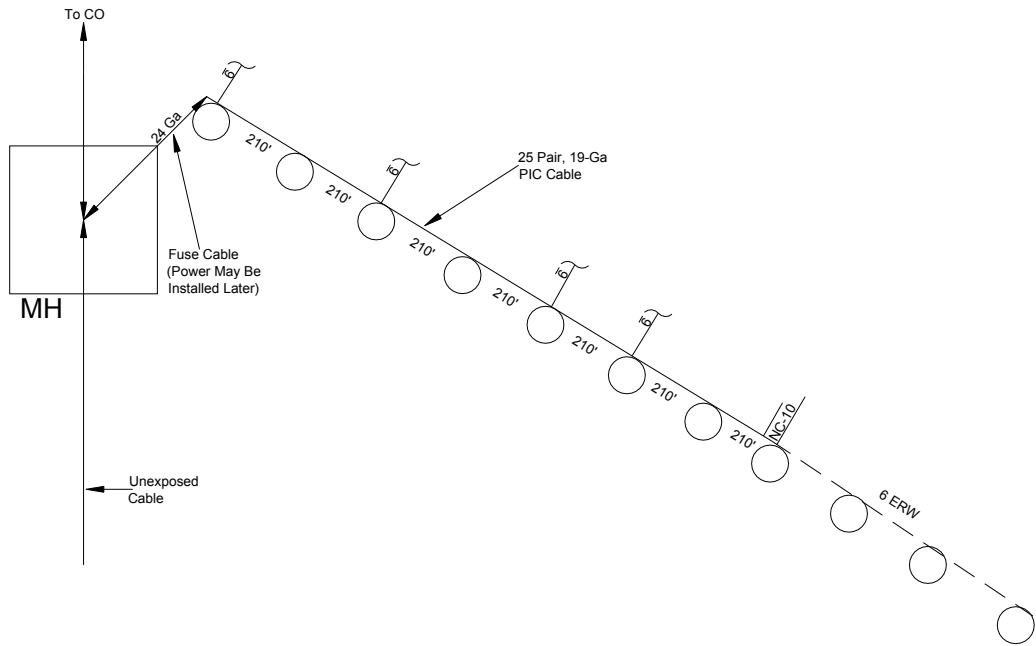


Figure 3-1A – Aerial Plant Exposed to Lightning, Cable Protectors Installed at Each Terminal

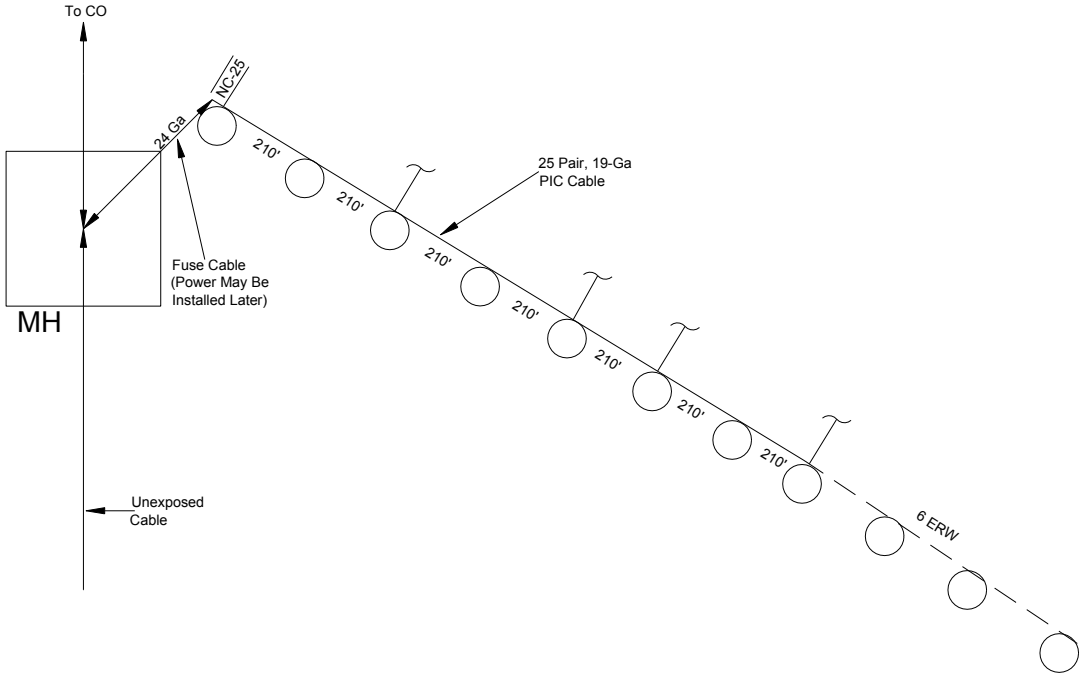


Figure 3-1B – Aerial Plant Exposed to Lightning, Full Count Protection at Junction with Unexposed Cable

**BSP 918-216-100MP
ISSUE A, July 2003**

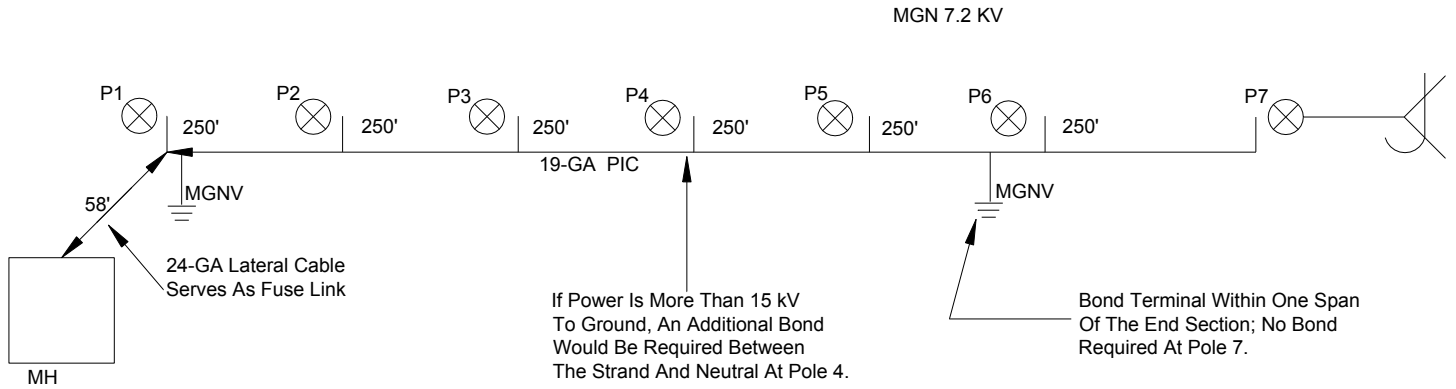


Figure 3-2 – Aerial Cable in Joint Use with MGN Power Operating at Less Than 15 kV to Ground (26 kV Phase-to-Phase)

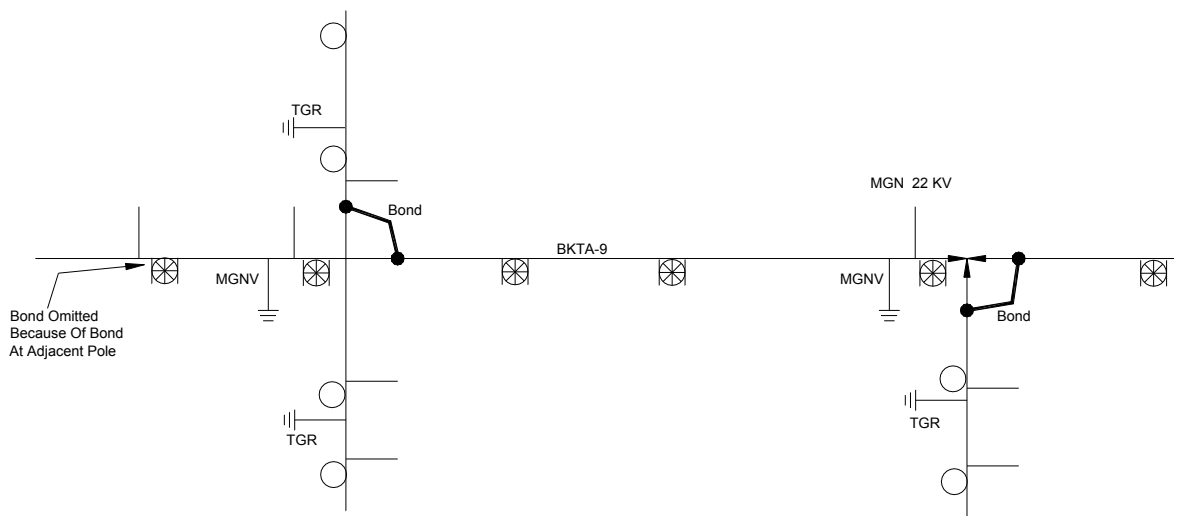


Figure 3-3 – Crossing with, and Branch from Aerial Cable in Joint Use with MGN Power Operating at More Than 15 kV to Ground (26 kV Phase-to-Phase).

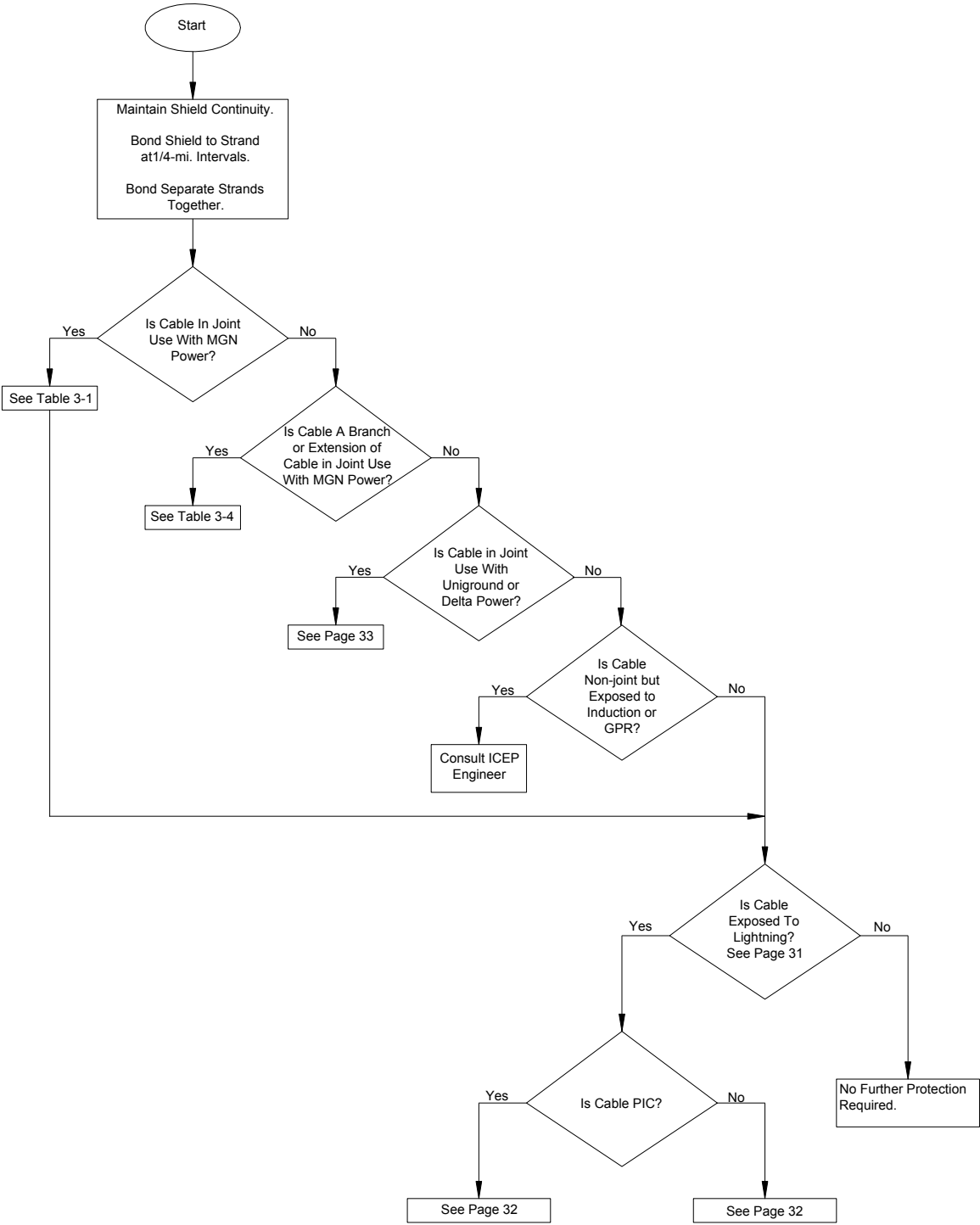


Figure 3-4 – Protection of Aerial Cable

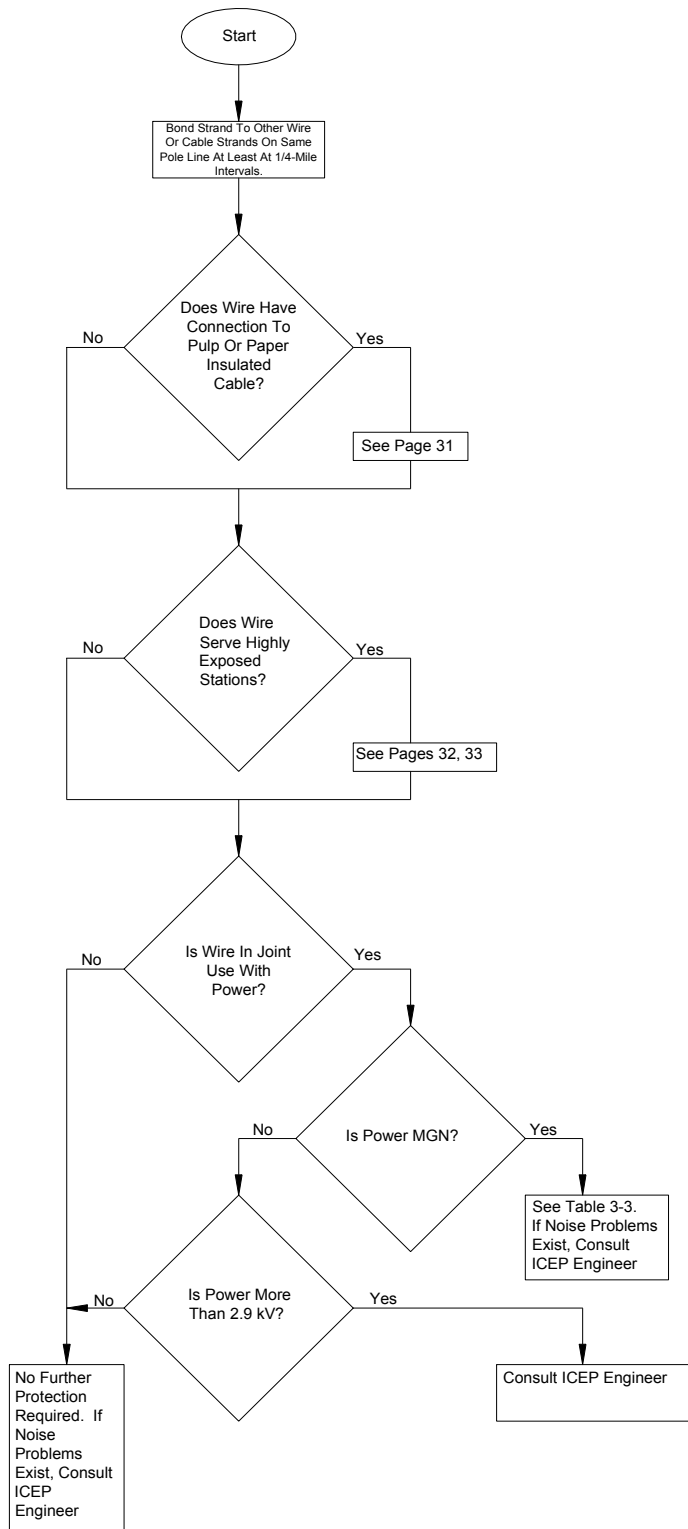


Figure 3-5 – Protection of Aerial Wire

Table 3-1
Protection Requirements For Aerial Cable In Joint Use With MultiGrounded Wye Power ¹

Minimum Requirements	Power System Voltage In kV To Ground (Power System Voltage In kV Phase-to-Phase)			
	0.3 - 2.9 (.5 - 5.0)	2.9 - 15 (5.0 - 26.0)	15 - 34.6 (26.0 - 60.0)	34.6 - 86.6 ² (60.0 - 150.0)
Bonding Interval Strand To Neutral	Both Ends of Section and 1/4 Mile Intervals ⁴	Both Ends of Section and 1/4 Mile Intervals ⁴	Both Ends of Section and 1/8 Mile Intervals ⁴	Every Pole
Umbrella of Lower Voltage Power Conductors Required Between Cable and Power	No	No	No	Yes
Ampacity (I^2t) of Strand Must Be Verified ³	No	Yes ⁵	Yes	Yes
Bond Every Terminal to MGN	No	No	Yes	Yes
Metallic Shield Construction Required For Branches (No Wire)	No	No	No	Yes
118 Type Protectors or 10-Mil Blocks Required On Wire Branches to Pulp Cable	No	Yes	Yes	Wire Branches Not Permitted
Bonds Between Protector and Power Service Ground At Stations Must Be Verified	No	No	Verification Of Bonds Recommended At Customer Locations Served By Terminals In The HVJU Section	Yes

1. Where MGN is not available, See Table 3-2.

2. Joint use with MGN power exceeding 86.6 kV to ground (150 kV phase-to-phase) is not presently recommended.

3. See Page 33. Where maximum I^2t values cannot be met, bonds must be placed at every terminal.

4. May be omitted if there is a bond at an adjacent pole.

5. Not required for self-supporting cable; not required if there is a secondary power cable or telephone strand having an adequate I^2t value between the primary power and the plant to be placed.

For more information, refer to BSP 876-400-100MP.

**Table 3-2
Protection Requirements For Aerial Cable In Joint Use With Uni-Grounded Wye and Delta Power In Areas
Where Bonding to Neutrals is Not Allowed**

Minimum Requirements	Power System Voltage In kV To Ground (Power System Voltage In kV Phase-to-Phase)			
	0.3 - 2.9 (.5 - 5.0)	2.9 - 15 (5.0 - 26.0)	15 - 34.6 (26.0 - 60.0)	34.6 - 86.6 ¹ (60.0 - 150.0)
Grounding Interval - Strand To Telephone Ground Rod	Both Ends of Section and 1/4 Mile Intervals ³	Both Ends of Section and 1/4 Mile Intervals ³	Both Ends of Section and 1/8 Mile Intervals ³	Every Pole
Umbrella of Lower Voltage Power Conductors Required Between Cable and Power	No	No	No	Yes
Ampacity (I ² t) of Strand Must Be Verified ²	No	Yes ⁴	Yes	Yes
Ground Every Terminal to Telco Provided Ground Rod	No	No	Yes	Yes
Metallic Shield Construction Required For Branches (No Wire)	No	No	No	Yes
118 Type Protectors or 10-Mil Blocks Required On Wire Branches to Pulp Cable	No	Yes	Yes	Wire Branches Not Permitted
Bonds Between Protector and Power Service Ground At Stations Must Be Verified	No	No	Verification Of Bonds Recommended At Customer Locations Served By Terminals In The HVJU Section	Yes

1. Joint use with power exceeding 86.6 kV to ground (150 kV phase-to-phase) is not presently recommended.

2. See Page 33. Where maximum I²t values cannot be met, bonds must be placed at every terminal.

3. May be omitted if there is a ground at an adjacent pole.

4. Not required for self-supporting cable; not required if there is a secondary power cable or telephone strand having an adequate I²t value between the primary power and the plant to be placed.

For more information, refer to BSP 876-400-100MP.

Table 3-3. Protection Requirements for Aerial Wire Plant in Joint Use with MGN Power

WIRE TYPE	POWER VOLTAGE TO GROUND (kV) (kV PHASE-TO-PHASE)		
	0.3 – 2.9 (0.5 – 5)	2.9 – 15 (5 –26)	15 – 34.6 (26 – 60)
Single Pair Rural Wire ¹	No protectors required	Protectors required at ^{2,3} <ul style="list-style-type: none"> • Both ends of section ⁵ • Each drop 	Protectors required at ² <ul style="list-style-type: none"> • Both ends of section ⁵ • Each drop • Bonding between station protector and power ground must be verified
Multiple Line Wire 19 Gauge* 22 Gauge 24 Gauge	Bond Support wire to MGN at both ends of section and at intervals not exceeding ¼ mile.		
	No protectors required	Protectors required at ^{3,4} <ul style="list-style-type: none"> • Both ends of section ⁵ • Each drop 	Protectors required at ³ <ul style="list-style-type: none"> • Both ends of section ⁵ • Each drop • Bonding between station protector and power ground must be verified

1. Block wire fuse is required on all station drops connected to fuseless protectors.
2. Use 118-type protectors and connect ground wire to MGN vertical down lead.
3. Use protectors equipped with 6 mil carbon blocks or gas tubes. Connect protector ground wire to MGN vertical down lead or to the support wire if it is bonded to the MGN at an adjacent pole.
4. Protectors not required if wire plant is installed beneath grounded cable or wire strand.
5. Full count protection at the beginning of the section is not necessary if the wire is fed by cable plant that is protected against voltages in the same range. Protection at the end of the section is not necessary if the section is 5 spans or less long.

For more information, refer to BSP 876-102-100, Issue 3, June 1982, BSP 876-402-100, Issue 2, July 1980 and BSP 873-503-101 Issue 2, January 1983.

**BSP 918-216-100MP
ISSUE A, July 2003**

Table 3-4 Protection Requirements for Branches and Extensions from, and Crossings with, Cable in Joint Use with MGN Power Operating at More Than 15 kV to Ground (26 kV Phase to Phase).

SITUATION	BOND BETWEEN STRAND AND POWER NEUTRAL OR GROUND REQUIRED
<p>Branch, extension, or crossing on joint use poles with secondary power - secondary neutral connected to primary neutral or Crossing on joint-use poles with secondary or lower voltage power - neutrals of separate power systems not connected.</p>	<ol style="list-style-type: none"> 1. At beginning of branch or extension, or at crossing. 2. 1/4 mi. from beginning of branch or extension, or at end of section if less than 1/4 mi. long; or 1/4 mi. on either side of crossing. 3. At every terminal located within 2000 ft. of beginning of branch or extension. Exception: Bond at terminal may be omitted if there is a bond on an adjacent pole.
<p>Branch or extension on joint-use poles with secondary power - secondary neutral not connected to primary neutral.</p>	<ol style="list-style-type: none"> 1. At beginning of branch or extension. 2. At pole where secondary neutral begins. 3. 1000 ft. from junction with cable that is in joint use with higher voltage power, or at end of section if less than 1000 ft. long. 4. At every terminal located within 1000 ft. of junction with cable in joint use with higher voltage power. Establish a driven ground if bonding is impossible.
<p>Branch, extension, or crossing on non joint-use poles.</p>	<ol style="list-style-type: none"> 1. At beginning of branch or extension, or at crossing. 2. At first pole from beginning of branch or extension, or at first pole on either side of crossing, establish a driven ground.

Note: In each of the above cases, the presence of a fuse link in the plant, and a bond between protector ground and power ground at each station within critical area (1000 ft., 2000 ft., or 1/4 mi. as appropriate) must be verified.

BURIED PLANT PROTECTION MEASURES

Buried Plant Exposed to Lightning

The following protection measures apply to buried plant that is exposed to lightning:

- Establish and maintain cable shield continuity.
- ASP (waterproof), PAP, or PASP sheath is recommended.
- Use cable protectors in terminals at aerial drop or wire branches:
 - Where the subscriber station is highly exposed to lightning (such as with services to fire towers, radio stations, and airport control towers) or where drop is exposed to lightning and the cable is not exposed.
 - Where specified by the ICEP engineer.

Buried Plant Exposed to Power

The measures described here should be used for the protection of telephone cable that is buried in the vicinity of power conductors. Distinctions in protection requirements are made on the basis of the distance between the two systems.

Joint buried plant (with one foot separation) is telephone plant buried in the same trench with power conductors where a minimum of one foot of well tamped earth is maintained between the two systems. The telephone plant is considered to be unexposed to power contacts under this condition. Nevertheless, joint buried plant with one foot separation is subject to the bonding requirements for telephone plant buried with less than a three-foot separation from power conductors as highlighted on page 45.

Joint random buried plant is plant that is buried in the same trench with power conductors where a minimum one foot separation has not been maintained. Joint random spacing is limited to subscriber end distribution cable that is joint with power cables operating at no higher than a nominal 20 kV (22 kV maximum) to ground for MGN systems, and a nominal 2.9 kV (3.05 kV maximum) to ground for delta systems. Feeder pairs should not be routed through cables in joint random construction. The permissible length of joint random construction is limited for noise reasons. See BSP 873-503-101 Issue 2, January 1983. In California, joint random construction with power voltages above 300 volts rms phase to phase is prohibited.

In addition to voltage limitations placed upon joint random construction, the National Electrical Safety Code specifies that the power conductors must also include a bare or semiconducting jacketed grounded conductor in continuous contact with the earth. The grounded conductor may be a sheath, shield, or both, separate conductor in close proximity to the power conductor, or concentric neutral conductors.

The concentric neutral conductors may be bare, or covered with a semiconducting outer jacket which affords mechanical protection while maintaining contact between the neutral conductors and the earth. The presence of semiconducting jacketed (carbon-black impregnated) power cable(s) in joint buried construction may contribute to the corrosion of the buried telephone plant unless additional corrosion protection measures are taken. (See RL83-07-018.)

BSP 918-216-100MP
ISSUE A, July 2003

Plant that is joint random buried with power operating at more than 300 volts to ground is considered to be exposed. Observe the bonding requirements for telephone plant having less than a three foot separation from power conductors as highlighted on page 45. In addition, fuse cable or fusible links are required at customer drops served from 19 and 22 gauge cable. If pedestals are not employed, the use of 24 or 26 gauge cable in joint random buried plant makes fused station protectors or special fusing arrangements unnecessary. See Figure 3-6 for an example of joint buried construction.

Joint burial of the telephone service wire with the power secondary service cable is recommended to achieve greater depth of burial and reduced likelihood of a dig-in. The telephone service wire is not classified as exposed to power as secondary power voltage is less than 300 volts rms to ground. The extent of telephone service wire jointly trenched with power distribution cables should, however, be minimized. A jointly trenched service wire that comes in contact with a primary power phase conductor would not be protected by the finer gauge pairs in the distribution cable or fusible links in the service terminal. Protection of the service wire pairs should be provided by a fused protector.

Power and telephone companies should work out agreements on procedures to be followed in the event of a power fault or damage to telephone cable in joint buried construction. Prompt repair will involve cooperative efforts of telephone and power crews. See BSP 917-356-101 Issue 2, May 1981 for guidelines in setting up such agreements.

BONDING REQUIREMENTS: LESS THAN THREE-FOOT SEPARATION

Where a buried telephone cable is separated by three feet or less from a buried power cable operating at more than 300 volts to ground, whether in the same or separate trenches, the following requirements apply:

- Establish and maintain the continuity of the telephone cable shield.
- Bond the telephone cable shield to the power neutral or to the power apparatus as follows:

At the telephone terminal nearest to each transformer. Bond either to the transformer itself, to the primary neutral, secondary neutral, or secondary pedestal served from the transformer.

At least at every other terminal, including pedestal-type cable closures and buried closures supplying service wires or cables. The bond shall not be omitted on any two adjacent terminals.

At all above ground telephone terminals, apparatus cases, and cable closures that are located within six feet of any above ground power apparatus. Such bonds shall be made directly to the above ground power apparatus.

Not more than 1,000 feet apart (no point on the telephone cable shall be more than 500 feet from a bond .

BONDING REQUIREMENTS: MORE THAN THREE-FOOT SEPARATION

Where a buried telephone cable is separated by more than three feet from a buried power cable operating at more than 300 volts to ground, the following requirements apply:

Establish and maintain the continuity of the telephone cable shield.

Bond all above ground telephone terminals, apparatus cases, or cable closures to above ground power apparatus that is located within six feet of the telephone equipment.

Note: The National Electrical Safety Code (NESC), Rule 350F states that bonding should be provided between all above ground metallic power and communications apparatus that are separated by a distance of 6 feet or less. (See IL-86/08-031.)

**BSP 918-216-100MP
ISSUE A, July 2003**

Bonding, in addition to that highlighted on page 45 is recommended, but may be subject to economic restrictions. The decision whether to make extra bonds should be made locally by considering the following factors:

- From a safety standpoint, when the separation between completely buried power and telephone cables is more than three feet, there is little chance of a person making accidental contact between the two. Bonding is important, however, between telephone cables and power systems serving the same customer to limit the interchange of current at the customer's location during power fault conditions or during lightning disturbances. In the absence of bonds, fault current flowing from the power neutral to the telephone ground at the customer's location may result in excessive current over the telephone service wire. In addition, large lightning currents flowing between the telephone and power ground at the customer's location have been one of the factors contributing to voltage surges between telephone equipment and power lines at customer locations. These currents can be reduced by placing bonds between power neutrals and cable shields as described for joint trench construction.
- Bonding also lowers impedance to ground and may help to reduce noise. When bonds are specified for noise control, they should be placed at convenient points at or near both ends of the parallel trenches, and at least once every mile.

Cable buried in same right of way with aerial power - Where buried telephone cable is located in the same right of way or easement with an aerial power line operating at between 300 volts and 34.6 kV to ground (60 kV phase to phase), bond all above ground closures and terminals to MGN or secondary vertical down leads that are located within six feet of them.

A bond must not be made to the vertical down lead of a power system lightning arrester unless the vertical down lead also is connected to the neutral of an MGN system.

In addition, the telephone cable shield must be bonded to the power neutral at or near both ends of the exposure, and at least once every mile. Where the aerial power operates at more than 34.6 kV to ground (60 kV phase to phase), the telephone plant may not be capable of safely carrying the associated fault currents. These cases should be referred to the ICEP engineer to determine whether bonding or isolation is preferable.

Bonding methods - Bonds must be made using No. 6 AWG solid copper wire and approved clamps. Convenient bonding locations should be chosen to minimize the length of the bonding wire and to facilitate connection to the power neutral. These locations will generally be at the transformers or at power pedestals where power company employees have access to the power neutral ground wire. Where local procedures have been established, bonds may be made directly to the primary or secondary neutrals at locations other than at transformers and pedestals. These bonds may be required where transformers and/or power pedestals are more than 1000 feet apart.

Figure 3-7 can be used to help determine the protection requirements for buried cable.

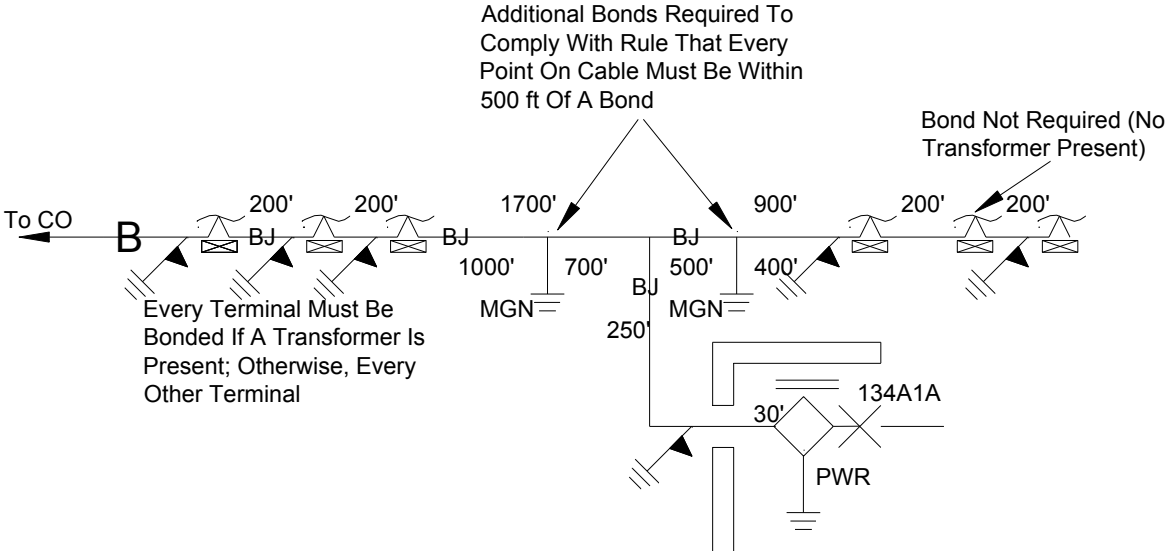


Figure 3-6 – Joint Buried Cable with Less Than a Three-Foot Separation from Power Conductors. Power and Telephone Have Separate Above Ground Fixtures.

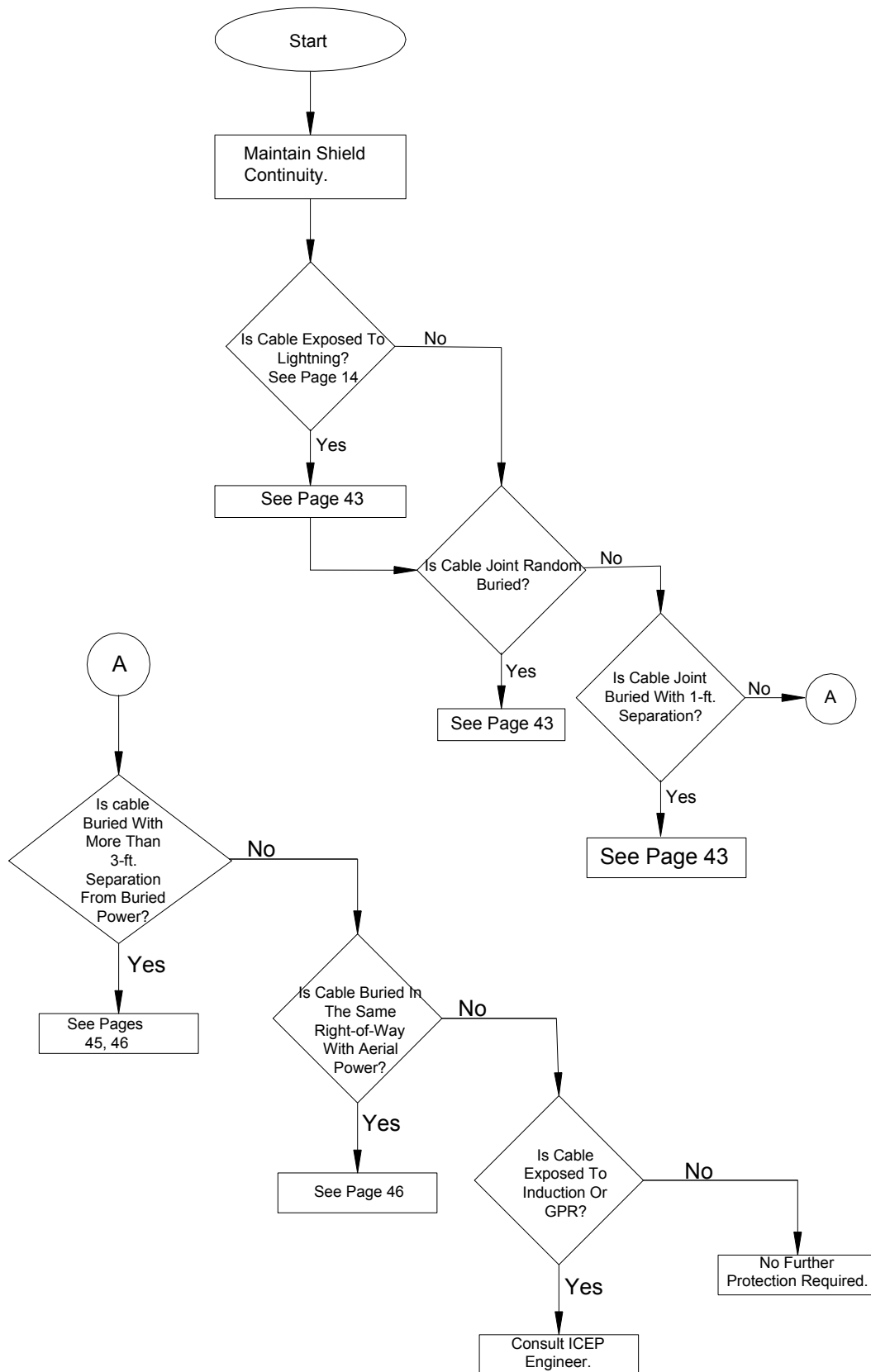


Figure 3-7 – Protection of Buried Paired Conductor Cable

ARMOR-PROTECTED CABLE (Aerial or Buried)

- Maintain continuity of armor.
- Bond armor and cable shield together at each end of armored cable run.
- Ground armor in BEF, CEF, repeater huts, and manholes.
- Bond cable armor to power ground at the same locations required for shield.
- Connections to the armor should be made external to pressurized closures. Bond across pressurized closures with a No. 6 AWG conductor to maintain continuity of armor.
- Bond armor of aerial cable to support strand at least every 1/4 mile.
- Do not ground the cable shield through the armor or its ground wire. However, the armor may be grounded through the cable shield ground connection.

UNDERGROUND PLANT PROTECTION MEASURES

General Measures for All Underground Plant

The following measures provide an acceptable level of protection for most underground plant, and must be applied regardless of exposure:

- Establish and maintain shield continuity in cable.
- Bond together all cable shields and apparatus cases in manholes, and connect them to the manhole grounding system. Plastic sheath and coaxial cables need not be bonded at pull-through manholes.
- To minimize inductive interference, the cable shield must be continuous and well grounded. Where interference is of concern, special attention should be given to sheath grounding (873 Division Practices).

In rural areas where only one or two cables are installed in the underground, excessive lightning-caused troubles may be experienced with alpeh cable. PAP or PASP sheath cable is recommended.

Aerial-Underground Junctions

If an aerial cable exposed to lightning is connected to a single underground cable which extends for 1000 feet or more before paralleling other cables, ground the shield and supporting strand to an MGN vertical ground lead, if one exists. Otherwise, use a telephone company provided driven ground rod.

B. OPTICAL FIBER CABLE PROTECTION

There are many types of construction and configurations used in the manufacture of optical fiber cable. The main distinction from an electrical protection perspective is whether or not the cable contains metallic components. An all-dielectric optical fiber cable, i.e., one without metallic sheath components or metallic strength members and containing no tip and ring pairs, is in itself nonconductive for lightning and electric power currents and therefore requires no electrical protection. However, there may be protection considerations for plant associated with all dielectric cable such as support strands and repeaters in aerial plant or conductors placed with optical fiber cable in buried plant. Optical fiber cable containing metallic components (strength member, moisture barrier, armor or tip and ring pairs) may require electrical protection. Service wire or other metallic cable which has been buried along with optical fiber cable to serve as a means to locate the cable and/or provide a metallic pair facility may also require electrical protection.

AERIAL OPTICAL FIBER CABLE PROTECTION MEASURES

General Measures for All Exposed Aerial Optical Fiber Cable Plant

Apply the following protection measures to all exposed aerial optical fiber cable plant, regardless of the source of exposure:

- Establish and maintain continuity of all metallic components (strength member, shield, moisture barrier, armor) across splices.
- Bond metallic components to the support strand at splice locations.
- Bond together the strands of separate cables at least once every 1/4 mile. Bond together the strands of separate cables at each crossover and at each branch.

Additional Measures for Aerial Optical Fiber Cable Exposed to Lightning

Where exposure to lightning is severe, the support strand should be grounded at 1/4 mile intervals, maximum. Use an MGN ground or secondary neutral, when available, to take advantage of its low impedance characteristics. Do not bond to a lightning arrester down lead unless it is also connected to the MGN. If an MGN or secondary neutral is not available, a ground rod may be used.

Additional Measures for Aerial Optical Fiber Cable Exposed to Power

Apply the following additional protection measures to aerial optical fiber cable that is exposed to power:

- When in joint use with MGN power, bond the optical fiber cable support strand to the MGN as for paired conductor cable. Bond locations are given as a function of the power system voltage in Tables 3-1 and 3-2.
- Verify the I²t capability of the support strand in joint use as for paired conductor cable.
- Place bonds between all metallic cable components and the support strand at least once every 1-1/4 miles.

Bonding intervals greater than 1-1/4 miles are permissible when warranted by compelling economic or operational factors. An examination of the power environment is necessary to determine that induced voltages will not be excessive. Consult your ICEP engineer and BR 876-410-100. Bonds should not be spaced more than three miles apart under any circumstances.

See Figure 3-8 for an example of joint aerial optical fiber cable.

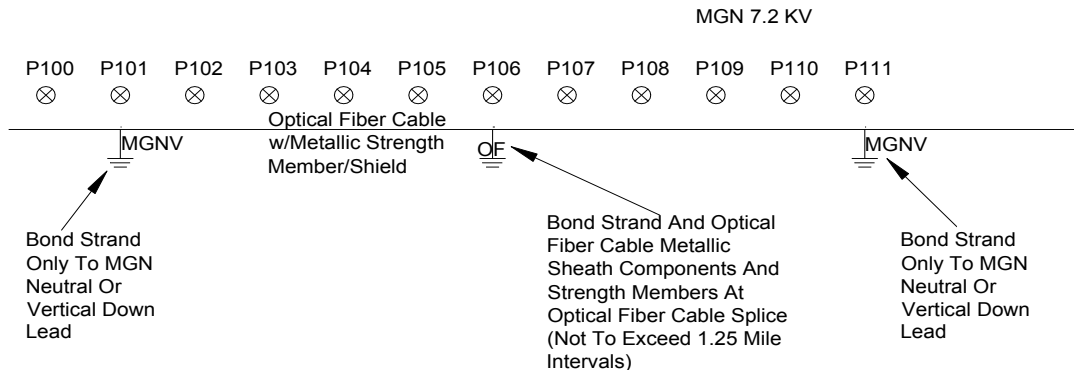


Figure 3-8 – Aerial Optical Fiber Cable (with Metallic Sheath Components and Strength Members) in Joint Use with MGN Power

BURIED OPTICAL FIBER CABLE PROTECTION MEASURES

The following measures apply to buried optical fiber cable facilities occupying a common right-of-way with aerial power and to buried non-joint facilities. Joint installations of optical fiber cable with power having random separation, or separations of less than 3 feet, have not been a frequent occurrence. Protection practices for these installations have not yet been formulated.

General Measures for All Exposed Buried Optical Fiber Cable Plant

Apply the following protection measures to all exposed optical fiber buried plant, regardless of the source of exposure:

- Establish and maintain continuity of all metallic sheath components and strength members in the cable.
- Bond metallic sheath components and strength members to metallic components of repeater housings and cases, closures and pedestals.
- Apply protectors (gas tubes or equivalent) to metallic pairs at talk locations.

Additional Measures for Buried Optical Fiber Cable Plant Exposed to Lightning

Apply the following protection measures to buried plant that is exposed to lightning.

- When buried optical fiber cable is placed in a common right-of-way with power transmission facilities, maintain sufficient distance from tower footings and counterpoise wires to preclude arcing. Consult the ICEP engineer.

**BSP 918-216-100MP
ISSUE A, July 2003**

- When calculated lightning trouble rates for buried optical fiber cable are excessive, shield wires may be placed above the optical fiber cable to reduce the possibility of lightning damage. Consult the ICEP engineer and BR 876-410-100.

Additional Measures for Buried Optical Fiber Cable Plant Exposed to Power

The following additional protection measures apply to optical fiber cable that is exposed to power:

- Bond together all above ground metallic apparatus associated with the optical fiber cable and any above ground power apparatus located within six feet. (This includes an MGN or secondary vertical down lead, conduit, power closure or apparatus cabinet.)
- A bond must not be made to the vertical down lead of a power system lightning arrester unless the vertical down lead is also connected to the neutral of the MGN system.
- Ground optical fiber cable repeaters to the vertical down lead of an MGN power system, to a ground rod, or if necessary to reduce touch potential, to a ground ring established at the repeater location. (See BR 876-410-100.) (Repeaters served by all dielectric optical fiber cable need not be grounded unless required by the presence of ac power service.)

Paired Conductor Cable or Buried Service Wire Placed With All Dielectric Optical Fiber Cable

To minimize the possibility of lightning damage to the optical fiber cable should a paired conductor cable or service wire that has been placed with it sustain a lightning stroke, a minimum spacing of one foot should be maintained. Random placement of optical fiber cable and service wire is to be avoided. At talk wire appearances, ground the cable or service wire shield to the pedestal or other grounded enclosure.

ARMOR PROTECTED OPTICAL FIBER CABLE (Aerial or Buried)

- Maintain continuity of armor
- Bond armor to the support strand at the same locations required for other metallic cable components
- Ground armor in building and cable entrance facilities, at repeaters and closures and in manholes

UNDERGROUND OPTICAL FIBER CABLE PROTECTION MEASURES

The installation of optical fiber cable with power conductors in separate ducts of the same conduit structure, or in joint handholes or manholes should be avoided. When a splice occurs in a manhole, the strength member and other metallic sheath components are to be bonded to the manhole grounding system. Bond all closures and apparatus cases to the manhole ground. No bonding is required in handholes and manholes where the cable is pulled through without a splice.

SPECIAL SITUATIONS

Under certain conditions extra steps must be taken to ensure the electrical protection of paired conductor cable, wire and optical fiber cable plant. These procedures are described in the following publications:

- Increased bonding intervals for optical fiber cable metallic sheath components and metallic strength members, BR 876-410-100
- Sheath grounding where inductive interference is a problem, 873 Division Practices
- Lightning trouble rate predictions for paired cable and optical fiber cable, BSP 876-400-100MP and BR 876-410-100
- Shield wire protection of buried coaxial cables, BSP 876-404-100 Issue 3, March 1976
- Protection of paired facility carrier telephone systems, BSP 876-500-100 Issue 2, June 1978 and Addendum 1, December 1980
- Protection of leased facilities, BSP 876-600-100 Issue 5, January 1967 and BSP 876-601-100 Issue 2, January 1967
- Bonding and grounding of CATV and other communications systems in joint use with telephone plant, BSP 876-400-100MP
- The need for ground rings at repeater locations, BR 876-410-100

4. CUSTOMER LOCATION PROTECTION

Telecommunications cables entering a building should have all metallic components, such as a strength member, shield or vapor barrier grounded. All working and nonworking telecommunications pairs exposed to power and/or lightning that are terminated in a building require protectors. This applies to pairs contained in both paired conductor cable and optical fiber cable. Exposed unterminated pairs within a building must be either grounded or isolated from ground within a closure. Fuse cable or a fuse link is required if the building is served by pairs larger than 24 gauge that are exposed to power contact and fuseless protectors are installed. A conductor is considered to be exposed if the cable or any branch of the cable is exposed. However, where ac powered equipment is located at a customer's location, protectors are required if the power is exposed to lightning, even though the telecommunications cable is classified as unexposed.

Spare pairs contained in a buried service wire that are connected to a distribution cable pair at a service wire pedestal or splice must either be equipped with a protector or grounded. A convenient grounding location is the ground lug of an existing station protector. The number of spare pairs that may be grounded on an existing protector ground lug depends upon the ground wire size and may be determined from Table 4-2, Ground Wire Capacity for fuseless protectors. Buried service wire pairs that are not connected to a distribution pair at a service wire pedestal or splice do not require protectors or grounding at the customer's location.

The National Electrical Code (NEC), Articles 770 and 800, cover the installation of telecommunications facilities at customer locations. The NEC distinguishes between optical fiber cables that contain metallic pairs and those that do not. Those that contain metallic pairs are treated as communications cables as per Article 800; those containing no metallic pairs are treated as optical fiber cables as per Article 770.

PROTECTION MEASURES

General Measures for All Customer Locations Served by Exposed Conductors

Fuse requirements - If the customer's location is served by 19 or 22 gauge paired conductor distribution cable, or by rural or open wire that is exposed to power, a fuse cable (or fusible link) is required between the protector placed at the customer's location and the exposed plant. Where the customer's location is served by paired conductor cable, the fusible link may consist of any of the following:

- A 24 or 26 gauge cable having a minimum length of 2 feet under the cable's shield; or
- The 24 or 26 gauge cable stub of a terminal block or building entrance protector.

The fusible link may be located within the customer's location, provided that it is under the metal shield of a grounded cable. Where the customer's location is served by open or rural wire, a minimum two foot length of block wire located in the outside plant serves as the fusible link.

When a ready access terminal is installed within a building or on an exterior combustible wall, conductors terminated on the connecting blocks must be two gauge sizes coarser than the fuse cable or the fusible link. This is necessary to prevent the fanned-out terminating conductors from fusing, should they conduct sustained power fault currents. The fuse must be located between the exposed plant and the terminating conductors. If the fuse is located within the building or on an exterior combustible wall, it must consist of 24 or 26 gauge metallic shielded and grounded cable.

Where an optical fiber cable containing metallic pairs is exposed to power, a fuseless protector with an associated fuse link is required for each metallic pair. The fuse link may be one of the following:

- The 24 or 26 gauge tip and ring pairs contained in the optical fiber cable
- The 24 or 26 gauge conductors in the input cable stub of a multiple pair station protector
- A minimum two foot section of 24 or 26 gauge, metallic shielded cable placed in series with the optical fiber cable pairs between the power exposure and the customer location (typically at the first splice out if there is no power exposure between the splice location and the customer).

Where the optical fiber metallic cable pairs themselves are to serve as the fuse link, that portion of the optical fiber cable routed within the customer's building should have a full circumferential metallic shield. If not, the cable within the building should be contained in a metallic or PVC conduit appropriate for the purpose.

If a protector stub cable is to serve as the fuse link, the stub cable pairs must be contained under a metallic shield and the protector should have no exposed backplane wiring. The optical fiber cable to stub cable splice should be contained in a fire retardant splice case.

When a fuse link such as a protector stub cable or fuse cable is used, the optical fiber metallic cable must coordinate with the 24 or 26 gauge fuse link conductors. If not, the optical fiber cable pairs must have a full circumferential metallic shield, or be run in a metallic or PVC conduit appropriate for the purpose, where it is routed inside a building.

Electrical protection and a fuse link are required on pairs contained in a service wire or cable that has been buried with an exposed all -dielectric optical fiber cable.

Fusible link requirements for all types of exposed plant are given in Table 4-1.

Fuse cable does not protect a connecting cable from lightning exposure because the operating (time-current) characteristics of fuse cable or a fuse link of any type are such that lightning surges will usually pass through the fuse without operating it.

Table 4-1 - Fusible Link Requirements

Exposed Plant	Fusible Link
Paired-Conductor Cable:	
19 or 22 ga	24 or 26 ga
24 or 26 ga	Not Required
Open Wire	Block Wire
Rural Wire:	
14, 19 or 22 ga (with aerial service wire drop)	Block Wire ¹
22 ga (with 1 Pr. Drop)	Not Required
Urban Wire:	
24 ga	Not Required
Metallic Pairs in Optical Fiber Cable:	
19 or 22 ga	24 or 26 ga
24 or 26 ga	Not Required ²

1. Older types of multiple drop wire (0.027-inch diameter) or block wire must not be used because this wire cannot be protected against fusing on the premises. Available fuse link block wire has approximately the same fusing characteristics as the multiple drop wire and will not provide proper fusing coordination.
2. Optical fiber cable must have a full circumferential metallic shield, or be placed in metallic or PVC conduit, where routed inside a building.

Protector requirements - Fused protectors are required under the following conditions:

Where no fusible link has been provided, as in the following examples:

Drop wire is directly connected to wire terminals mounted on 19-gauge rural wire.

Buried service wire is connected to 19 or 22 gauge conductors of joint random buried distribution cable in encapsulated splices, and the protector is located on an exterior combustible wall or within the building being served.

Drop wire is run more than one span on joint use poles with primary power and is not shielded by a grounded strand.

Optical fiber cable contains 19 or 22 gauge metallic pairs.

The customer's location has battery feed from two or more drop wires.

Note: The above requirements are provided so existing installations of fused protectors can be evaluated. Fused protectors are no longer available.

Fuseless Protectors should be installed in all other cases.

Central office type connectors - Where central office type connectors as described in Section 2 are used at customer buildings, they must be listed by a Nationally Recognized Testing Laboratory. The central office type connector stub must be two gauges coarser than the pairs of the serving cable.

Approved protector grounds - At customer locations the primary protector must be grounded to an approved ground. The power service ground is the first choice for grounding the protector. In new construction, an accessible means for grounding the protector should be provided by the electrical contractor as required by the National Electrical Code. It may be either the exposed metallic service entrance conduit, power grounding conductor, or an external connection provided on the service equipment. In the past, the first choice for a ground has been a metallic water pipe that is connected to a metallic municipal or utility company water distribution system. However, the water system is no longer the first choice as a grounding electrode due to the increased use of nonmetallic pipe, insulating joints, and plastic water meters. Figure 4-1 should be used to select the approved protector ground. When selecting a primary protector ground at the customer's location, also keep in mind that:

- The power service ground and telephone ground must be bonded together.
- The metallic sheath components of a building entrance cable must not be used as the protector ground.
- The ground wire must be kept as short and as straight as possible.
- The proper size ground wire must be used for a given number of protected circuits. Refer to Table 4-2.
- Mobile homes have special bonding requirements. See Special Situations.

In newly constructed buildings, the power system may not yet be installed at the time the protector is installed. In this situation, the protector should be grounded to the best available ground in accordance with Figure 4-1. The builder or customer should be notified to inform the operating telephone company when the power ground is placed so that a return visit can be made to properly ground or bond the protector. When power is on the premises, but the power ground is not accessible, the customer should be requested to have it made accessible so that the protector can be grounded to it.

In Figure 4-1, "power on premises" indicates that the power hardware needed for grounding the protector is in place; the power meter may or may not be installed, and the power service conductors may or may not be connected.

Table 4-2 - Ground Wire Capacity

Ground Wire Size (AWG)	Max. No. Protected Circuits	
	Fuseless	Fused *
No. 12	5	6
No. 10	6	7
No. 6	7 or more	8 or more

Note: The ground wire between protectors shall be the same size as the ground wire between the protector and the grounding electrode.

*Note: : This information is provided so existing installations of fused protectors can be evaluated. Fused protectors are no longer available.

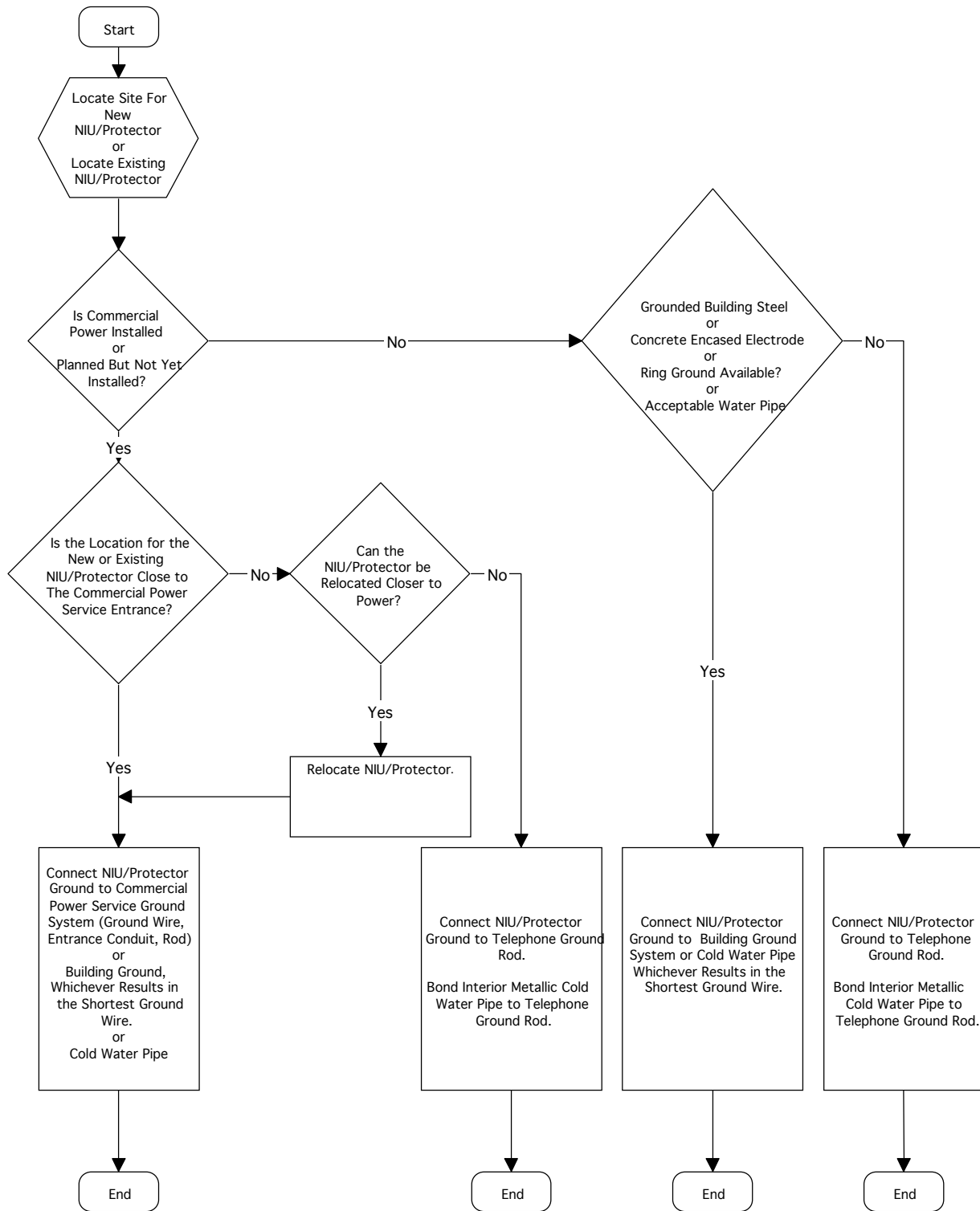


Figure 4-1 – Selecting an Approved Ground (Does not include mobile homes)

Bonding and grounding in buildings served by exposed cable

The metallic sheath components and strength members of cable must be grounded as close to the entrance to the customer's building as practical but not more than 50 feet from the entrance. Protectors must be placed as close as practical to the entrance. In accordance with the NEC, the point of entrance is considered to be the point of emergence through an exterior wall, a concrete floor slab, or from a rigid metal conduit or an intermediate metal conduit as specified in NEC articles 344 and 342 and is grounded to the approved protector ground.

In accordance with the NEC, not more than 50 feet of nonlisted cable (outside plant type cable) may be run beyond the building entrance unless it is contained in metallic or nonmetallic conduit.

All splices in entrance cables containing fewer than 400 pairs and located on the central office side of the protector must be enclosed in a fire retardant splice case. This also applies for the splice of optical fiber cable metallic pairs to a protector stub cable.

Where nonmetallic splice cases are used on cables containing more than 400 pairs, metallic sheath components on the central office side of the splice must be connected to the protector ground terminal or the protector grounding electrode, whichever is closer. This must be done even where the protector is installed within 50 feet of the building entrance.

Where insulating joints are installed inside a building, metallic cable sheath components and strength members must be grounded on the customer side of the insulating joint. If there is more than one entrance cable, bond the metallic sheath components and strength members together on the central office side of the insulating joint with No. 6 AWG copper wire or bonding ribbon. Metallic sheath components and strength members of entering optical fiber cables should be bonded to the shields of entering paired conductor cables. All cables, together with all associated metal (such as capacitors, pressure pipes and bonding ribbon) must be isolated from ground on the central office side of the insulating joint. Insulating joints should be bridged with appropriate capacitors where required for lightning mitigation and power exposure (Figure 2-6).

The protector or protected cable terminal must be grounded to an approved ground in accordance with Figure 4-1 using copper ground wire. The protector ground and the power ground must be bonded together.

Figures 4-2 and 4-3A, B, C and D illustrate bonding and grounding of exposed building entrance cables. Figure 4-4 can be used to help determine the bonding and grounding requirements for exposed building entrance cable, both paired conductor and optical fiber types.

Bonding and grounding in buildings served by drop or buried service wires

Ground the protector to an approved ground (see Figure 4-1). The protector ground and the power ground must be bonded together.

Connect the buried service wire shield to the protector ground terminal.

If the buried service wire is fed from buried cable, bond the service wire shield to the grounding lug at the distribution terminal.

BSP 918-216-100MP
ISSUE A, July 2003

If the buried service wire is fed from aerial cable,

And the length of the service wire exceeds 700 feet, bond the service wire shield to the grounding lug at the distribution terminal.

And the length of the service wire is less than 700 feet, do not bond the service wire shield at the distribution terminal.

If the wire is highly exposed to lightning, follow the protection methods outlined in BSP 460-300-143 Issue 3, April 1978.

Caution: The secondary neutral of an electrical service to dairy farms in rural areas may be deliberately isolated from the primary neutral by the electric utility company. Dairy cows can be sensitive to stray voltages as low as 1/2 volt ac. Separation of primary and secondary neutrals mitigates stray neutral voltages which may adversely affect milk production. Bonding of cable shields and service wire shields to the secondary neutral in such cases could circumvent the intended mitigation. The isolation of these neutrals may be difficult to detect in the field. It is recommended that procedures be established with the electric utility company to identify locations with isolated neutrals and that procedures be established to protect them. Consult the ICEP engineer

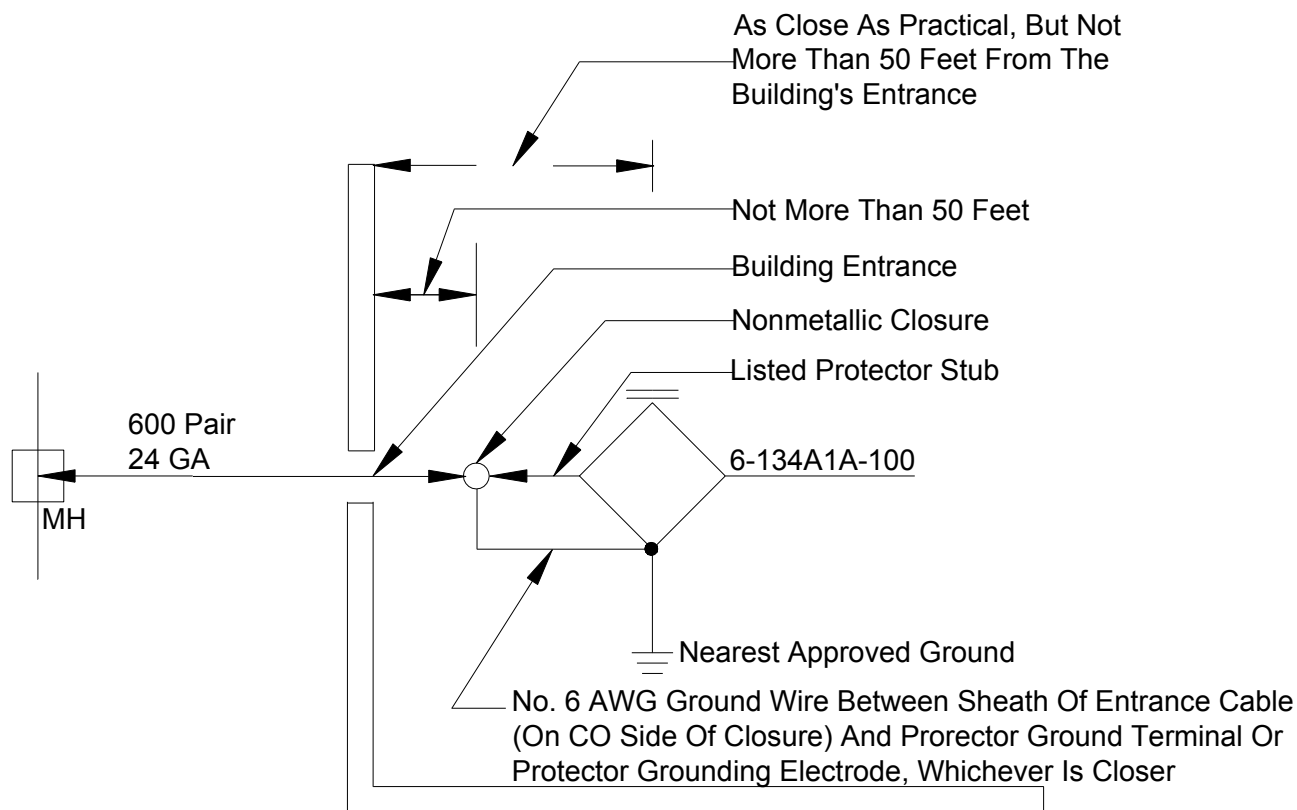


Figure 4-2 – Exposed Building Entrance Paired Conductor Cable with Nonmetallic Closure Installed Ahead of Protectors

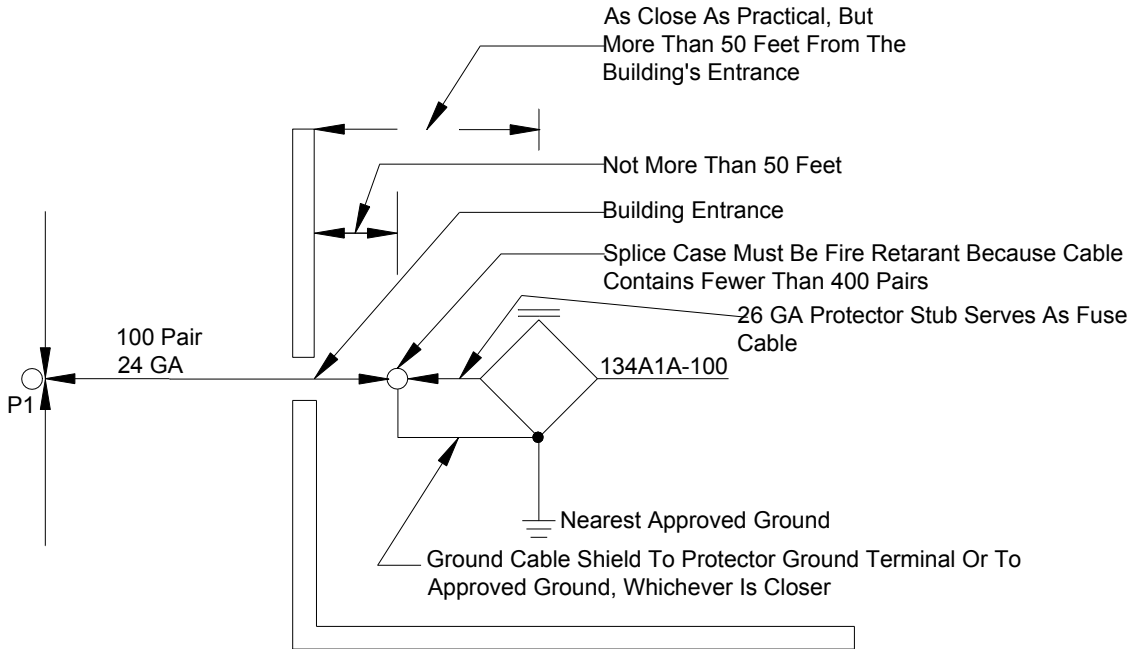


Figure 4-3A – Exposed Building Entrance Paired Conductor Cable with Protector More Than 50 Feet from Cable Entrance Point

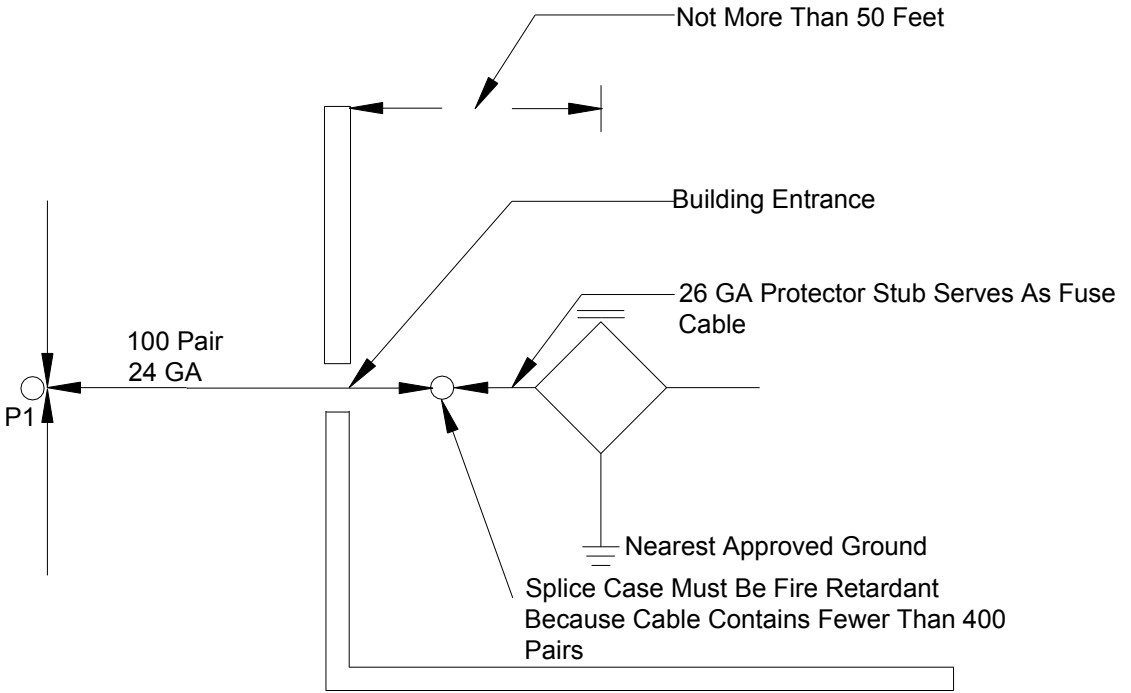


Figure 4-3B – Exposed Building Entrance Paired Conductor Cable with Protector Not More Than 50 Feet from Cable Entrance Point

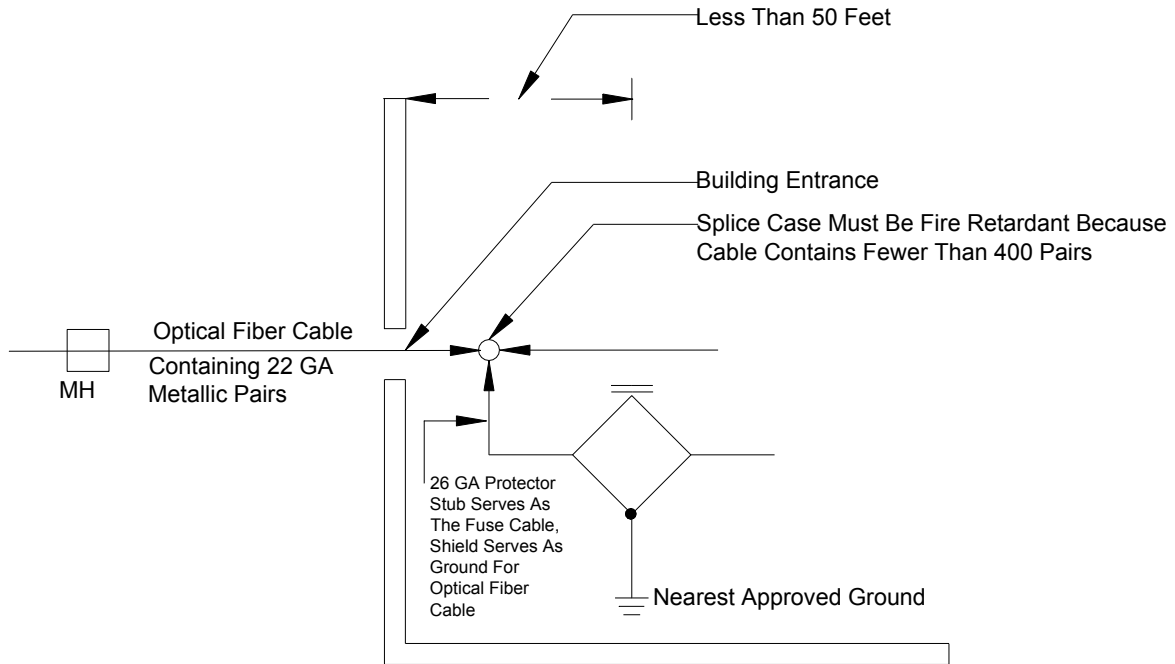


Figure 4-3C – Exposed Building Entrance Optical Fiber Cable with Protector for Metallic Pairs not More Than 50 Feet from Cable Entrance Point

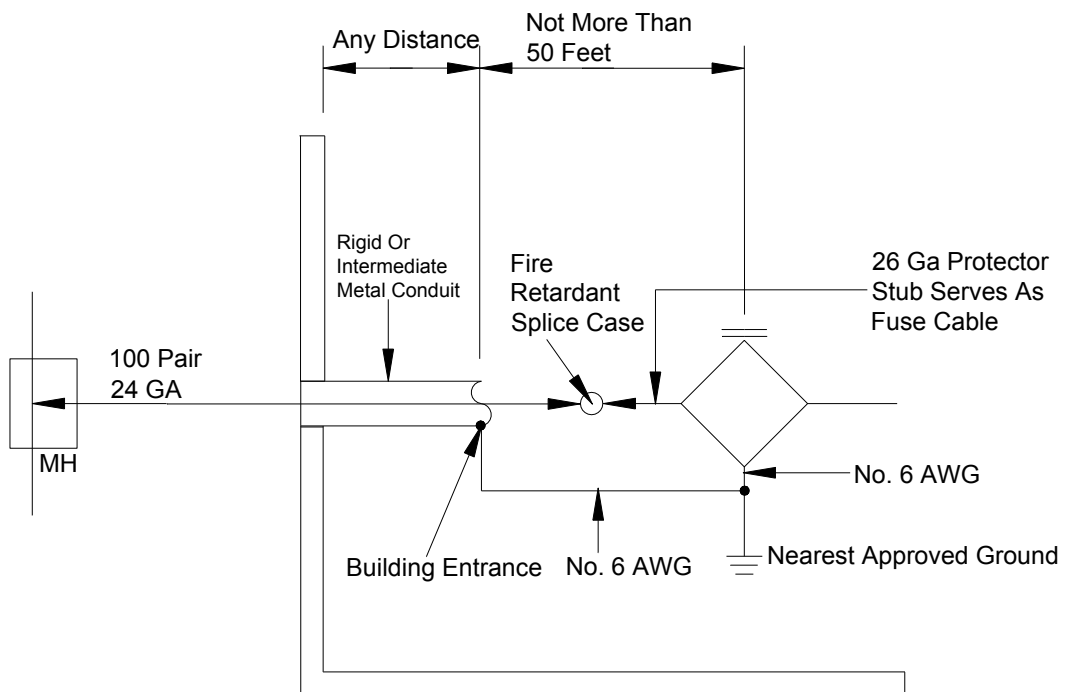


Figure 4-3D – Exposed Building Entrance Cable – Building Entrance at Point of Emergence from Metallic Conduit

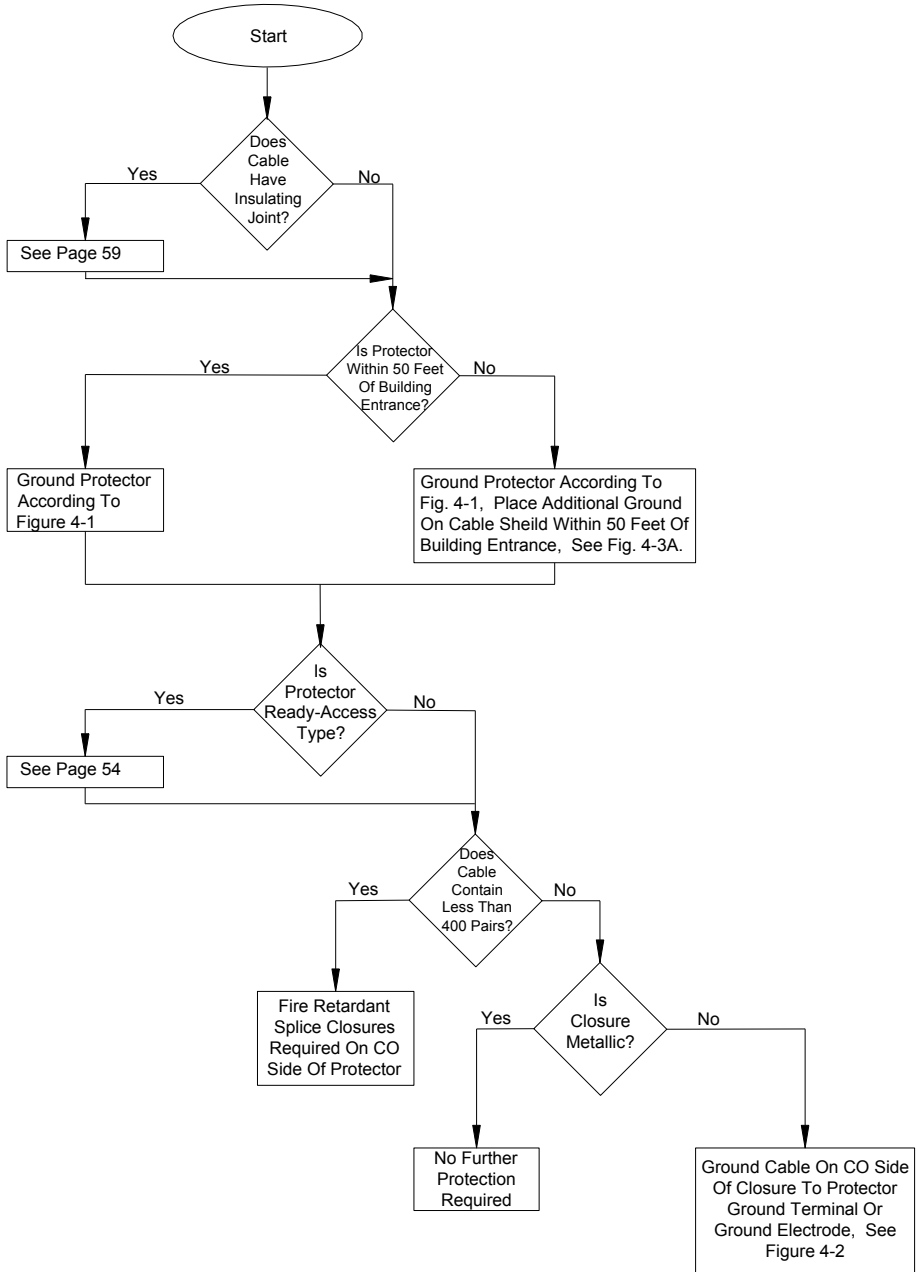


Figure 4-4 – Bonding and Grounding of Exposed Building Entrance Cable

Bonding and grounding in high-rise and low-wide commercial and industrial buildings

In high-rise or low-wide commercial and industrial buildings certain protection measures are necessary if the building is exposed to lightning, even though it may be served by cable classified as unexposed. Certain terminal equipment may be sensitive to lightning surges conducted by the building structure. A building is considered to be exposed to lightning unless it is located within a cone of protection afforded by higher buildings nearby. A high-rise building is a building of steel or reinforced concrete construction that consists of more than three stories. Low structures covering large areas (such as warehouses and shopping centers) are considered to be low-wide buildings.

BSP 918-216-100MP
ISSUE A, July 2003

If service to the exposed building is provided by exposed cable, the bonding and grounding requirements for buildings served by exposed cable also apply. See page 59.

In high-rise buildings:

Where paired conductor riser cables are being placed in a high-rise building, shielded riser cables should be used. If for any reason it is not feasible to use shielded riser cables, run a No. 6 AWG copper ground riser along each unshielded riser cable route. The wire ground riser must be grounded as specified below for the riser cable shield.

Maintain continuity of metallic components, such as a shield for paired conductor riser cable or metallic strength member (and shield, if present) for optical fiber riser cable, over the entire riser cable length. If shielded network terminating wire is used, continuity must be maintained between the cable shield of the network terminating wire and the metallic components of the riser cable.

Metallic sheath components and strength members for riser cables should be bonded to an approved floor ground, using No. 6 AWG copper wire at every point where conductors or optical fibers enter or leave the riser cable. Where pairs enter or leave the cable to feed more than one floor above or below the floor where the riser cable metallic components are grounded, an additional ground for metallic cable components is required on the floor that is fed. The riser cable metallic components must be connected to a grounding terminal in the riser closet, and the grounding terminal must be connected to one of the following approved floor grounds:

- Building steel
- Metallic water pipes
- Power feed metallic conduit supplying panel board(s) on the floor
- The grounding conductor for the secondary side of the power transformer feeding the floor
- the connection to the transformer's grounding conductor must be made by a licensed electrician
- A grounding point specifically provided in the building for the purpose

DANGER: If the approved ground (or approved floor ground) can only be accessed inside a dedicated power equipment room, then connection to this ground must be made by a licensed electrician.

Riser cables, both paired conductor and optical fiber that contain metallic members (including talk pairs), should be run as close as possible to vertical grounded conductors in the central portion of the building. Lightning currents are minimal near the center of the building, and the mutual induction of the riser cable and the vertical grounded conductor limits induced potentials on the talking pairs.

In both high-rise and low-wide buildings:

The metallic components of the entrance cable must be bonded to an approved ground in the building entrance facility (BEF). See Figure 4-1 for guidance in selecting an approved ground.

A suitable grounding terminal must be provided in the BEF and in each satellite closet. If the entrance is protected, the grounding terminal in the BEF must be on the protector or as close to the protector as possible, and must be bonded to the entrance cable metallic components and protector grounding lug with No. 6 AWG copper wire. If the entrance is not protected, connect the BEF grounding terminal to the nearest approved ground (see Figure 4-1) using No. 6 AWG copper wire.

In some cases, the customer may request a coupled bonding conductor (CBC).. A CBC is utilized with paired conductor riser cable to protect sensitive electronic terminal equipment from voltage transients that may occur if the building steel conducts lightning currents. A CBC is not required with an optical fiber cable containing intact and continuous metallic sheath components and/or a metallic strength member. A CBC may be required with an all-dielectric optical fiber cable containing metallic pairs if the pairs connect to sensitive electronic terminal equipment.

General Protection Measures for PBX and Other Customer Premises Switching Equipment

Often a customer requests cable pairs to serve off premises extensions, protection must be applied at both the remote extension end and the customer switching equipment end if the pairs are exposed. In addition, a fusible link is required between the point of exposure and the protector. Off premises extensions exposed only to lightning and served by shielded paired conductor cable of 140 feet or less that is grounded at both ends require no protectors. For protection purposes, an off premises extension is defined as a station that is not located in the same building as the customer's switching equipment.

SPECIAL SITUATIONS

Under certain conditions extra steps must be taken to ensure the electrical protection at the customer premises. These procedures are described in the following Practices:

- Stations located in the vicinity of a power substation, BR 876-310-100MP
- Stations located in power stations, BR 876-310-100MP
- Commercial radio and TV stations, BSP 876-210-100, Issue 4, November 1973 and Addendum 1, January 1978
- Mobile homes and recreational trailers, BSP 461-220-100

REFERENCES

PROTECTION - GENERAL

Practice	Title
BSP 876-100-100,	Electrical Protection – Principles, Issue 9, May 1983
BSP 876-100-102,	Electrostatic Effects Near EHV Power Lines - Description and Mitigation, Issue 1, March 1981
BSP 876-101-100,	Electrical Protection Devices Issue 5, November 1980
BSP 876-101-130MP	Electrical Protection Grounding, Issue A, July 1999
BSP 876-210-100,	Electrical Protection of Radio Stations, Issue 4, November 1973, Add 1, January, 1978
BSP 876-700-100,	Protection Practices – Characteristics and Measurement of Grounds, Issue 3, January, 1967
BSP 876-701 -100,	Protection Practices - Earth Resistivity Measurements – Use of Ground Megger, Issue 1, June 1946

CENTRAL OFFICE PROTECTION

Practice	Title
BSP 876-200-100,	Electrical Protection – Central Offices, Issue 5, October 1983
BSP 916-55-770,	Cable Terminating Facilities – Central Office Type, Issue 10, August 1982

PROTECTION OF WIRE AND CABLE

Practice	Title
BSP 621-205-215,	Erecting Poles – Installing Lightning Protection, Issue 2, December 1968
BSP 623-195-205,	Open Wire - 116-Type Protectors, Issue 1, June 1968
BSP 623-195-210,	Open Wire - 118A Protector, Issue 1, March 1968
BSP 624-070-015,	Clearances for Multiple Line Wire in the Light Loading Area, Issue 1, September ,1963
BSP 624-070-016,	Clearances for Multiple Line Wire in the Medium. Loading Area, Issue 1, October, 1963
BSP 624-070-017,	Clearances for Multiple Line Wire in the Heavy Loading Area, Issue 1, October, 1963

Practice	Title
BSP 624-300-100,	Wire Terminals – Description and Installation, Issue 3, September, 1977
BR 627-020-005	Bonding and Grounding Aerial Plant (Metallic Conductor and Optical Fiber Cable) - General
BSP 629-020-100,	Buried Plant – Installation - Telephone and Power in Same Trench and in Separate Trenches in Same Easement, Issue 4, June 1977
BSP 629-720-200,	Buried Service Wire Terminations, Issue 5, January 1980
BSP 629-720-205,	Buried Plant - Terminations of Buried Wire at Junctions with Buried Plant, Issue 6, November 1978
BSP 633-020-208,	Bonding and Grounding Methods Buried and Underground Plant, Issue 1, October 1982
BSP 876-102-100,	Contacts with Power Circuits - General Aspects, Issue 3, June, 1982
BSP 876-400-100MP	Electrical Protection – Cable, Issue A, December 1998
BSP 876-402-100;	Protection Considerations Multiple Line Wire, Single-Pair Rural Wire and Buried Wire, Issue 2, July 1980
BSP 876-404-100,	Shield Wire Protection of Buried Coaxial Cable, Issue 3, March 1976
BR 876-410-100	Optical Fiber Cable – Electrical Protection - Engineering Considerations
BSP 917-356-101,	Buried Cable Systems - Joint Random Separation, Issue 2, May 1981
BSP 918-117-090	Clearances for Aerial Plant, Issue 4, June 1979
BSP 918-117-099	Power Line Crossings and Conflicts, Issue 1
BR 918-117-103,	Clearance and Separation Considerations for Long Span Joint Use Construction Issue 2, January 1984
BSP 919-120-560,	Power Lines - Grounding or Insulating Guys, Issue 4, December 1981

STATION PROTECTION

Practice	Title
BSP 460-300-950, 1, September 2001	Buried Service Wire (BSW) Bonding and Grounding Requirements, Issue
BR 631-400-102	Cable and Terminal Grounding in Subscriber's Building - General
BSP 876-300-100MP	Electrical Protection At the Customer Premises
BSP 876-310-100MP	Electrical Protection of Wire Plant Communication Facilities Serving Power Stations