Section 876-300-100MP
Issue A, December 1998

ELECTRICAL PROTECTION

AT CUSTOMER LOCATIONS

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ELECTRICAL PROTECTION

AT CUSTOMER LOCATIONS

1. GENERAL

1.01 This Bell Service Practice (BSP) contains the requirements for the electrical protection applied to network telephone facilities at customer locations. "Station protection" is the customary terminology used to describe this protection. Although the SBC Local Exchange Carriers (SBC LECs) no longer have responsibility for the station set or terminal equipment, the term "station protection" will still be used in this BSP to describe electrical protection at customer locations.

1.02 When this BSP is reissued, the reason for the reissue will be contained in this paragraph.

1.03 Station protection is intended to provide primary electrical protection against power contacts and lightning. Station protection also reduces the possibility of damage to the customer's location and the telephone plant. The proper application of protective devices and methods will help considerably in maintaining the reliability of telephone service.

1.04 The purpose of this BSP is to provide SBC LEC personnel with an overall understanding of station protection. This document does not restrict the discussion solely to SBC LEC's electrical protection responsibilities. It presents a comprehensive discussion of station protection.

1.05 An essential part of any protective system is the adherence to good construction and maintenance practices. The possibility of damage resulting from contact with electric power or from exposure to lightning can be significantly reduced where standard clearances are observed and protectors are properly installed and maintained.

1.06 In determining the protection requirements for a particular design of telephone plant, the exposure status with regard to power contacts, induction, ground potential rise, and lightning must be considered. Lightning and power exposure status is related to the environment of the telephone plant, whether the environment is metropolitan, suburban, or rural as defined in BSP 876-100-100. For example, aerial cable in metropolitan and in some suburban areas will generally be exposed to accidental contact with electric power but may be minimally exposed to lightning because of the shielding afforded by overhead power conductors and tall structures. In rural areas, however, aerial cable will most likely be exposed to both electric power and lightning. In rural areas and suburban areas, buried cable will usually be exposed to lightning, and all stations served by the cable will require protection even though there may be no exposure to electric power. Requirements for station protection are sometimes based on administrative considerations and on possible future rearrangements of outside plant construction, particularly with regard to changes in power distribution voltages.

1.07 In general, block and house cable facilities are not exposed to electric power and do not require station protection. If exposure to lightning is a factor, station protection may be necessary. For example, telephone facilities serving extension stations or a PBX may not be subject to contact with electric power but could be exposed to lightning. Such facilities would require protection.

1.08 In the following discussion, the term "fuse cable" generally refers to 26 or 24 gauge copper conductors. The term "fine gauge" or "fuse link" is also used with the same meaning. If the telephone plant consists of aluminum conductors, then 24 or 22 gauge would be considered as "fuse cable". These sizes of aluminum conductors have fusing characteristics comparable to 26 and 24 gauge copper conductors, respectively.

2. FACILITIES REQUIRING ELECTRICAL PROTECTION AT CUSTOMER LOCATIONS

A. National Electrical Code (NEC) Requirement

2.01 The requirement to protect communication circuits is set forth in Article 800-30 of the 1999 NEC* as follows:

*This partial listing of requirements set forth in Article 800-30 is reprinted from the 1999 National Electrical Code, Copyright National Fire Protection Association, Quincy, MA 02269.

> **Protective Devices.** A listed primary protector shall be provided on each circuit run partly or entirely in aerial wire or aerial cable not confined within a block. Also, a listed primary protector shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be exposed to accidental contact with electric light or power conductors operating at over 300 volts to ground. In addition, where there exists a lightning exposure, each interbuilding circuit on a premises shall be protected by a listed primary protector at each end of the interbuilding circuit. Installation of primary protectors shall also comply with Section 110-3(b).
>
> (FPN No. 1): The word "block" as used in this article means a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed, but not any street. The word "premises" as used in this article means the land and buildings of a user located on the user side of the utility-user network point of demarcation.
>
> (FPN No. 2): The word "exposed" as used in this article means that the circuit is in such a position that, in case of failure of supports or insulation, contact with another circuit may result.
>
> (FPN No. 3): On a circuit not exposed to accidental contact with power conductors, providing a listed primary protector in accordance with this article will help protect against other hazards, such as lightning and above-normal voltages induced by fault currents on power circuits in proximity to the communications circuit.
>
> (FPN No. 4): Interbuilding circuits are considered to have a lightning exposure unless one or more of the following conditions exist:
>
> 1. Circuits in large metropolitan areas where buildings are close together and sufficiently high to intercept lightning.
>
> 2. Interbuilding cable runs of 140 ft (42.7 m) or less, directly buried or in underground conduit, where a continuous metallic cable shield or a continuous metallic conduit containing the cable is bonded to each building grounding electrode system.
>
> 3. Areas having an average of five or fewer thunderstorm days per year and earth resistivity of less than 100 ohm-meters. Such areas are found along the Pacific coast.

Location. The primary protector shall be located in, on, or immediately adjacent to the structure or building served and as close as practicable to the point at which the exposed conductors enter or attach.

For purposes of this section, the point at which the exposed conductors enter shall be 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 grounded to an electrode in accordance with Section 800-40(b).

(FPN): Selecting a primary protector location to achieve the shortest practicable primary protector grounding conductor will help limit potential differences between communications circuits and other metallic systems.

2.02 The NEC requirements are primarily based on power contact and lightning exposure. SBC LEC requirements, however, take into consideration all sources of electrical disturbances or exposure, including lightning, power contact, induction, and ground potential rise, and are intended to provide adequate protection.

B. Telephone System Requirements

2.03 Telephone circuits (cable, wire, strand, etc.) that are subject to disturbances from lightning, ground potential rise (GPR), possible contact or induction from electric power circuits in excess of 300 volts rms to ground are classified as exposed. A customer served by exposed circuits, including an exposed line, drop or terminal is classified as an exposed and station protection is required.

2.04 Protection against lightning is achieved by using Telephone Line Protector Units (TLPU) at the Network Interface (NI). Protection against power exposure is achieved by using fusible links between the customer's location and the power exposure in addition to TLPUs at the NI. These protection applications are discussed subsequently in this BSP. It should be noted that all exposed working cable pairs entering the customer's location must be equipped with TLPUs. Exposed nonworking pairs entering the customer's location must be equipped with TLPUs, grounded or terminated in a splice case to confine any possible arcing or electric shock hazard. Nonworking pairs that are not connected through to exposed outside plant cable pairs are considered unexposed.

3. CLASSIFICATION OF TELEPHONE PLANT AND AREAS

A. General

3.01 From an administrative standpoint, it is not practical to consider each line or circuit individually to determine its exposure. The best practice is to establish areas in which all lines or circuits are classified as exposed and require station protection, or as unexposed and not requiring station protection. With the exception of a building or group of buildings having a feeder cable used exclusively to serve stations within the buildings, the entire area of a block should be classified as either exposed or unexposed.

3.02 Station protection as discussed in paragraph 2.04 should be provided initially in areas that appear to be unexposed if the possibility exists that future plant rearrangements or changes to the power system could result in exposure.

B. Telephone Plant Exposed to Power

3.03 All aerial plant (cable shield, supporting strand, or wire plant including distribution wire) is classified as exposed, whether power is present or not, since there is no assurance that power will not be built at some later date. The only exception is when the aerial plant is located within a block.

3.04 Underground or buried plant subject to possible power faults resulting in a rise in ground potential or 60-Hz induction exceeding 300 volts rms to ground is classified as exposed. Buried and underground plant must be classified as exposed if connected to exposed aerial plant. Buried plant must be classified as exposed when placed at random separation in a common trench (joint random) with primary power distribution circuits (over 300 volts rms to ground). Power exposure considerations for buried plant are contained in BSP 876-102-100.

C. Plant Exposed to Lightning

3.05 In general, all telephone stations served by aerial plant are exposed to lightning, with the exception of stations in metropolitan areas where buildings are close together and sufficiently high (relative to the telephone plant) to provide "cone-of-protection" shielding. Two cones overlapping the telephone cable, one from each side, are preferable. (The cone-of-protection principle is explained in BSP 876-210-100). In such situations, lightning strokes are generally diverted from the telephone plant, and surge current is harmlessly dispersed over public water systems and/or other extensive buried metallic structures.

3.06 Underground or buried plant must be classified as exposed to lightning except:

(a) Plant located in a metropolitan area under the conditions discussed in paragraph 3.05.

(b) Plant 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.

(c) Plant located where significant data is available to indicate that lightning damage is negligible.

3.07 Results of systems studies indicate that a short buried or underground cable run having a continuous shield, that is properly grounded at both ends in accordance with paragraph 9.05, may also be considered unexposed to lightning. Such situations may occur within a campus environment or at a remote subscriber loop carrier hut serving a customer's location. When there is no cone-of-protection shielding present, the cable run may extend up to 140 feet without requiring station protectors at each end. The risk of lightning-related damage is no greater than that which would be encountered in the unexposed exception of paragraph 3.06(b).

3.08 The 140-foot length applies to a cable with no cone-of-protection shielding. Where cone-of-protection shielding is present, the permissible length of unprotected cable run between structures affording a cone-of-protection may be determined from Figure 1. Where the cone-of-protection is different at each end of the cable run, the larger of the two cones is used with Figure 1. Consider, as an example, a cable run between two buildings affording 40- and 60-foot cones-of-protection, respectively. Consulting Figure 1 for the larger cone of protection(60 feet) yields a maximum permissible length of cable outside the cones-of-protection of 80 feet. The permissible unprotected cable run length will consist of the 40- and 60- foot cone-protected segments plus an additional 80-foot segment for a total of 180 feet.

3.09 A cable run that is exposed to power will require TLPUs regardless of its lightning exposure status. The elimination of TLPUs based upon lightning considerations must not conflict with our requirements and the National Electrical Code regarding the placement of protectors due to power exposure. Consider, for example, a customer served by a subscriber carrier system utilizing a remote terminal hut located 100 feet from the customer's location. The distribution pairs between the hut and the customer's location are unexposed to power and per paragraph 3.07 may also be considered unexposed to lightning. The outside plant pairs between the remote hut and the CO terminal are exposed to power. Station protection will be required where the distribution pairs enter the customer's location due to the power exposure of the CO to remote terminal pairs.

D. Unexposed Plant

3.10 Plant is considered unexposed when it is not subject to possible contact with electric power operating in excess of 300V rms to ground, rise in ground potential in excess of 300V rms to ground, induction in excess of 300V rms to ground, or exposed to the effects of lightning. Underground or buried cable is not considered exposed to power contact when placed in the same trench with primary distribution circuits if standard separations (not random separation) are maintained and the underground or buried plant is not fed by exposed plant (see paragraphs 3.12 to 3.15).

Warning: When telephone plant is classified as unexposed in an urban environment because it is underground all the way back to the central office and cone-of-protection shielding is adequate, caution is advised if the associated power facilities are aerial without cone-of-protection shielding. Under such conditions, ac-powered telephone equipment may be damaged by lightning surges on the power facilities. Even though the telephone plant is considered unexposed in this particular case, TLPUs should be used, thus providing a method of common bonding and grounding (See paragraph 7.06).

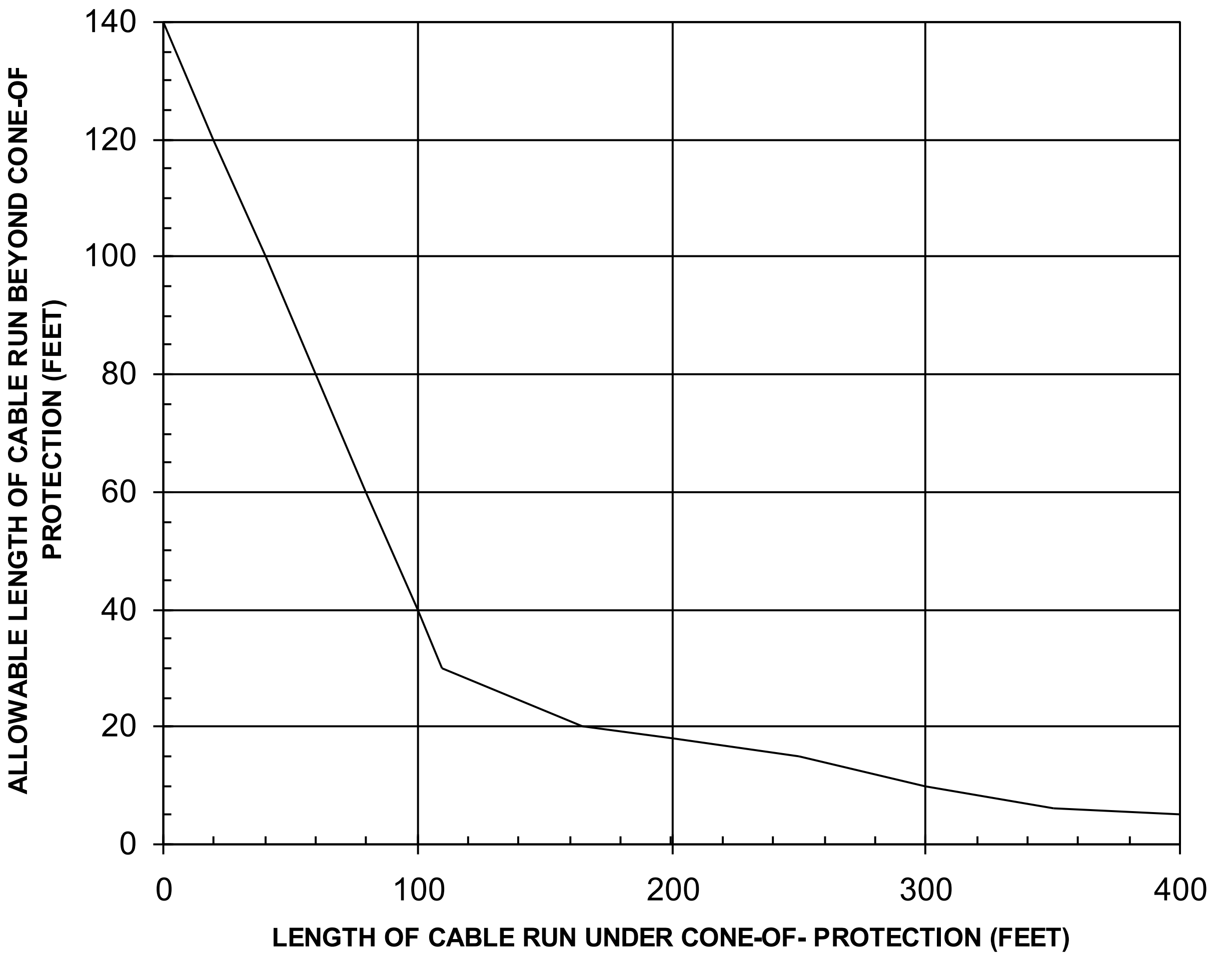


Figure 1 - Allowable Length of Cable Run as a Function of Cone-of-Protection

E. Exposed Cable Shield and Pairs

3.11 In reviewing a particular cable to determine its exposure status or the requirement for protection, it will be helpful to consider the cable in terms of exposed cable shield and exposed pairs. An exposed cable is one which has one or both of the following:

(a) An exposed cable shield

(b) Exposed Pairs.

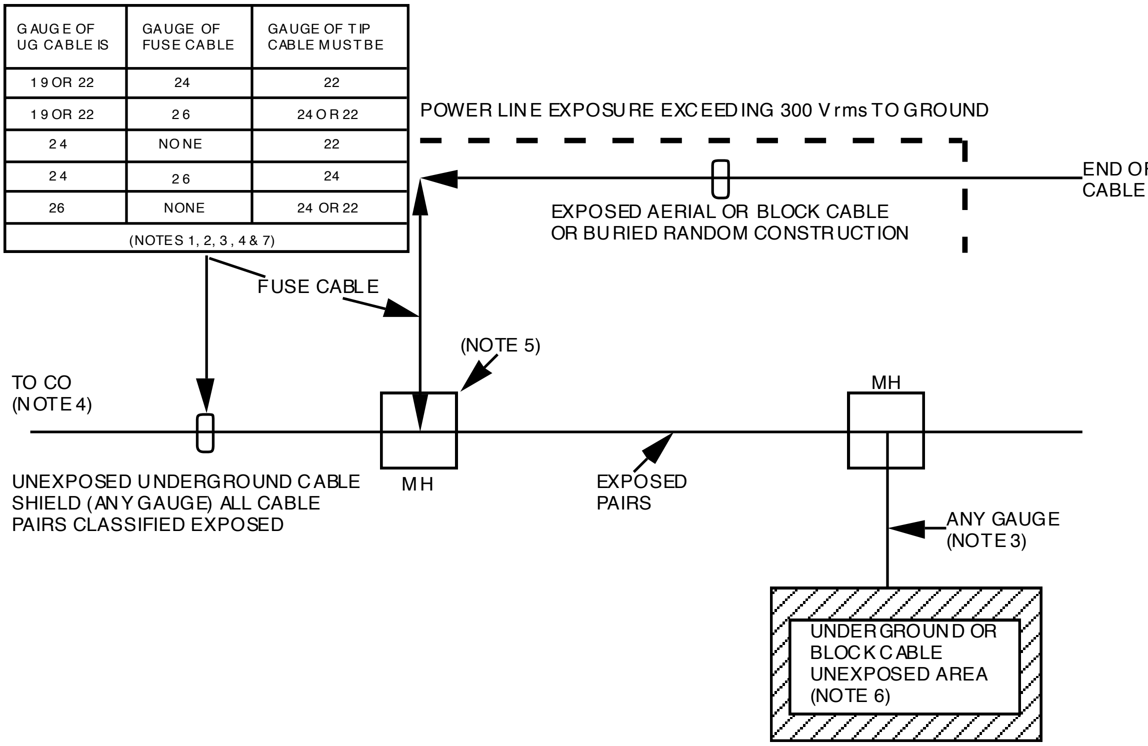
Note: Protection applications must consider all sources of exposure; not only power contact but ground potential rise, power induction, and lightning. Protection against lightning surges is provided by using over-voltage limiting TLPUs. Protection against power exposure is provided by using fusible links in addition to over-voltage TLPUs.

Exposed Cable Shield

3.12 An exposed cable shield is defined as any cable shield that has a possibility of coming in physical contact with power. Standard practice is to place a fuse (fine gauge) cable at the aerial to underground junction (Figure 2) to separate aerial cable exposed to power from otherwise unexposed underground cable. With a fuse cable in all aerial branches of stations directly connected to underground cable, the requirements for fusing are satisfied. However, this does not eliminate the need for TLPUs at the customer's location. If the fuse cable is omitted at an aerial to underground junction, the entire underground cable (all of the cable pairs) must be considered as exposed.

3.13 The purpose of the fuse cable is to prevent the overheating of the TLPUs in the central office and at the customer’s location (resulting from power contact, induction, or ground potential rise of sufficiently high value and duration to operate the protectors). A fuse cable will usually fuse open before the time-current rating of coarser gauge underground cable pairs is exceeded, and it permits maintaining complements of exposed and unexposed pairs in the same cable (Figure 3). Fuse cable may not always prevent damage either to the cable pairs to which it is connected or to other pairs in the same underground cable. 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. BSP 876-101-100 should be used for comparisons of time-current characteristics of some of the commonly used conductors, station protector fuses, and operated TLPUs. The graphical data presented in BSP 876-101-100, Figures 40, 41 and 42 show that cable and wire pairs ordinarily used will fuse open before the time current limit of an operated TLPU is exceeded, thereby mitigating a possible fire hazard at the customer's location as well as at the central office main frame. Accordingly, the location of the fusible links and the placement of station TLPUs must be such that, if a pair is fused open, any hazardous potential remaining on the energized section of the telephone circuit will not endanger the customer or customer's property.

GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2, 3, 4 & 7)		



NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:

   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.

   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM FROM UNEXPOSED UNDERGROUND COMPLEMENT.

   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.

2. WHEN A CABLE CONTAINING BOTH VOICE PAIRS AND VIDEO PAIRS OR COAXIALS IS EXTENDED AERIALLY, ONLY THE VOICE PAIRS MUST HAVE FUSE CABLE. FOR THE PRESENT, THIS REQUIREMENT CAN BE MET BY USING SEPARATE CABLES IN THE LATTERAL TO THE POLE OR STUBS IN THE MANHOLE.

3. IN ADDITION TO THE FUSE CABLE LOCATED AT THE AERIAL TO UNDERGROUND CABLE JUNCTIONS, BUILDING OR BLOCK CABLE MAY ALSO REQUIRE A SPECIFIC COMBINATION OF CONDUCTOR GAUGES TO ELIMINATE A POSSIBLE FIRE HAZARD WHERE READY-ACCESS TERMINALS ARE USED (SEE BSP 638-205-015).

4. ALL PAIRS REQUIRE PROTECTION AT THE C. O.

   THE GAUGE OF THE TIP CABLES MUST BE AT LEAST TWO (2) GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.

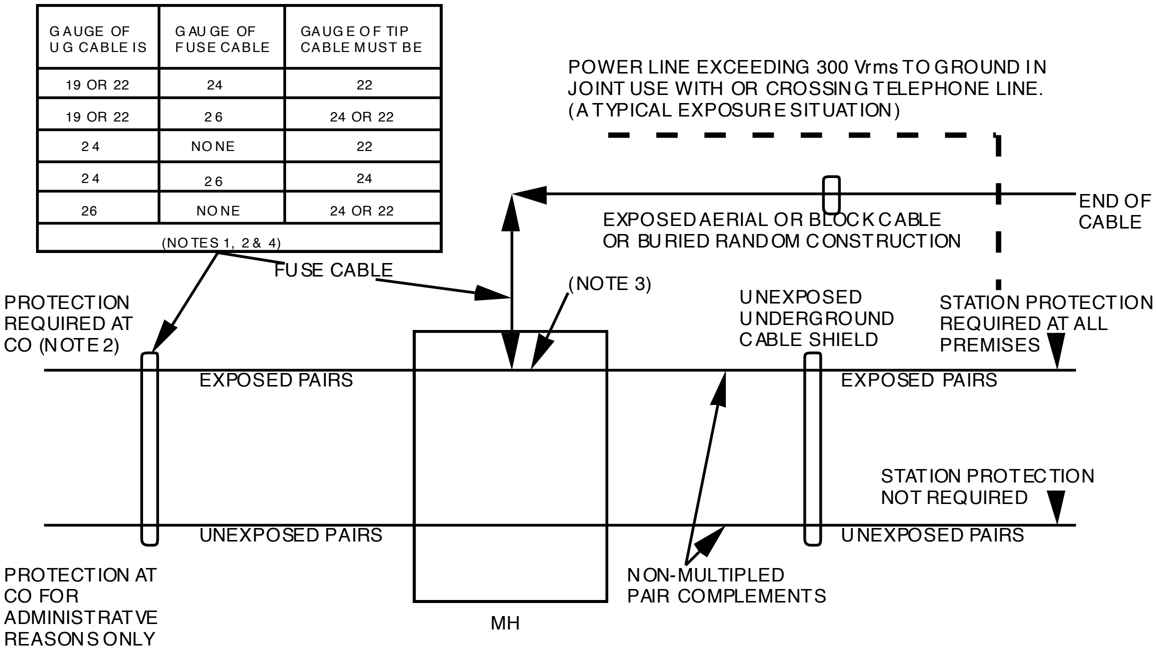
5. FOR LIGHTNING PROTECTION CONSIDERATION, REFER TO BSP 876-400-100MP.

6. STATION PROTECTION IS REQUIRED BECAUSE PAIRS ARE MILTIPLED WITH EXPOSED CABLE CONDUCTORS.

7. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Figure 2 - Underground Cable Containing Only Exposed Pairs

GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2 & 4)		



NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:

   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.

   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM FROM UNEXPOSED UNDERGROUND COMPLEMENT.

   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.

2. THE GAUGE OF THE TIP CABLES MUST BE AT LEAST TWO (2) GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.

3. FOR LIGHTNING PROTECTION CONSIDERATION, REFER TO PBS-500-051PT.

4. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Figure 3 - Underground Cable Containing Exposed and Unexposed Pairs

Exposed Cable Pairs

3.14 All pairs in aerial or block cable exposed to power or lightning are classified as exposed, regardless of whether or not they appear at terminals. These exposed pairs must be protected when they are terminated at the customer's location. Pairs in underground unexposed cable that connect to pairs in exposed cable are classified as exposed (Figure 2 and Figure 3).

F. Examples of Exposed Pairs

3.15 The following examples of exposed cable pairs are typical of situations frequently encountered in the field or in the design of subscriber plant. The examples may be used as a guide in determining the exposure status of cable pairs or the requirements for station protection.

(a) Where underground cables contain both exposed and unexposed pairs (Figure 3), two approaches are available for determining protection requirements.

(1) If most of the cable pairs are exposed, all pairs should be classified as exposed to simplify administration. Protection at the customer's location will then be required on all pairs, and either 26 or 24 gauge conductors will be used to coordinate with fuseless station TLPUs and the central office tip cables (Figure 2).

(2) If both an exposed and an unexposed status are maintained for cable pairs, the fuse cable at the aerial to underground junction must conform to the requirements specified in Figure 3. When these requirements are met, the status of the unexposed pairs remains unchanged and station protection will not be required on these pairs. The combination of conductor gauges prescribed in Figure 3 provides the best protection for exposed and unexposed pairs that can be obtained with existing cables. These requirements should be applied in all new work and, where practical, to rearrangements and changes in existing plant.

(b) Where an underground primary power circuit is brought to a distribution transformer mounted on a pole in an unexposed block area, the exposure status of the area is not changed, providing that the following conditions are met:

(1) The primary electric power conductors are arranged so that contact with telephone plant is unlikely.

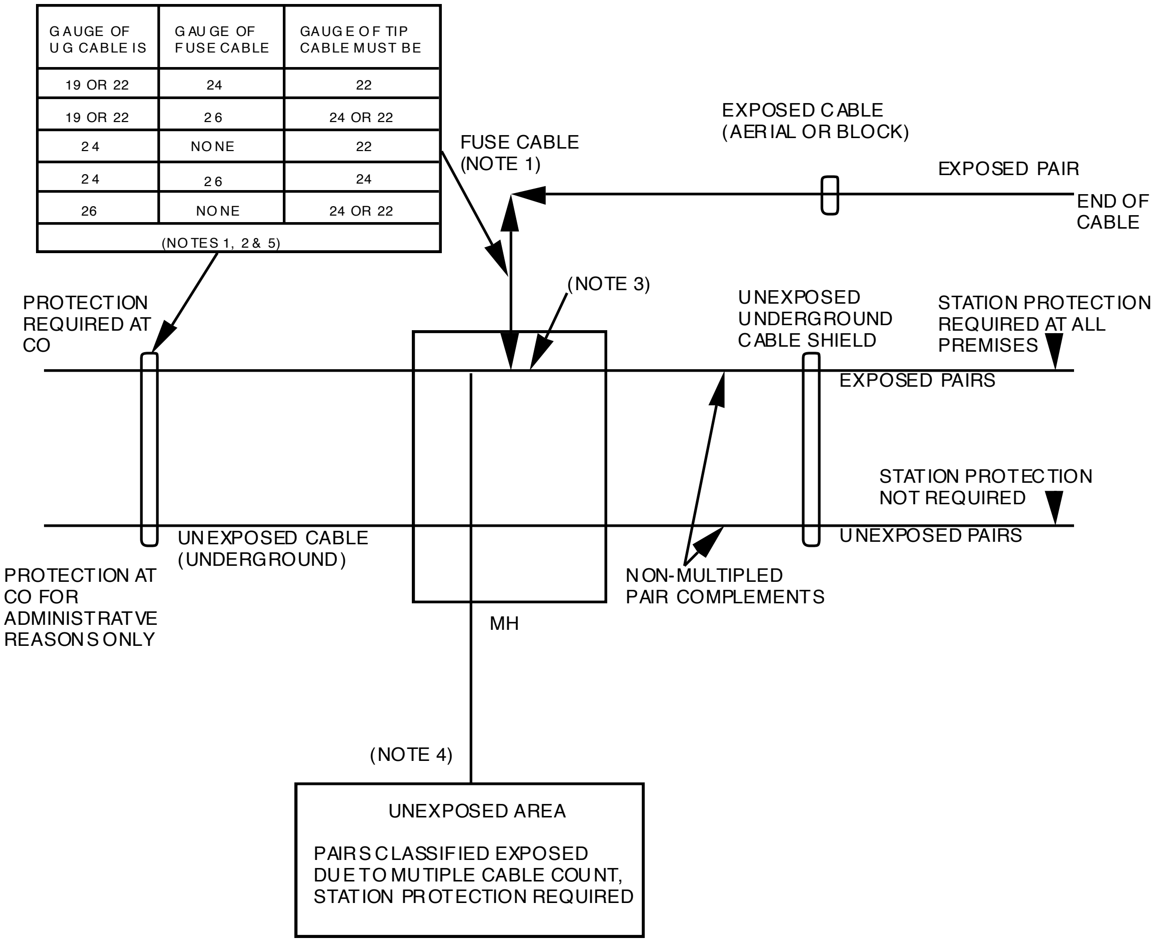
(2) The primary electric power conductors are not extended aerially from the transformer.

(c) Unexposed cable pairs terminating in unexposed areas become indirectly exposed by extending (multipling) them into an exposed area, even though fuse cable is used at the aerial to underground junction, as shown in Figure 4.

(d) The multipling of unexposed cable pairs with exposed cable pairs through cross-connecting facilities should be avoided. Administrative measures should prohibit the bridging of underground cable pairs that feed exposed stations with pairs serving unexposed stations. These measures should also ensure prompt removal of bridge wires on nonworking circuits at the cross connection terminal.

(e) Where both exposed and unexposed pairs appear at a building terminal in an unexposed area, an indirect exposure is created. All pairs appearing in such terminals are regarded as exposed and require station protection as indicated in building B of Figure 5. With this arrangement, adequate protection is ensured for all stations without establishing complicated rules to avoid the transfer of an unprotected station to an exposed cable pair.

(f) Where only unexposed pairs enter a building (as shown in Building A of Figure 5), station protection is not required at the building terminal.



GAUGE OF U G CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2 & 5)		

NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:

    (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.

    (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM FROM UNEXPOSED UNDERGROUND COMPLEMENT.

    (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.

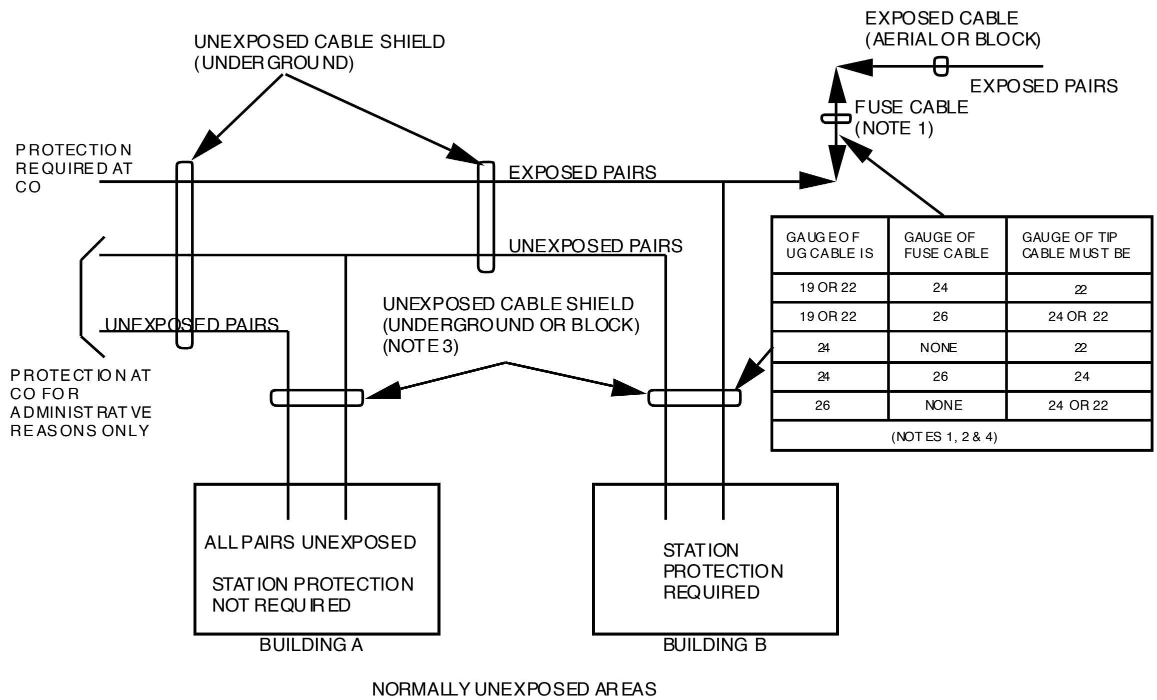
2. THE GAUGE OF THE TIP CABLES MUST BE AT LEAST TWO (2) GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.

3. FOR LIGHTNING PROTECTION CONSIDERATION, REFER TO BSP 876-400-100MP.

4. UNEXPOSED UNDERGROUND OR BLOCK CABLE, ANY GAUGE, EXCEPT WHERE READY-ACCESS TERMINALS ARE USED. SEE BSP 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.

5. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Figure 4 - Indirectly Exposed Cable Pairs



GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2 & 4)		

NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:

   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.

   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM FROM UNEXPOSED UNDERGROUND COMPLEMENT.

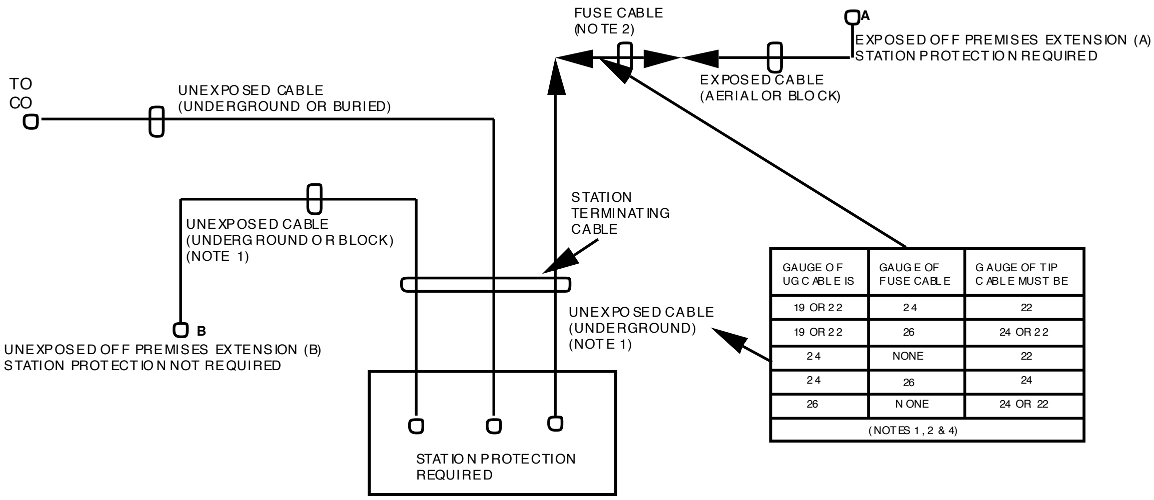
   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.

2. THE GAUGE OF THE TIP CABLES MUST BE AT LEAST TWO (2) GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.

3. AREA B: WHERE READY ACCESS TERMINALS ARE USED, SEE BSP 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.

4. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Figure 5 - Effect of Indirect Exposure on Unexposed Pairs



NOTES:

1. WHERE READY ACCESS TERMINALS OR MAIN FRAME TIP CABLES ARE USED, SEE BSP 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.

2. THE FUSE CABLE IN THIS CASE PROTECTS STATION TERMINATING CABLE OR MAIN FRAME CABLE AND OFF PREMISES EXTENSION (B), BUT DOES NOT PROTECT OFF PREMISES EXTENSION (A) STATION PROTECTORS SERVED BY THE EXPOSED COMPLEMENTS SINCE THE FUSE CABLE IS NOT BETWEEN THE STATION AND THE EXPOSURE. THEREFORE AN ADDITIONAL FUSE LINK IS REQUIRED BETWEEN POWER EXPOSURE AND STATION (A).

3. THE GAUGE OF THE TIP OR TERMINATING CABLE MUST BE AT LEAST TWO (2) SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.

4. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Figure 6 - Indirect Exposure at Station

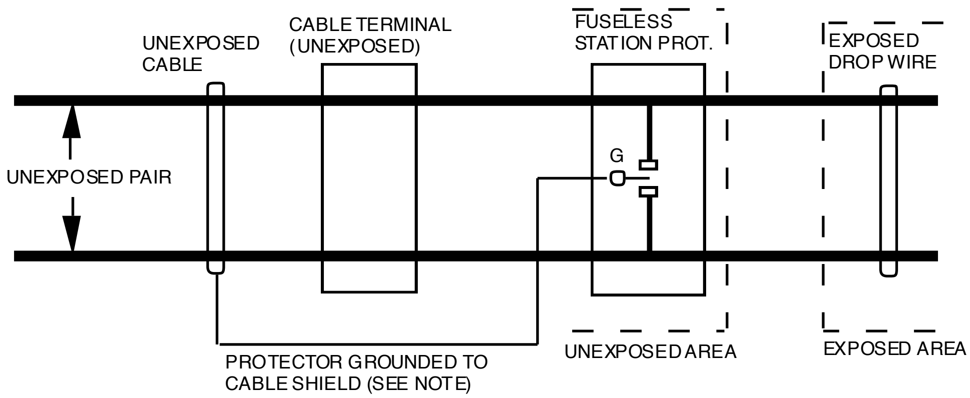
(g) If any exposed cable pairs enter a building, whether or not under the same sheath, all pairs must be protected (see Figure 6). However, if most cable pairs entering a building are unexposed, and there are exposed drops that enter the building, it is not necessary to apply station protection to the unexposed cables, provided the circuits from the drops are protected before appearing in any terminal equipment containing the exposed pairs.

G. Exposed Drops from Unexposed Cable

3.16 When drop wire is run from an unexposed terminal into an exposed area (Figure 7), the cable pairs need not be considered as exposed if (a) a TLPU is installed at the distribution terminal, and (b) the cable shield is effectively grounded.

3.17 With the protection arrangement shown in Figure 7, all pairs in the cable (including those serving the exposed drop wire) can be classified as unexposed. The effectiveness of the protection depends on having the cable shield electrically continuous and grounded. Before station protection is installed, a check should be made for insulating joints and cross-connecting terminals to ensure that there are no shield interruptions. If insulating joints are required for corrosion reasons, they must be bridged with a KS-14595, List 1 or 2 capacitor, or equivalent, to provide a path to ground in the event of a lightning or power surge.

3.18 Where exposed drop wires are served from unexposed cable, protection as shown in Figure 7 should be installed at the location where the exposed drop enters the building.



NOTE:

CABLE SHIELD MUST BE ELECTRICALLY CONTINUOUS TO UNDERGROUND CABLE OR GROUNDED TO AN APPROVED STATION GROUND, SUCH AS THE POWER GROUNDING ELECTRODE.

Figure 7 - Exposed Drop from Unexposed Cable

4. PROTECTORS FOR CUSTOMER LOCATIONS SERVED BY EXPOSED PLANT

A. General

4.01 Information pertaining to the electrical characteristics of TLPUs used at customer locations are contained in BSP 876-101-100.

4.02 There are two general types of TLPUs in use at customer locations: "fused" (equipped with two 7-ampere fuses) and "fuseless". Fused protectors are no longer available. Fuseless protectors are available in single-pair and multiple-pair units for use at indoor and outdoor locations. All fuseless TLPUs used at customer locations are equipped with voltage limiting devices such as carbon block assemblies, gas tubes or solid state elements.

B. Fuseless Protectors

4.03 Fuseless protectors have a much higher current-carrying capacity than fused protectors. In conjunction with the use of fuseless protectors where power exposure exists, a fusible link is required between exposed plant and the protector to minimize any fire or shock hazard at the station in the event of a sustained power contact. The fusible link may be one of the following:

(a) A 24 or 26 gauge cable having a minimum length of 2 feet under a grounded shield

(b) The 24 gauge conductors in a cable terminal stub

(c) The 24 or 26 gauge conductors in the input cable stub of a multiple pair station protector

(d) The 24 gauge conductors of urban wire

(e) Block wire (or equivalent) bridling between drop wire and open wire or rural wire.

4.04 Because of the savings in investment and maintenance expense, fuseless TLPUs should be used at all premises where the fusible element or link described in paragraph 4.03 can be provided.

4.05 Fuseless TLPUs should be used at customer locations served from buried distribution cable that is directly connected to exposed aerial cable, provided either cable has 24 or 26 gauge conductors so located that they serve as a fuse link. This requirement is met if the fine gauge conductors are located at one of the following points:

(a) In the aerial or buried cable at the junction pole (see note)

(b) In the buried cable section between the first pedestal terminal and the aerial junction (see note)

(c) In the connecting block wiring at the pedestal terminal.

Note: A minimum of 2 feet (not including connections) of fine gauge (24 or 26 gauge) cable is satisfactory for protection reasons.

4.06 Only 24 or 26 gauge copper distribution cable should be used in random separation construction with buried distribution closures. This permits the use of fuseless TLPUs. (Fuse links cannot be constructed in a buried splice.) The recommendations to use 24 or 26 gauge distribution cable is made with the view of simplifying administrative procedures and ensuring proper coordination of fusing requirements. The use of 19 or 22 gauge distribution cable in all-buried construction is prohibited unless the fusible element or link described in paragraph 4.03 is in place.

4.07 Fuseless protectors may also be used at all customer locations served by open wire, multiple line wire (19 through 24 AWG), or rural wire (single pair, 14 AWG) subject to the following conditions:

(a) The bridling between aerial drop wire and open wire or rural wire must consist of at least 2 feet of block wire (0.027-inch diameter) fusible link (or equivalent), installed as described in BSP 462-240-200. See Table A for acceptable combinations.

(b) The aerial drop wire must consist of either a single-pair drop wire or aerial service wire of 22-gauge. **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 at customer locations (available fuse-link block wire has approximately the same fusing characteristics as the multiple drop wire and will not provide proper fusing coordination).**

(c) Buried service wire or armored service wire must not be used because a fuselink of block wire will not protect the buried wire.

TABLE A
BRIDLE FUSE COMBINATIONS

PLANT	DROP	BLOCK WIRE BRIDLE FUSE REQUIRED
Open Wire	1 Pair or Aerial Service Wire	Yes
19 AWG Rural Wire	1 Pair or Aerial Service Wire	Yes
22 AWG Rural Wire	1 Pair	No
22 AWG Rural Wire	Aerial Service Wire	Yes

24 AWG Urban	1 Pair or Aerial Service Wire	No
14 AWG CU-S Rural Wire	1 Pair or Aerial Service Wire	Yes

C. Fuse-Type Protectors

4.08 Fused protectors were used when the fusing requirements in paragraphs 4.3 through 4.6 could not be met. When fused protectors are found in use and the fusing requirements of paragraphs 4.3 through 4.6 are met, the fused protector should be replaced.

4.09 A fused protector was also required when it was necessary to run more than one drop or block wire for battery supply. Detailed arrangements using fused protectors for this purpose are described in BSP 160-100-400.

D. Protected Terminals

4.10 With fuseless protected building terminals, it is necessary to have a short length of 24 or 26 gauge protective cable between the exposed plant and the terminal to prevent dangerous overheating of the TLPUs and possible fire hazard within the terminal. Most multipair protected terminals are equipped with either 24 or 26 gauge, metallically shielded, stub cables which serve as a fusible link. Conductor fusing is confined within the shield and reduces the potential fire hazard. Ready-access terminals, however, present a special problem because the PIC cable conductors, terminated on connecting blocks, cannot serve as fusible links without creating the danger of fire within the enclosure. For example, if an exposed cable is 24 gauge and if 24 gauge PIC cable is extended to a ready-access terminal in the building, it is likely that conductor fusing will occur at or near the terminal posts of the protector. Conductors have a tendency to fuse where they are separated, rather than under the shield. This is because conductors within a cable shield are closely packed and pairs adjacent to the wires carrying current help to dissipate the heat. To eliminate a possible fire hazard, the PIC cable terminating on the protected ready-access terminals must be at least two gauges (AWG) larger than the fuse cable. Where a ready-access terminal is installed on the exterior of a noncombustible wall or in a fire-resistant enclosure on the exterior of a combustible wall, 24 or 26 gauge PIC cable in the terminal may serve as the fusible link. Specific applications of fine-gauge protective cable to provide safe fusing arrangements for ready-access terminal installations are described in BSP 638-205-015.

E. Sneak-Current Protection

4.11 Power contacts or induction may result in voltages on the telephone pairs that are below the operating level of the TLPU at the customer’s location. Depending upon the terminal equipment's impedance to ground, these voltages can result in currents which cause overheating of network terminating wire and premises wire. Sneak Current Protection (SCP) in the form of fuses or heat coils is intended to limit these currents, which are too small to operate fuse links, stub cables, or the fuse of a fuse-type protector. Sneak Current Protection devices do not provide lightning protection.

4.12 Sneak current protection was provided in the past for ground start trunks, tie trunk, ringing feeders, and in some cases off-premises PBX extensions. SCP was associated with these specific service types due to the terminal equipment's impedance to ground.

4.13 SBC LECs no longer have information describing the AC fault impedance characteristics of customer owned terminal equipment. Therefore, SCP should no longer be provided in new building entrance terminals. SCP, now provided within customer premises equipment (CPE), will minimize any hazard caused by overheated CPE or premises wiring. All SCP that has been placed in the past should be left in place.

F. PBX Protection-General

4.14 Where exposed cable pairs are extended into buildings, protectors with 26 or 24 gauge conductors in the input stub cable are often used for PBX protection. Where exposed to power, ground start or 1-way DID CO trunks serving PBXs may be equipped with sneak-current protection. In addition, off-premises station interface circuits may also be equipped with sneak-current protection. (See paragraph 4.12)

4.15 When central office type protector connectors that are not listed by a Nationally Recognized Testing Laboratory (such as the 302- or 303-type connectors) are used in subscriber buildings, they must be mounted in a dedicated, enclosed space used exclusively for telephone communications equipment (see note).

Note: All station protectors not located in dedicated equipment rooms must be "listed" by a nationally recognized testing laboratory such as Underwriters Laboratories. Also, all newly approved protector connectors, TLPUs and building entrance terminals must be listed products.

G. Customer Location Electronic Equipment

4.16 Electronic-type station equipment installations, especially those utilizing local ac power, may require special protection and grounding considerations. It is recommended that protection and grounding requirements be reviewed with the customer or the equipment vendor prior to the installation of the network service.

4.17 Typically, a single point ground (SPG) terminal is provided on electronic station equipment. It is the only acceptable point for connection from the equipment to the external protection grounding system. When such a connection is required, access to the SPG should be provided by the customer or the customer's agent at the Network Interface (NI). The protected building entrance terminal's ground may then be brought to the NI and connected to the customer's SPG access at the NI (see RL 83-02-135)

4.18 All talking and signaling pairs associated with electronic PBX and KTS systems that leave the building containing the equipment via exposed facilities must be protected at both ends. If the facilities are exposed to only lightning, then TLPUs are required at both ends. (See paragraphs 3.5 through 3.9.) If the facilities are exposed to lightning and/or power, then TLPUs and fuse links (fuse cable) are required at both ends.

4.19 A coupled bonding conductor (CBC) may be used to connect the SPG to the protected building entrance terminal or entrance cable ground at the building entrance facility. It is a conductor that is closely coupled to the pairs feeding the station equipment. Mutual coupling or transformer action between the CBC and the cable pairs minimizes lightning surge voltages between the station equipment and local ground.

4.20 The SBC LEC portion of the CBC may consist of a continuous cable shield or a No. 6 copper conductor that is tie-wrapped to the house cable and run between the protected building entrance terminal or entrance cable ground and the NI. A termination is provided at the NI for the customer to extend the CBC to the electronic station equipment. A combination of methods may be used in a single installation, e.g., a cable shield from the BEF to the riser closet ground and a No. 6 conductor tie wrapped between the closet and the NI.

4.21 Where a cable shield is used for a CBC, it is imperative to maintain shield continuity. It should be verified that bonds have been constructed using approved hardware.

4.22 As part of the CBC arrangement, all TLPUs located in the same building including those for trunks and off-premises extensions should have their ground terminals bonded to the equipment single point ground terminal (which has been made available to the telephone company at the NI by the customer) and to the approved ground in accordance with the external wiring and spacing criteria shown in Figure 8A or Figure 8B, as applicable.

5. LOCATION OF PROTECTORS

A. General

5.01 The general requirements for selecting TLPU locations are provided in the following paragraphs. These requirements are based on the 1999 NEC.

B. Indoor Stations

5.02 Where TLPUs are placed inside a building that is served by underground or directly buried facilities, it is necessary to select a location for the point of entrance for the serving facilities and the TLPU that is within 20 feet of the point where the power service enters the building. If the serving facilities point of entry cannot be located within 20 feet of the power service's point of entry, then the shield of the serving cable or drop wire must be grounded to the building's grounding electrode system at the point of entry. Also, TLPUs should be located with the idea of limiting the length of ground wire. To ensure that the voltage on the ground wire cannot rise sufficiently to create a hazard, the length of ground wire from the TLPU to the grounding electrode should be as short as possible. Minimizing the length of separate bond wires from the TLPU to the power ground is also important.

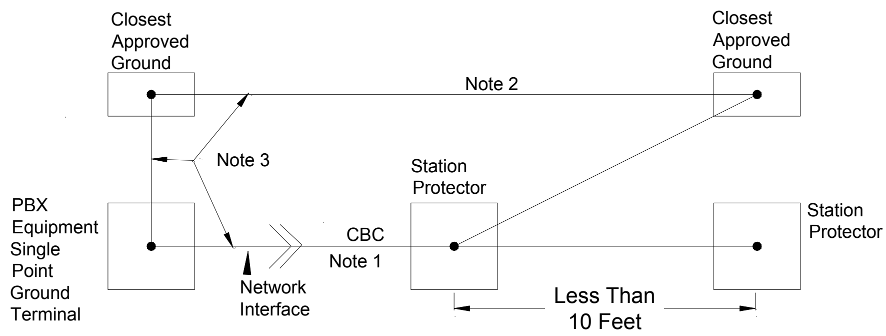


Figure 8A

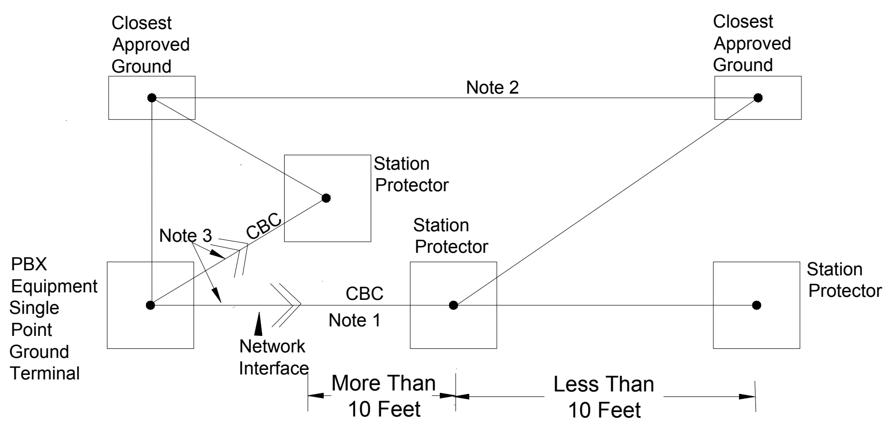


Figure 8B

NOTES:
1. See Paragraph 4.20
2. All Approved Building Grounds or Must Be Common Bonded
3. Customer Provided Ground Connections.

Figure 8 – External Wiring for CBC Protection Grounding and Bonding

5.03 In selecting a location for fused protectors, a compromise between length of ground wire and length of drop conductors may be necessary. In such cases, it is preferable to have the conductors on the line side (CO side) of the protector as short as possible. This is recommended because the line conductors are likely to remain energized for some time after the fuses operate.

C. Outdoor Stations

5.04 In general, outdoor stations served by exposed conductors require standard station protection with the ground connected as specified in Section 7 and must be located as described in paragraph 5.02. Standard TLPUs should be used for many stations (particularly coin telephones, Figure 9) that have in the past been treated as unexposed. For example, TLPUs are necessary because of lightning exposure of aerial power facilities serving the station or booth or because of lightning exposure of the serving underground plant. (Refer to BSP 506-410-400 for treatment of single-slot coin telephones under exposure conditions.) However, some outdoor stations require special grounding arrangements to prevent a possible shock hazard to persons using the telephone. These stations are as follows:

(a) Public Telephones: Metallic outdoor station assemblies, such as booths, drive-up or walkup telephones that have a power supply for lighting, should be grounded as instructed in BSP 508-100-100. At these stations, the telephone set housing and booth structure must be connected to the electric service ground to prevent exposed metal parts from becoming accidentally energized by a short circuit in the internal power wiring. Grounding the station assembly to the power ground ensures operation of the branch circuit fuse or circuit breaker, thereby mitigating a possible shock hazard. Common grounding of power and telephone protection is automatically provided when the station protector ground is connected to the housing assembly of the telephone set or to the booth structure.

(b) Stations on Wood Poles: Where a station served by exposed conductors is to be installed on a wood pole, a location having the best available ground for the TLPU should be selected. The most desirable location is a pole that has an existing vertical ground wire connected to a multigrounded neutral conductor and a grounding electrode. The vertical ground wire should be used for grounding the station protector. Where a vertical run of ground wire is to be established, telephone company personnel may drive a ground rod and run the wire to the top of the telephone space.

At this point, the wire should be bonded to the cable strand and left in a coil of sufficient length for the power company to extend to the multi-grounded neutral conductor. **A station should not be placed on a pole having a power vertical ground wire for lightning protection unless the ground wire is connected to a multigrounded neutral conductor.** The reason for this precaution is to avoid the effects of a rise in voltage-to-ground resulting from the operation of lightning protection devices on the power system.

This condition might present a shock hazard or interrupt telephone service by grounding the TLPU. If an acceptable grounding medium (such as a multigrounded neutral) is not available, the TLPU should be grounded to a station ground rod placed 2 feet from the base of the pole, provided that the station is served from cable. Where the station is served from wire plant (open, rural, urban), the ground rod should be supplemented by a ring of bare #6 AWG ground wire placed approximately 6 inches deep and enclosing the area on which a telephone user would stand.

(c) Stations on Metal Poles: Wherever possible, the use of metal poles for telephone stations should be avoided due to special installation and maintenance measures which may be necessary and increase the cost of the installation. More important, however, is the possibility of electric shock and damage to station equipment, which may be difficult to eliminate. To guard against such hazards, the following precautions must be observed:

(1) Where telephone conductors are unexposed and the power circuits on the metal pole are not in excess of 300 volts rms to ground, station protection or special precautions are not required. (In some cases the presence of power circuits on a single pole may not affect the exposure status of the telephone plant, as explained in paragraph 3.15 (b)). Where exposed telephone conductors are involved, however, the TLPU ground should be connected to the metal pole.

This precaution must be observed in all cases, even though other means of grounding the TLPU are employed. If the metal pole is bonded to a low-impedance ground such as a multigrounded neutral or equivalent, no additional grounding of the TLPU is required. If the metal pole is not effectively grounded, the TLPU ground should be connected to a station ground rod placed 2 feet from the pole. The ground rod should be bonded to the pole near the ground line.

(2) Where a metal pole supports power circuits (open-wire or in conduit) of more than 300 volts (rms) to ground, the telephone station should not be installed unless the pole can be grounded to a multigrounded neutral. Where telephone circuits are exposed, the TLPU ground need only be connected to the pole, which must be bonded to a multigrounded neutral.

6. LOCATIONS REQUIRING SPECIAL PROTECTIVE MEASURES

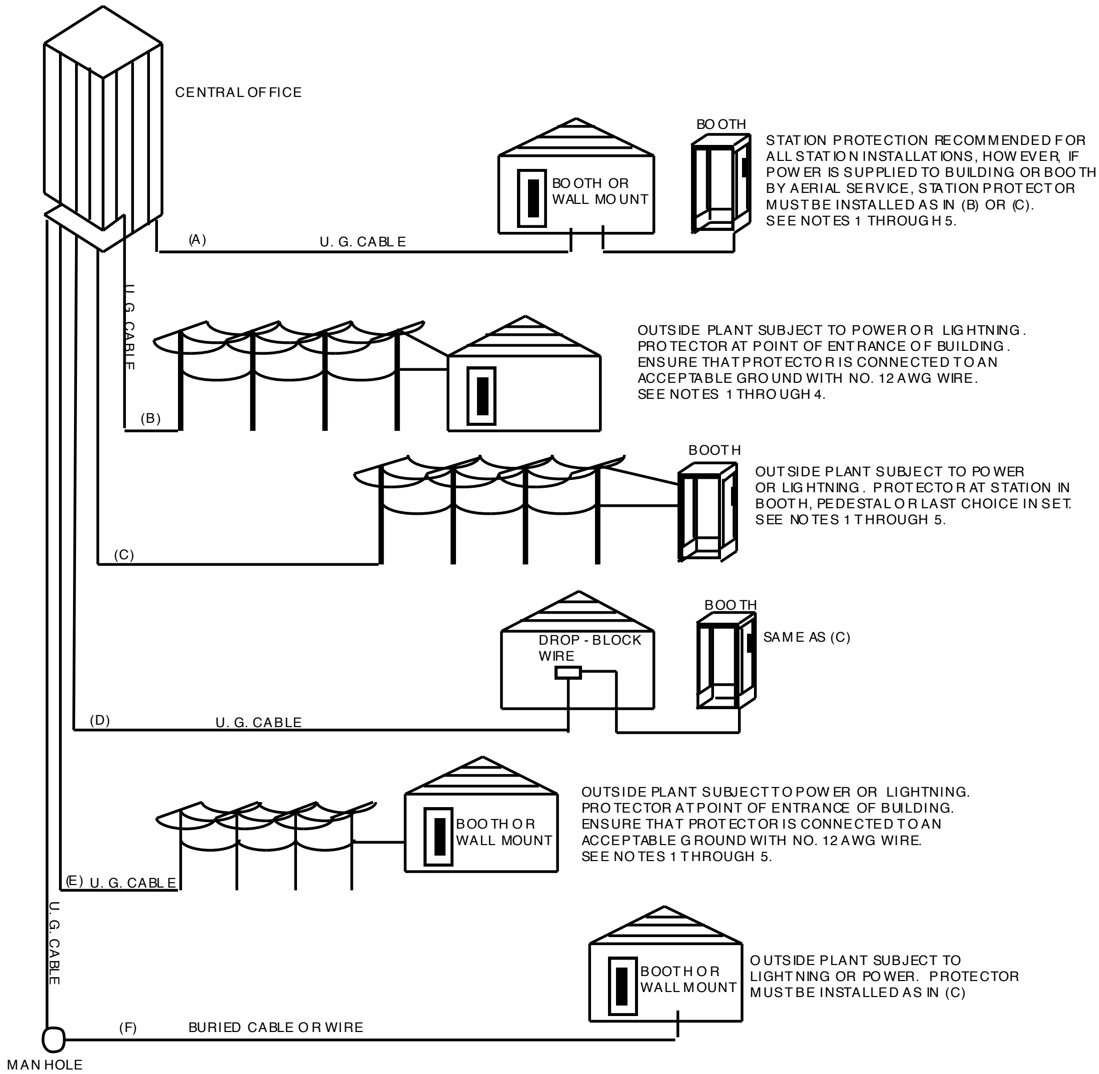
A. General

6.01 Special protective measures are generally required when serving customers located in areas where abnormal electrical disturbances external to the telephone system can create a shock hazard or cause damage to telephone facilities. Locations requiring special protection considerations are as follows:

(a) Power substations, generating stations, co-generation locations or high voltage electric power transmission towers where excessive ground potential rise may be experienced.

(b) Where privately owned communication circuits are connected to telephone company circuits, and the privately owned facilities are in structural conflict or in joint use with power circuits not suitable for general joint use.

6.02 The application of special environmental protective measures at the locations in paragraph 6.01(a) are described in BSP 876-310-100MP. Measures applicable to the situations in paragraph 6.01(b) are described in BSP Division 876, Layer 6 (876-6XX-ZZZ). Described in paragraphs 6.03 through 6.09 are other installations where it is desirable to use special or auxiliary protection so that maintenance of TLPUs may be reduced.



NOTES:

1. FOR ADDITIONAL INFORMATION ON STATION PROTECTOR AND SIGNALING GROUNDS, REFER TO BSP 462-005-100.

2. HOUSINGS OF ALL OUTSIDE STATIONS MUST BE GROUNDED. IF SET IS NOT MOUNTED IN A GROUNDED ENCLOSURE, RUN A NO. 12 AWG WIRE FROM STATION TO NEAREST APPROVED GROUND.

3. CARBON BLOCKS THAT BREAK DOWN PREMATURELY CAN CAUSE FAILURES OF COIN COLLECT OR REFUND. CARBON BLOCKS, IN AREAS OF HIGH THUNDERSTORM ACTIVITY SHOULD BE REPLACED BY GAS TUBE PROTECTORS. SEE SECTION 506-100-100.

4. WHEN THE PROTECTOR IS MOUNTED IN AN ENCLOSURE SUCH AS A BOOTH OR SHELF, BOND THE ENCLOSURE AND PROTECTOR GROUND TOGETHER WITH NO LESS THAN NO. 12 AWG WIRE. SEE BSP 508-100-100.

5. WHEN PROTECTOR IS MOUNTED INSIDE SET, CONNECT WIRING PER THIS SKETCH.

6. UG MEANS UNDERGROUND.

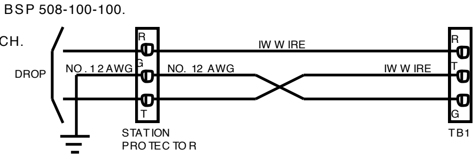


Figure 9 - Coin Telephone Protection Requirements

B. Power Substation Vicinity

6.03 Careful consideration should be given to the problems and consequences of serving subscriber locations located within the influence of a power station ground grid. For example, if a residential development or an industrial or business complex is affected, and there is extensive grounding of carbon blocks, the Network Interfaces in the area should be equipped with gas tubes. When ground potential rise exposure magnitudes are large and when the dielectric strength of the serving facilities could be exceeded (affecting service reliability), high voltage protection may be required. Telephone cable serving a power station or other high ground potential rise location should be dedicated to that purpose. Other subscribers within the influence of the same power station should be served, when necessary , by a separate cable or, as an alternative, the splice point from a common cable serving the power station and other subscribers should be made at a sufficient distance from the power station so that ground potential rise limits will coordinate with requirements of the power station communication services. BSP 876-310-100 should be consulted for protective measures, cable splicing, and grounding requirements if these exposure conditions are encountered.

C. Remote Locations

6.04 Telephone stations are sometimes bridged on circuits of trunk open-wire lines and are called "toll stations." These stations and remote rural subscriber stations may serve fire warden towers, airports, etc., where continuity of service is very important. At such stations, lightning exposure may be severe, and prompt maintenance of service is often difficult because of the remoteness of the location. To improve the maintenance at these highly exposed stations, carbon block TLPUs should be replaced with gas tubes.

D. Radio Transmitting and Receiving Stations

6.05 Protection considerations for telephone facilities at radio stations are described in BSP 876-210-100.

E. Mobile Homes and Recreational Vehicles

6.06 The metallic structure of mobile homes, as well as the environment of their location (often in trailer parks having nonstandard power wiring and where acceptable water pipes do not exist) require some special protection measures. The preferred location for the Network Interface is adjacent to the power service that feeds the mobile home. This will limit the length of the TLPU ground wire or the bond wire between the TLPU and the power where they are grounded to separate electrodes. This is based on the assumption that the power ground is usually the best available ground. In addition, a separate bond wire may be required between the TLPU ground and the chassis of the mobile home. Protection and grounding requirements for mobile homes are covered in BSP 461-220-100. Telephone service and protection and grounding requirements for recreational vehicles, such as camp trailers, camper trucks, and motor homes differ from that of mobile homes and are covered in BSP 461-220-101.

F. Docks and Boats

6.07 Electrical protection of telephones located on boats or on docks requires some special treatment because of the environment at these locations. Good grounds normally are not available on docks, because acceptable metallic pipes or power conduits do not exist. Water pipes and conduit are either wholly or partially of plastic. This also makes bonding to other utilities impossible on the dock.

6.08 Because of these factors, it is recommended that TLPUs for all of the stations served from the dock be located on land near the end of the dock and adjacent to the power service equipment that feeds the dock. In some cases, this could be within a nearby building. This will permit the TLPU to be grounded to the power service ground as a first choice. If the protector cannot be located near the power service, or the power ground is not accessible or not present, the TLPU should be grounded to a telephone ground rod. This is not intended to prohibit grounding or bonding to other approved electrodes. For instance, metal pipes or bulkheads that extend into the water are suitable grounding electrodes. However, it is recommended that these be used to supplement the telephone ground rod and not as the only source of ground.

6.09 Where signal ground is required at the station, it should be provided via the shield of the service wire or cable. Shield continuity should be maintained between the remote cable termination by the station and the TLPU ground. Bonding or grounding should not be attempted either on the dock or in a boat. Connecting the ground (yellow wire) to boat ground would defeat the isolation between boat ground and shore power ground which is deliberately maintained in some boats as a corrosion protection measure.

7. STATION PROTECTOR GROUNDING AND BONDING

A. General

7.01 If telephone equipment and wiring are isolated from ground (earth) and from metallic or grounded structures such as gas and water pipes, heating systems, power conduit and wiring, and other communication facilities, abnormal voltages may develop on these systems as a result of power or lightning disturbances. The voltage differences that may exist between the various structures are equalized or limited by common bonding and grounding to reduce shock hazard and to prevent arcing and damage to equipment or property.

B. Effective Station Grounding Systems

7.02 The equalization of voltage differences between the telephone conductors and the power ground system is achieved by grounding the station protector to the power service ground. The effectiveness of any telephone station power ground system is a function of the surge impedance (rather than resistance) of the entire grounding system. The potential difference between telephone equipment and other objects bonded to the power grounding system depends primarily upon the surge impedance of bonding and grounding conductors through which surge currents pass and which are not common to the two systems. Since the resistance of the bonding and grounding conductors is small, it can usually be neglected when calculating surge voltages in bonding systems. The potential difference between the two systems (V_F) is approximated by the following expression:

Where:

$$V_F = L_G * \ell \frac{di}{dt}$$

L_G= Self-inductance of the bonding or grounding conductor in Henrys per foot

ℓ= Distance from end to end of the bonding or grounding conductor in feet

di/dt = Rate of change of current in amperes per unit of time in seconds.

7.03 The following discusses the practical application of the above expression. Refer to BSP 876-101-130MP for a list of references and extensive discussion of grounding theory, impulse characteristics of grounds, effective grounding systems, self-inductance and surge impedance.

7.04 Figure 10 illustrates the transient voltage relationships that exist when a telephone protector is discharging lightning current. Assume that lightning either strikes the drop or the associated plant in the vicinity of a customer's location. Some portion of the total stroke current will discharge through the protector gaps and flow on the grounding conductor through the connection to the power service ground at point **b**. Ultimately this stroke current reaches earth via the neutral grounding conductor and the buried section of water pipe. The voltage **V** produced by current **I** flowing on the noncommon portion of the bonding system between points **a** and **b**, will appear between the telephone set and the power equipment enclosure. Another source of extraneous longitudinal potential that can appear in the vicinity of a telephone set is from lightning surges entering the premises over the power service conductors and producing a potential drop in the neutral grounding conductor between points **b** and **c**. Since no current flows in the station protector ground lead between points **a** and **b**, there will be no difference in potential between grounded power appliances and the telephone. However, a voltage difference may exist between the telephone and the metallic water pipe. The magnitude of such voltage is a function of the length of the power neutral grounding conductor, over which we have little control.

7.05 To obtain some quantitative feel for the magnitude of inductive voltage likely to develop when stroke current enters a station conductively, consider the voltage **V** which develops in the protector ground lead between points **a** and **b**. The discharge voltage developed in the protector and mounting will supplement the potential drop appearing in the ground path. Under heavy current discharges, the drop across the protector may equal that of its initial sparkover. Referring back to the formula in paragraph 7.02, assume the following conditions:

(a) The simplified waveshape of lightning stroke current from Figure 11 (di/dt) at the station is 1000 amperes/microsecond.

(b) ℓ = length of conductor from **a** to **b** = 10 feet

(c) L = 0.4 X 10^{-6} Henrys/foot self-inductance (an approximate figure for telephone work due to mutual impedance effects of nearby conducting objects).

The voltage may be calculated as:

$$V=(0.4*10^{-6})*(10)*(1.0*10^{3}/10^{-6})=4{,}000 \text{ Volts}$$

7.06 The calculation in paragraph 7.05 shows the voltage that might appear between components of the subscriber's telephone set and a grounded power enclosure (**V**, Figure I0) would be about 4000 volts on the front of the surge. Although this voltage is rather high, it exists for a very short interval of time (approximately 10 microseconds). This example demonstrates why effort should be made to avoid long ground leads in the planning of a subscriber installation. Ideally, power and telephone should enter the premises at approximately the same point to minimize the length of the grounding conductor.

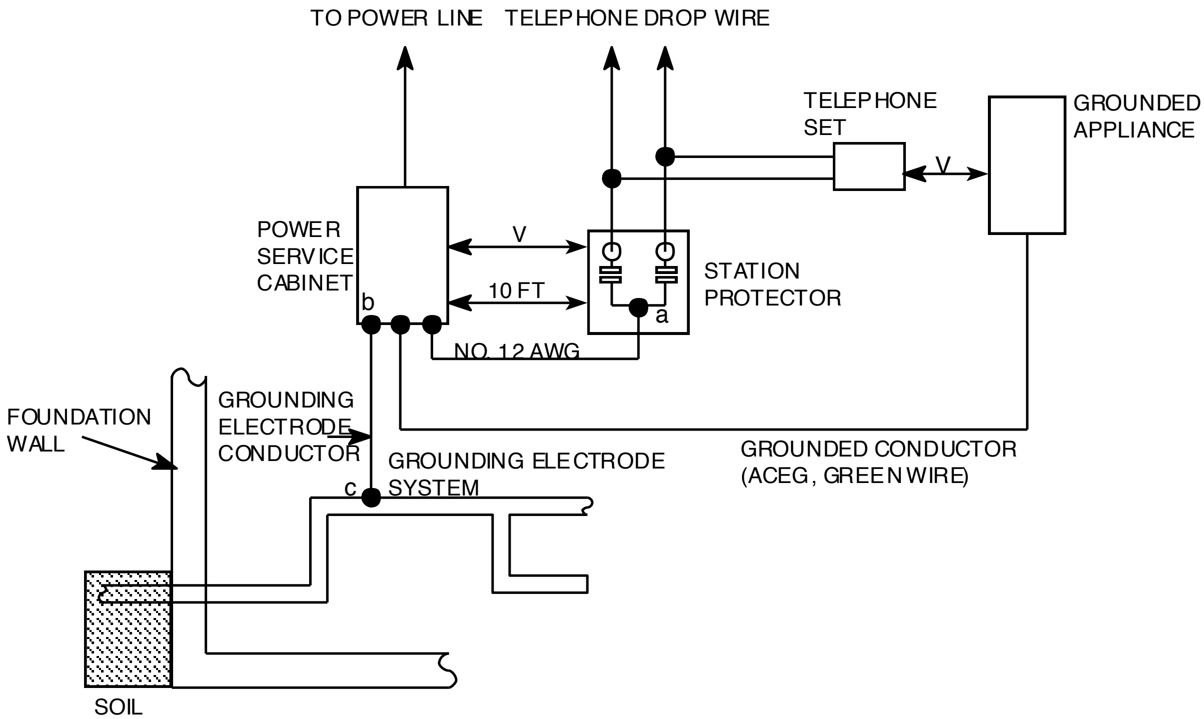


Figure 10 - Customer Location Protection Example

C. Hazard of Separate Grounds

7.07 If unbonded or separate grounds were to be used for telephone and power, a difference of potential could develop between the two systems which may exceed the dielectric strength of the terminal equipment. This situation could expose the user to electrical shock and the equipment to damage. For example, in telephones employing 60-Hz power for the dial light, the transformer is exposed continuously to voltage differences between the primary winding associated with the power source and the secondary winding connected to telephone wiring. The prevention of electric shock and station damage demonstrates the need for common grounding to equalize or limit hazardous voltage differences.

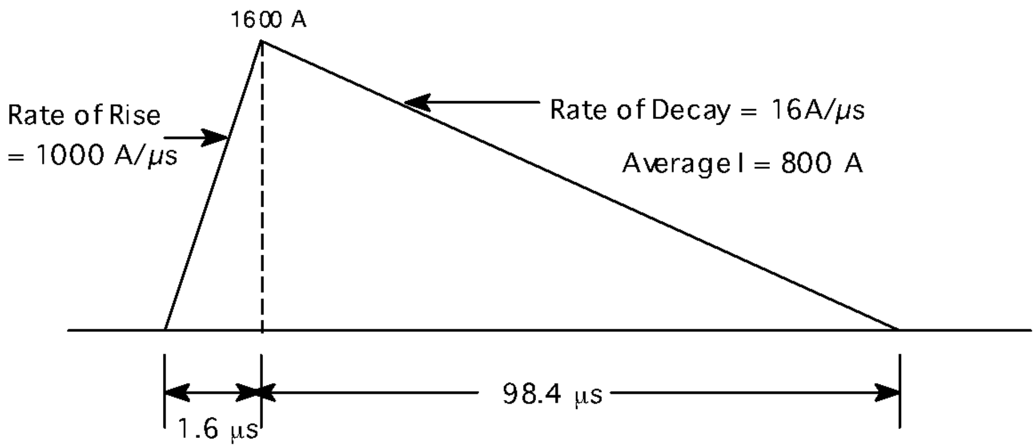


Figure 11 - Simplified Waveshape of Stroke Current in Station Ground Lead

D. Selection of Grounds

7.08 The building entrance facility protector must always be connected to an approved ground via the shortest and straightest practical route (see BSP 631-400-102). Figures 12 through 14 illustrate methods for selecting an approved protector ground.

7.09 The increasing use of nonmetallic underground piping (such as those made of plastic or concrete) have made both public and private water systems substantially less reliable as grounds. New construction very often uses plastic underground piping and existing metal systems are often repaired, replaced, or altered using plastic piping. The NEC now recognizes this fact in Article 250 covering grounding of power services and Article 800 covering grounding of communication protectors. Water pipes are no longer the first and only choice as a grounding electrode. The NEC requires the bonding together of all available electrodes into a grounding electrode system and the preferential choice for grounding the power is to any point on that system. The system consists of a bonded assembly of all of the following electrodes if available at the premises or structure:

(1) The metal frame of a building where effectively grounded.

(2) "An electrode encased by at least 2 inches (50.8mm) of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 20 feet (6.1m) of one or more steel reinforcing bars or rods of not less than 1/2 inch (12.7mm) diameter, or consisting of at least 20 feet (6.1 m) of bare copper conductor not smaller than No. 4 AWG."

(3) A buried ground ring described in the NEC as follows:

"A ground ring encircling the building or structure, in direct contact with the earth at a depth of not less than 2-1/2 feet (760 mm), consisting of at least 20 feet (6.1 m) of bare copper conductor not smaller than No. 2 AWG. "

(4) A metal underground public or private water pipe with at least 10 feet of metal pipe in direct contact with the earth.

7.10 The first choice for a station protector ground is the nearest accessible location on the power grounding system as indicated in Figure 12. For new construction, the NEC, in Article 250-92(b) requires an accessible means be provided (as part of the power service installation) for bonding and grounding other systems (such as the telephone) to the power ground. This may consist of the following:

(a) A metallic service entrance conduit

(b) A power grounding conductor

(c) An external connector provided on the electric power service equipment or service raceway.

Choose a location on the power grounding system for grounding the protector which results in the shortest run of grounding conductor. <u>Do not use a gas pipe as the grounding electrode for the TLPU.</u>

7.11 The NEC requires that the power and telephone grounds be bonded. This is accomplished automatically when the station protector is grounded to the power grounding system. In installations where the power ground is inaccessible, the power is not grounded or there is no power present at the premises, a ground rod should be used to ground the station protector per Figure 12. The ground rod should be bonded to the interior metallic water system. Where the power ground is inaccessible or the power is not grounded, the customer should be notified that an unsafe condition may exist.

7.12 The telephone technician is not expected to determine whether the power ground is properly installed. However, if it is found obviously defective, such as the ground wire disconnected or broken, do not use it as the approved ground, but use one of the alternative choices in Figure 12. The defective condition of the power ground should be reported to the customer.

7.13 The use of water pipes for grounding or bonding should be avoided due to the increased use of plastic components in plumbing systems. If it is necessary to use a water pipe for grounding or as part of the bonding conductor between the TLPU and the power grounding system, verify that it is continuously metallic to the point where the power ground is connected to it. Connections to water pipe electrodes should be made at the point where normal maintenance of meters and pumps or the installation of plastic water meters or insulating pipe sections for reducing vibration will not interrupt the grounding circuit. Insulated sections of pipe should be bypassed with a No. 6 AWG bond wire (after consultation with the property owner) to maintain common grounding of the interior piping section.

Note: The trend in the industry is to restrict or eliminate the use of the cold water as a grounding electrode or bonding conductor. SBC LECs should make every effort to limit the use of water pipes.

7.14 Where the elements of the grounding system are present at the location, follow the flow chart (Figure 13) to attain the best grounding and bonding results.

7.15 Where the elements of the grounding system do not exist, it is still essential that power and telephone grounds be common. Where a separate ground rod is used for the protector ground and the power ground is neither present nor accessible, the telephone ground rod must be bonded to the interior water piping (Figure 13).

7.16 Grounded metallic structures (such as uncoated buried tanks, pipes, conduits, and building steel) may be used for protector grounds when such structures will provide a better ground than a driven electrode. Also, ensure that there is a bond to the interior metallic water pipe. If the electric service is grounded to a buried metallic structure, the telephone protector ground should also be connected to the same structure. Do not use a gas pipe as the grounding electrode.

7.17 Where none of the previously described grounding electrodes are available, standard E Station ground rods must be used for grounding station protectors. When an E Station ground rod is used, bond the interior metallic water pipe to the ground rod.

8. BONDING OF POWER AND TELEPHONE GROUNDS

8.01 The procedures outlined in paragraphs 7.07 through 7.15 are intended to accomplish common bonding of power and telephone grounds at the customer's location. Wherever the situation results in separate grounds, the following arrangements must be followed:

(a) Where power and telephone grounds are connected to separate rods, they must be bonded together using a No. 6 AWG copper wire. When structural conditions make it impractical to run a wire for the entire distance between rods, a metallic pipe of a cold water system (which is not likely to be disconnected or rearranged) or building steel may be used as a part of the bonding run. If a cold water pipe is to be used as part of the bonding run, the considerations of paragraph 7.13 apply. In such cases, the telephone ground rod must be bonded to the water pipe with a No. 6 AWG copper wire.

Note: The trend in the industry is to restrict or eliminate the use of the cold water as a grounding electrode or bonding conductor. SBC LECs should make every effort to limit the use of cold water pipes.

(b) Where a power ground is not provided, the telephone protector must be grounded to an acceptable ground (See Figure 12).

8.02 To conform with requirements of the National Electrical Code, a No. 6 AWG copper wire must be used for bonding the telephone and power grounds. This is the minimum size wire having sufficient current-carrying capacity for practically all power fault conditions at subscriber stations.

8.03 Any grounding or bonding conductor which is run through a metallic conduit shall be bonded to the conduit at both ends. Splices in bonding or grounding conductors reduce reliability and are not recommended.

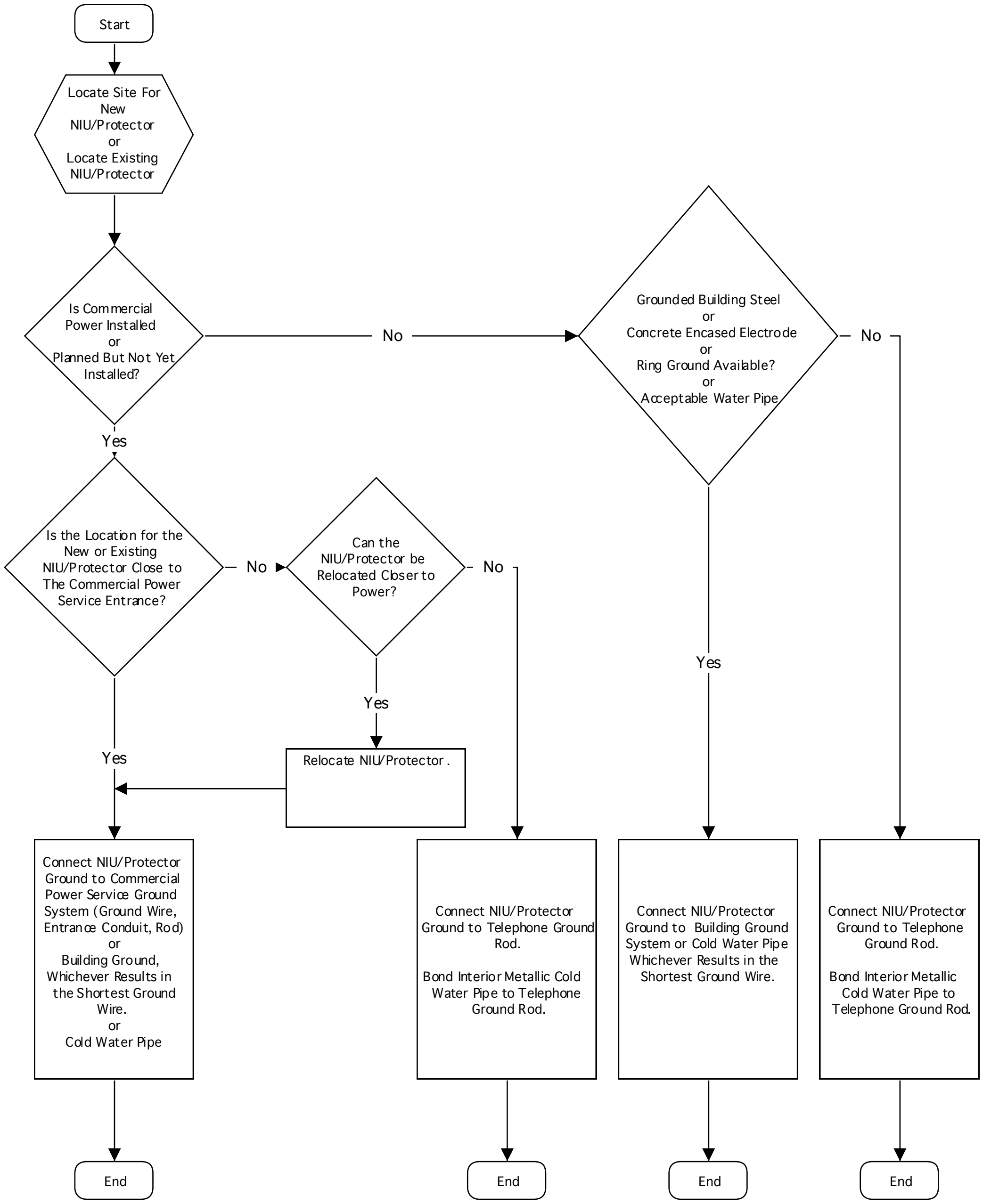


FIGURE 12 – Selecting An Approved Ground (Does Not Include Mobile Homes)

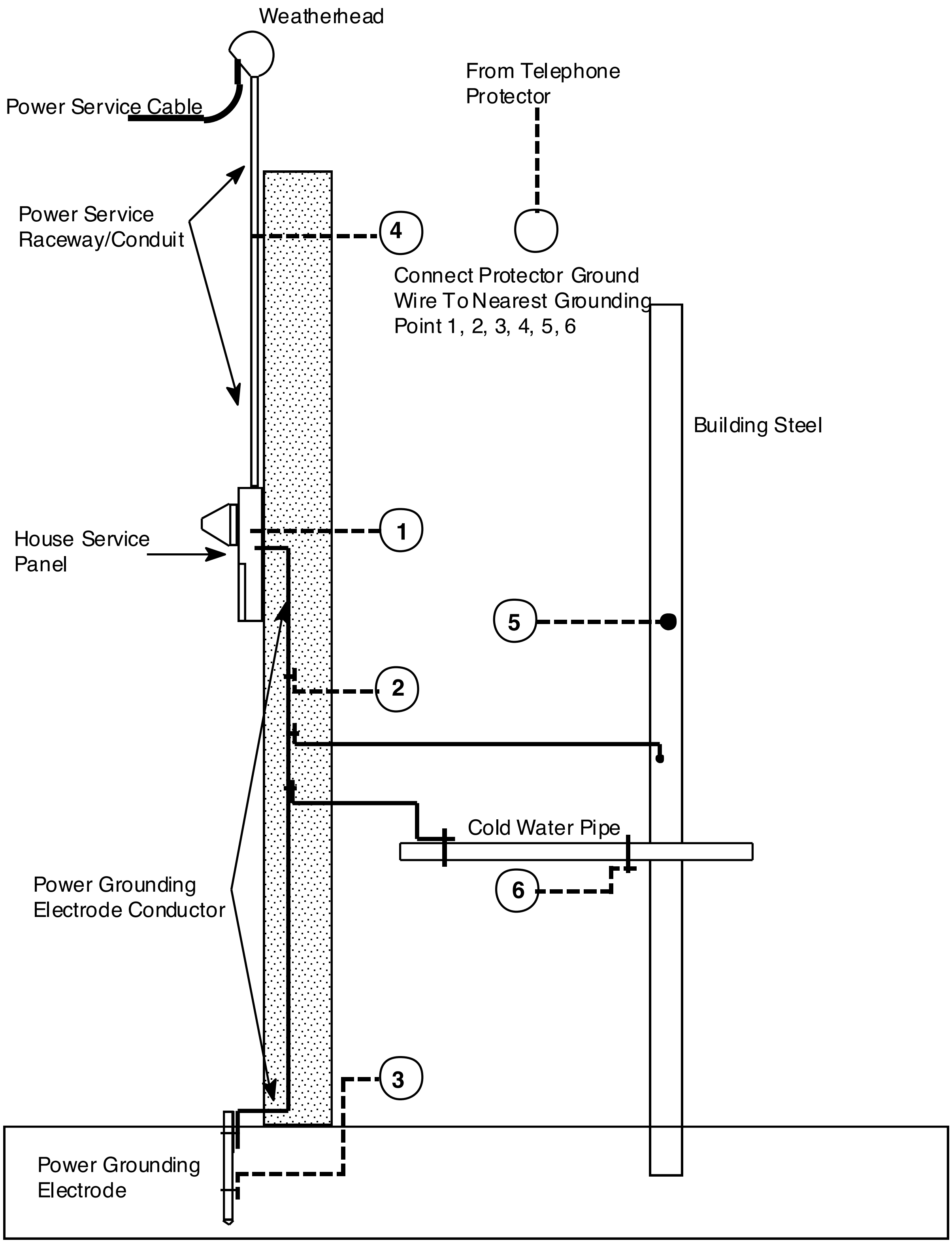


Figure 13 - Acceptable TLPU Grounding Connections to the Power Ground

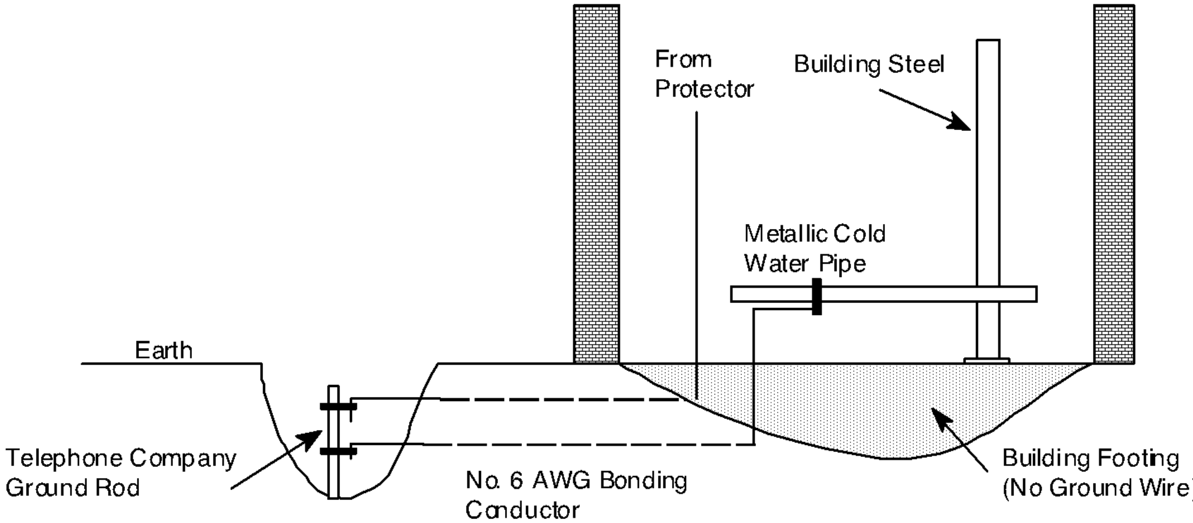


Figure 14 - Acceptable TLPU Grounding Connections When the Power Service is Not Grounded, Power Service Ground is Not Accessible, or There is No Power at the Customer's Location

8.04 The gauge of the TLPU grounding conductor depends upon the number of circuits served. The grounding conductor should be capable of safely conducting the greatest expected current that may be conducted from the cable pairs and shield to the ground terminal. See Table B for minimum grounding conductor sizes.

TABLE B

GROUNDING WIRE CAPACITY

Grounding Wire Size (AWG)	Maximum Number of Protected Circuits	
	Fuseless	**Fused**
No. 12	5	6
No. 10	6	7
No. 6	7 or More	8 or More

9. BONDING AND GROUNDING IN HIGH-RISE AND LOW-WIDE COMMERCIAL AND INDUSTRIAL BUILDINGS

A. General

9.01 Current telephone company experience reveals low lightning trouble rates for telephone equipment in all types of tall buildings. However in high-rise and low wide-area industrial or commercial buildings, there is a possibility of differences of potential being developed between telephone conductors and grounded conductors and steel structural members due to lightning strikes to the building or to the telephone or power conductors that serve the building. As discussed in paragraph 4.17, some electronic station equipment may be sensitive to such surges and special grounding and bonding procedures may be required to minimize them even when the telephone cable serving the building is classified as unexposed.

9.02 A high-rise building is considered to be any multistory building, over three stories, of structural steel or reinforced concrete construction. A reinforced concrete building is equivalent, electrically, to a structural steel building. This equivalency results from the use of steel reinforcing bars that are wire-tied so that they will remain in place while concrete is poured. The low wide-area building is typified by the large shopping mall, factory, or warehouse.

B. Recommendations

9.03 Recommendations are made in the following paragraphs, when a Coupled Bonding Conductor (CBC) is provided, to improve the bonding and grounding methods used in high-rise industrial and commercial buildings and to minimize longitudinal potential differences at the interface between local equipment ground and the cable pairs

9.04 Shielded Riser Cables: Cables of this type, which are now used in most buildings, should be used if possible. If unshielded riser cables are used or if shield continuity cannot be assured, see paragraph 9.09.

9.05 Shield Ground at Entrance: The entrance cable shield must be bonded to an approved ground at or near the point of entrance. The cable shield should be grounded as close to the entrance as possible but not more than 50 feet from the entrance. Where cable enters in conduit that is buried in a concrete floor, the point at which the conduit emerges from the floor is considered the entrance point.

9.06 Shield Continuity: Shield continuity should be maintained over the entire cable length. If shielded house cables are used, continuity should be maintained between the house cable shield and the riser cable shield.

9.07 Grounding Terminal: A suitable grounding terminal must be provided at the building entrance facility (BEF) and in each riser closet in a high-rise building and in each satellite closet in a low-wide building where cable pairs are broken out to serve the network equipment. The grounding terminal in the BEF must be on or as close to the protector as possible (if entrance is protected) and bonded to the entrance cable shield and protector grounding lug with a No. 6 AWG copper wire.

9.08 Shield Ground on Floors: The riser cable shield should be bonded to an approved floor ground, using a No. 6 AWG copper wire, at every point where the conductors enter or leave the shielded riser cable. Where pairs enter or leave the cable to feed more than one floor above or below the floor where the riser cable shield is grounded, an additional shield ground is required on the floor that is fed. If conductors do not enter or leave the cable on a floor, the cable shield does not require grounding on that floor. The connections from the shield to the approved floor ground must be done in the riser closet. The shield must be connected to the grounding terminal in the riser or satellite closet (paragraph 9.07) and the grounding terminal connected directly to one of the following approved floor grounds:

- Building steel
- Metallic water pipes
- Metallic power feeder conduit supplying panel board(s) on the floor
- The grounding conductor for the secondary side of the power transformer feeding the floor (If this option is selected, the connection to the grounding conductor should 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 connections to this ground should be made by a licensed electrician.

9.09 Unshielded Riser Cables: If it is not economically feasible to use shielded riser cable, or if shield continuity cannot be assured, a No. 6 AWG copper ground riser should be run in close proximity with the cable or cables in each unshielded riser cable route. The ground riser serves the same purpose as the cable shield. The ground riser should be grounded as if it were the cable shield in accordance with recommendations in paragraphs 9.05, 9.06, 9.07, and 9.08.

9.10 Riser Location: Riser cables should be run as close as possible to vertical grounded conductors such as building steel and in the central portion of the building. Lightning currents are minimal near the central portion of the building, and the mutual induction of the riser cable and vertical grounded conductors minimizes induced potentials on the cable pairs. Locations in the outside walls, particularly corners, should be avoided. Lightning currents are greatest at these locations. Although the riser shaft locations are not under our control, a choice may exist and the Building Industry Consulting Service (BICS) Engineer should request a favorable riser cable route.

9.11 Coupled Bonding Conductor (CBC): Where a CBC is required, the continuous cable shield discussed in paragraphs 9.04 to 9.07 serves as the CBC from the BEF to the approved floor ground in the riser closet or satellite closet. That portion of the CBC between the riser or satellite closet and the Network Interface (NI) is furnished by the telephone company as described in paragraph 4.21. The CBC is bonded both to the approved floor ground in the closet and to the termination (CBC Terminal Block) at the NI.

10. REFERENCES

10.01 The following practices pertain to electrical protection at customer locations:

BSP SECTION	TITLE
201-202-101	Main Distributing Frames - Type of Protection
201-207-801	300 -Type Connectors and Associated Protection Units Including 121 -Type Protectors
462-005-100	Station Protection and Grounds
461-220-100	Mobile Home Wiring Permanent
461-220-101	Recreational Vehicle Wiring Nonpermanent Type
631-400-102	Cable and Terminal Grounding in Subscriber's Buildings - General
636-300-100	300 -Type Connectors - Description, Installation
636-320-100	Description, Installation, and Marking 302 -Type Connectors
636-330-105	305 -Type Connectors - Description, Installation and Marking
636-330-100	303 -Type Connectors - Description
636-330-108	308 -Type Connectors - Description, Installation, and Marking
638-205-015	Fuse Cable Requirements
802-101-180MP	Grounding and Bonding Requirements Telecommunications Equipment, Power Systems, Central Offices and Other Structures
876-101-100	Electrical Protection Devices
876-101-130MP	Electrical Protection Grounding
876-210-100	Electrical Protection of Radio Stations
876-310-100MP	Electrical Protection of Wire Plant Communication Facilities Serving Power Stations
916-559-770	Cable Termination Facilities Central Office Type General
918-216-100	Electrical Protection of the Subscriber Outside Plant
876-400-100MP	Cable Electrical Protection Engineering Considerations

11 GLOSSARY OF TERMS

11.01 For convenience and additional information, the following glossary of terms is supplied.

Approved Floor Ground - A ground on a floor of a building suitable for connection to the grounding terminal in a satellite or riser. Such ground may be any one of the following: building steel, metallic water pipes, metallic power feeder conduit supplying panel boards on the floor, the grounding conductor for the secondary side of the power transformer feeding the floor, or a grounding point specifically provided in the building for the purpose.

Approved Ground - A ground suitable for connection to the BEF protector, the entrance cable shield, or the PBX equipment single point ground. The NEC stresses the importance of bonding together all available electrodes into a system. The first choice for grounding of protectors is to the nearest available location on the system, or to the power service entrance conduit or grounding electrode conductor connected to the system, whichever results in the shortest run of grounding conductor.

Arrester - A protection device used on power lines to limit the line-to-ground surge voltage due to lightning while simultaneously interrupting "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 on the customer premises for termination of distribution cable.

Carbon Blocks - A pair of electrodes made of carbon that provide an air discharge gap of a specified dimension.

Carbon Block Protector - A protector that uses carbon blocks for voltage limiting.

Coupled Bonding Conductor (CBC) - A conductor used to extend approved ground in the BEF (building entrance facility) 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 (coupled bonding conductor) and the cable pairs minimizes surge voltages between the equipment and its local ground. The CBC may consist of a continuous cable shield, a tie-wrapped conductor, or a combination of both.

Customer Premises Equipment (CPE) - Any equipment such as PBX systems, key systems, data sets, etc. This term is often used interchangeably with the term station equipment or terminal equipment in protection practices.

Exposed Facilities - Any outside plant facilities subject to the effects of lightning, power contacts, power induction, or differences in ground potential. Exposure to lightning necessitates the use of TLPUs. Exposure to power (above 300V rms to ground) necessitates the use of fuse cable, fusible links, or station fuses, as well as TLPUs.

Foreign Voltage/Foreign Current - Any voltage or current imposed on the telephone plant that is not supplied from the central office or from telephone equipment.

Fuse - An overcurrent protective 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 in the plant and intended to fuse open on foreign power currents before the cable station wiring or apparatus which it protects. It does not protect against lightning currents.

Fuse Link - A conductor, usually block wire, that serves the same purpose on wire plant as fuse cable on cable plant.

Gas Tube - A protective device that a has spark gap which discharge in a gas atmosphere within a sealed envelope.

Ground - A conducting connection, intentional, or accidental, between a circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Ground (Earth) Resistivity - The measured DC resistance of a volume of earth, usually expressed in meter-ohms.

Ground Potential Rise (GPR) - A voltage difference between grounding electrodes due to the conduction of earth return currents. Ground Potential Rise (GPR) on cable pairs can exist when lightning currents are conducted to the ground at the station protector. GPR is most widely recognized as voltages generated due to power fault current conducted to ground.

Ground Riser - A No. 6 AWG copper wire run as a coupled wire with a riser cable when a continuous shield cannot be assured. This wire must be grounded at locations where the riser cable shield would have required a ground.

Grounding Terminal - A suitable bar, bus, terminal strip, or binding post terminal where grounding and bonding conductors can be connected. Connections to the grounding terminals are considered to be terminations of grounding conductors and do not qualify as splices and thus are permitted. The grounding terminal in the BEF may be located adjacent to the station protector.

Heat Coil - A device which grounds a conductor when overheated by current.

High-Rise Building - Any multistory building over three stories of structural steel or reinforced concrete construction.

Induction:

(a) Electrostatic Induction - Voltage-controlled currents in a conductor, such as telephone lines as a result of capacitive coupling from the electric field of a nearby power line.

(b) Electromagnetic Induction - Currents in a conductor, such as telephone lines, produced by coupling from the magnetic field of a nearby power line.

Insulating Joint - A splice in a cable sheath where the continuity of the metal sheath, shield, or armor is deliberately interrupted to prevent the flow of electrolytic currents (dc) that may cause corrosion.

Joint Random Spacing (Separation) - Where telephone cable is buried in the same trench with power conductors and no deliberate attempt is made to maintain a separation between the two systems.

Low-Wide Building - A building typified by the large shopping mall, factory, or warehouse. The terminal equipment may be located remotely from the entrance facility protector, possibly requiring special grounding and bonding procedures.

Multigrounded Neutral (MGN) System - A power system where the neutral conductor is continuously present along with the phase conductors and is grounded at least four times per mile.

Network Interface - The location at all customer locations 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.

Primary Power - Power operating at more than 300 volts rms to ground.

Protector Grounding Conductor - A wire run from the ground lug on the protector to an approved ground via the shortest and straightest route.

Protector Unit - A device containing carbon blocks, or a gas tube, in combination with shorting devices and/or heat coils, that screws or plugs into a protector, protected terminal, connecting block or central office connector.

Riser Cable - A cable run vertically in a high-rise building for providing pairs to each floor. It is preferable that this cable be shielded. To minimize voltages due to lightning strokes to the building, the riser cables should run along the central axis of the building.

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

Secondary Power - Power operating at less than 300 volts to ground. Typically 120/240 or 227/480 volts rms.

Single Point Ground Terminal - A connecting point provided with some PBX and key systems. It is the only acceptable point for connection from the equipment to the external protection grounding system.

Sneak Current - A foreign current flowing to ground through terminal wiring and equipment that is driven by a voltage that is too low to cause a protector to operate.

Sneak Current Protection - Use of devices to protect against sneak currents either by interrupting the current (sneak current fuses), or grounding the conductor (heat coils).

Station Equipment - See customer premises equipment.

Station Fuse - A fuse which is used in place of a fuse link, stub cable, or fine gauge cable. The station fuse does not eliminate the need for station protectors.

Surge Impedance - The impedance of a ground wire or electrode at the frequency of the current wave applied. At low frequency, the surge impedance is close to the dc resistance. When a surge is applied, the instantaneous impedance varies with time and is dependent on the waveform of the surge and the physical characteristics of the particular grounding electrode.

Telephone Line Protector Unit (TLPU) (Station or Central Office) - A device which limits voltage between telephone conductors and ground. May be equipped with 3-mil carbon blocks, gas tubes or a solid state element.

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

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.