ELECTRICAL PROTECTION AT SUBSCRIBER STATIONS

CONTENTS

1. GENERAL

1.1 This section provides REA Borrowers, consulting engineers, contractors, and other interested parties with technical information for use in the design, construction and operation of REA Borrowers' telephone systems. This section includes an outline of station protection principles; application and installation of subscriber station protectors and applicable grounding techniques to be employed at telephone station installations. Supplemental information with respect to subscriber station installation is included with TE&CM 701, "Station Installation," and TE&CM 830, "Electrical Protection Assembly Units."

1.2 This revision replaces Section 805, Issue 7, dated August 1979. It updates the material contained herein to reflect changes in the National Electrical Code, REA's 511/515 Contract, and industry practices.

1.3 In order to limit hazards which occur as a result of power circuits and lightning, suitable protectors are required at all subscriber stations. This rule applies whether the stations are served by aerial or buried plant. All station protector installations must comply with applicable requirements of the National Electrical Code (NEC) and applicable local codes which are more stringent.

2. PROTECTION PRINCIPLES

2.1 Disturbing Potentials - Subscriber stations are subjected to abnormal voltages and currents caused by (1) lightning surges and (2) contacts between telephone outside plant conductors and power distribution conductors, or by induction from such power circuits. A detailed discussion of these sources is provided in TE&CM 801.

2.1.1 Lightning surges comprise the bulk of these abnormal potentials and may be (1) conducted to the station by the outside wire or cable or (2) they may be produced by a potential rise at the station protector ground electrode due to a nearby stroke. Lightning surge currents conducted to the station by outside plant wire or cable are not necessarily the result of a direct stroke to the outside plant but may arise from electromagnetic and/or electrostatic induction from the stroke.

2.1.2 The use of all-buried telephone wire or cable (i.e., circuits buried throughout their entire length) eliminates the likelihood of contact with power conductors except in instances in the joint use of trenches for burial of power and communications facilities. The economics involved in this practice, as well as environmental considerations, are causing more facilities to be installed in this manner.

2.2 Objectives - The objectives in the provision of protective measures at subscribers' stations are (1) the prevention of electric shock to the telephone user and damage to its premises or equipment; and (2) the assurance of service continuity by protecting the telephone equipment and wiring against dielectric failure and overheating.

2.2.1 Recent rulings by the FCC have made it easier for subscribers to attach their own equipment directly to the switched network where it will be subjected to the full impact of the transients discussed in 2.1. If such customer provided equipment (CPE) was to be damaged by these transients, and it could be shown that telephone company provided protection was not up to acceptable levels, the telephone company may be faced with the prospect of paying for the repairs. As a result, the provision of proper station protection is becoming more important than ever.

2.3 Methods - The basic principles applicable in the prevention of harmful potentials at telephone subscribers' stations are twofold (1) the prevention of harmful potentials from developing between the major station utilities connected to earth, by the common grounding[1] of these systems, and

[1]"common grounding" means the interconnection of the power system ground, the water system, the telephone protector and the CATV ground.

(2) the diversion to earth of lightning and power currents appearing in the connecting telephone wire or cable plant by the use of appropriate arresters at the station. The utilities requiring common ground are: (1) the telephone system, (2) the power system, and (3) the metallic water pipe system if available on the premises and CATV if available. Hardware associated with all of these systems are handled regularly by customers and the development of excessive voltages between them, representing a serious shock hazard, can be prevented only by common grounding. The grounding electrodes of all three of these systems must be bonded together in all installations. This must be done whether or not the water system is considered to be a "good" (low resistance) ground or not.

Additional information on grounding details is covered under Paragraph 5, in TE&CM 802. Figure 1 illustrates how a lightning surge arising in either the telephone or the power system easily produces hazardous potentials where these three grounded systems are not interconnected.

3. STATION PROTECTORS

3.1 Fuseless Type

3.1.1 Fuseless type protectors are preferred because they provide more effective protection than fused types, and because the maintenance associated with these units is normally lower than that for fused type protectors. Their use is controlled by rules of the NEC as covered under Paragraph 3.1.3.

3.1.2 The fuseless protector employs white coded (350 to 600V) carbon air-gaps, orange coded gas tubes, or equivalent surge arresters connected between each line conductor and ground. These arresters have a breakdown value adquate for the protection of personnel and well below the dielectric strength of telephone company furnished station apparatus and wiring. The protector is designed to have a current-carrying capacity in excess of that of the wire or cable pair with which it is associated. The use of fuseless protectors is desirable because the ground connection is maintained in the event of a contact, thereby aiding in the deenergization of the power circuit because of the current flow to ground. Elimination of fuses also prevents excessive potential on the drop wire or at the protector terminals after fuse operation in the event of a power contact, and this results in a reduction in station maintenance visits.

3.1.3 The NEC requires the use of "approved" insulated conductors in the form of drop wire or cable between the last outdoor support and the station protector. It also requires "approved" protectors and "approved" ground wire. The word "approved" commonly means acceptance for listing by Underwriters' Laboratories, Inc. or equivalent. The rules applying to the use of fuseless station protectors at stations served by drop wires require that in the event of a power contact to an outside plant conductor, the station drop wire, protector, and grounding conductor must be safeguarded against fire hazard by the fusing of a conductor not appearing at the station premises. Such conductors may be in the form of supplementary fusible links between the wire or cable plant and the station drop, or they may be the outside plant wire or cable conductors themselves. When cable is used between the last outdoor support and the station protector, the effectively grounded metal shield is primarily relied upon to prevent fire hazards. Present designs of multipair distribution wire (MPDW) must not be used between the last outdoor support and the protector. MPDW does not qualify as a cable because of the lack of a metallic shield, nor does it qualify as an "approved insulated conductor" because it does not meet flame resistance requirements.

3.1.4 Fuseless station protectors are permitted by Article 800-2(C) (1) of the National Electrical Code under the following conditions:

3.1.4.1 At stations served by metal shielded aerial cable; i.e., cable conductors are connected directly to station protector terminals, provided the cable shield is effectively grounded and the cable conductors are of copper and are 19-gauge or smaller, or have equivalent conductivity.

3.1.4.2 At stations served by drop wires from aerial cable under the following conditions: (1) the cable shield is effectively grounded; (2) where parallel-type drop wire[2] is used and either (a) the cable conductors are no larger than 24-gauge copper or (b) 24-gauge copper fuse links are inserted between the cable conductors and the drop wire.

3.1.4.3 At stations served from non-cable type facilities[3] under the following conditions: (1) the protector ground connections must be made to a continuous metallic water pipe system having at least 10 feet of buried pipe supplemented by a driven ground rod and/or to an MGN[4] grounding conductor or ground electrode; and (2) where parallel-type drop wire is used, a fusible link of 24-gauge copper or 20-gauge, 30 percent conductivity copper-steel bridle wire is inserted between the drop wire and the noncable plant. If it is not practicable to fulfill the above conditions, the fused-type protector

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[2] 18-gauge 30 percent copper-steel conductors.

[3] The term "noncable type facilities" means conductors which are not enclosed in a grounded metal shield. This includes open wire and MPDW.

[4] The term "multigrounded neutral" (MGN) refers to the neutral conductor of a wye-connected electrical supply system where the neutral conductor has at least four ground connections in each line in addition to the ground connections at individual services, and where the primary and secondary neutrals are solidly interconnected.

must be used. Every effort should be made to avoid resorting to fused-type protectors because of the inferior protection they render as compared with properly installed and grounded fuseless protectors.

3.1.4.4 At stations served from all-buried circuits, i.e., circuits that are buried throughout their entire length and are, therefore, not exposed to power contacts and on circuits that are all buried except for an aerial drop at the subscriber's premises. No fuse links are required in such circuits. Fuseless station protectors should also be used at all stations served from (1) buried pairs which appear in exposed aerial inserts and/or (2) buried pairs which are extended by exposed aerial facilities other than short drop wire. In these cases, the station protectors must be isolated from the exposed sections of the circuit by suitable fuse links in accordance with REA TE&CM 816, "Electrical Protection of Buried Plant." Also, where buried pairs are extended by aerial noncable-type facilities, the grounding provisions of Paragraph 3.4.3.3 must be met at each station where a fuseless protector is used.

3.1.4.5 In the proper application of REA construction practices, fuseless protectors should always be used except at stations served from noncable-type facilities having protector grounding electrodes which do not meet the requirements described in Paragraph 3.1.4.3.

3.2 Fused Type

3.2.1 Fused type station protectors employ white coded (350 to 600V) air-gap, orange coded gas tube, or equivalent surge arresters for the limitation of excessive potentials, and fuses to limit sustained currents to a value less than which the protector can safely carry (15 amperes per conductor continuously for most types of fused protectors.) The fuses are required to open the circuit on currents resulting from power contacts which would otherwise result in a fire hazard because of protector over-heating. One fuse is connected in each side of the line on the line side of the arrester.

3.2.2 With the fused type of protector, the ground connection for the drop wire is lost when the fuses operate, and the drop wire and protector line terminals may, therefore, remain energized at an excessive potential. For this reason, and because they are subject to high maintenance, fused protectors are not recommended. Their use should be avoided except where the requirements for fuseless protectors cannot be met.

Note: Because the line terminals of a fused-type protector may remain energized after the fuses have operated the craftsman should exercise caution in touching these terminals until it has been verified that they are safe.

3.3 Gas Tube Type

3.3.1 Gas tube station protectors which appear on the "List of Materials Acceptable for Use of Telephone Systems of REA Borrowers" may be used in place of air-gap type station protectors. See TE&CM 823, "Electrical Protection by Gas Tube Arresters", for further discussion of gas tubes, and the economic factors to be evaluated before they are employed.

4. PROTECTOR INSTALLATIONS

4.1 In planning and staking station installations the selection of protector locations should be made with primary emphasis on the achievement of common grounding of the telephone protector with the power system ground and the water system. See REA Standard PC-5A, "Service Entrance and Station Protector Installations".

4.2 Selection of the type of protector, and a discussion on indoor versus outdoor mounting is covered in TE&CM 701. Whatever decisions are made, the protector selected should be UL Listed and REA accepted for its intended use to insure the safest possible installation.

5. PROTECTOR GROUNDING AND BONDING--FIXED INSTALLATIONS

5.1 Copper has been found to be the most satisfactory material for bonding and grounding conductors and its exclusive use has been assumed throughout this section. If it becomes necessary to substitute another material for copper, specific measures not covered herein, will be required to insure equivalent conductivity, adequate resistance to corrosion, and proper installation and termination. No substitution of another material for copper should be made without first obtaining specific instructions from REA for its use.

5.2 As indicated in Paragraph 2.3, it is essential that the power and communication ground systems at the subscriber's station be connected to each other and to the metallic water piping systems in order to avoid dangerous voltage differences within the subscriber's premises. This is essential whether or not such piping systems meet the minimum requirements as preferred grounding electrodes and whether or not the telephone line facilities are buried. A low resistance ground is desirable in that it aids in assuring deenergization of the power system in the event of a contact; also, a low resistance ground is beneficial in minimizing the development of excessive potential differences between systems, but it is not a substitute for potential equalization by common grounding.

5.3 The ground of station protectors at the subscriber's premises is covered by Section 800-31 of the National Electrical Code, (NEC). Table 1, Station Protector Grounding Guide, is a flow chart to aid in proper selection of the grounding electrode in accordance with the NEC.

5.4 The choices of grounding electrodes, in order of preference as ranked by the NEC, are as follows:

5.4.1 The nearest accessible location on the premises grounding electrode system[5] or the power service conduit, service equipment enclosure, or grounding electrode where the power service grounded conductor is connected to the grounding electrode system.

5.4.2 If the electrodes in 5.4.1 are unavailable, to

5.4.2.1 A metallic underground water pipe having at least 3m (10') of metallic pipe in direct contact with the soil and which is supplemented by a driven ground rod, or

5.4.2.2 An effectively grounded metal building frame, or

5.4.2.3 An acceptable Ufer or rebar ground.

5.4.2.4 A ground ring of at least 6m (20') of #2 AWG Copper buried at a depth of 76cm (2½') or greater.

5.4.3 If the electrodes in 5.4.1 and 5.4.2 are unavailable, to the grounding electrode, grounding electrode conductor, service conduit, or service equipment enclosure of an MGN power system.

5.4.4 If none of the aforementioned electrodes are available, to an effectively grounded metal structure, or to a ground rod driven into permanently damp earth.

5.5 Ground rod or rods not interconnected with either water or electric service ground. Use of a ground rod as the only station protector grounding electrode is acceptable only when a station has no internal metallic water pipe and no electric service. In all other cases, it is essential that all of the ground electrodes be interconnected whether or not any or all of these are "low resistance" grounds. This is necessary since the passage of lightning surge currents into a ground electrode which is not interconnected with the other grounded facilities, develops hazardous voltages to other grounded systems not interconnected to the same ground electrode. These voltages may readily constitute a fatal shock hazard to telephone user.

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[5]The grounding electrode system, introduced in the 1978 NEC, is comprised any or all of the electrodes in paragraph 5.4.2 which are available on the premises being bonded together to form a system for grounding the premises.

5.6 Grounding connections from telephone protectors to the various grounding electrodes listed in Paragraph 5.3 and 5.4 should be as shown in the following table, using insulated copper wire.

Number of Pairs	Grounding Wire Gauge
1 - 2	12
3 - 5	10
6 or more	6

Table 2

5.7 Wherever separate ground rods are used for both the telephone and electric systems, they should be bonded together with a #6 or larger copper wire. If these rods are of dissimilar metals, corrosion may be a problem, as discussed in TE&CM 802.

5.8 Where conditions are such that the preferred location of the telephone protector is on the opposite side of the house from the electric service ground and a metallic water pipe system exists, interconnection may be accomplished by (a) running #10 or larger copper wire from the telephone protector to the water pipe, and then (b) a #6 or larger copper wire from the water pipe to the electric service grounding conductor. If the water system has less than 3m (10') of pipe in contact with the earth and the electric system is not of the MGN type the telephone protector should be connected to a ground as indicated under (a) and (b) above except that #6 copper grounding conductors should be used in connecting both to (a) and from (b).

5.9 Section 250 of the NEC covers bonding and grounding of the power system at the subscriber's premises. It stresses the interconnection of available grounds at the premises to form a grounding electrode system in order to prevent hazardous differences in potential between the various systems. It is primarily the subscriber's responsibility to see that this bond between the electric service driven electrode and the water system is provided by an electrician. If this bond is not installed, the subscriber should be notified and requested to have it installed. If the subscriber is unwilling to have this bond installed by an electrician, the telephone ground should be bonded to the power ground and the water pipe as part of the telephone installation. In most areas, the electric service ground and grounding conductor are part of the house wiring installation and are the property of the subscriber. It is, therefore, not normally necessary to obtain permission of the power distribution company before bonding to it.

5.10 Bonding between the electric service ground and a metallic water pipe system (suitable as a ground electrode) must have a current carrying capacity equal to or greater than 6-gauge copper. Such bonds should be made as short as practicable by connecting the water pipe close to the electric grounding conductor. The grounding conductor from the telephone protector should likewise be connected to the pipe as close as practicable to the telephone protector. In this manner maximum utilization can be made of the water pipe as the bonding member in addition to its serving as ground electrode.

5.11 During the early design state of the project, the Borrower's engineer is required to consult with the electric power company serving the area regarding joint use, use of the power system neutral for grounding telephone protectors, etc. During these conferences, the Borrower's engineer should also review the station protector grounding units covered in REA Form 515, "Telephone System Construction Contract," and obtain the power company's concurrences in the use of protector grounding units that will insure common grounding of the power, telephone, and water systems.

5.12 The design of multiple fuseless station protectors will include a common grounding bar as an integral part of the mounting. Where such a bar is furnished, two or more fuseless station protectors should be grounded by connecting an insulated copper wire (gauge shown in Table 2 following Paragraph 5.6) from the ground electrode to the grounding terminal on the protector assembly.

5.13 Where more than one single pair protector is installed, the ground posts of two or more protectors should be strapped together with a 10-gauge insulated copper wire, and the assembly grounded as described in Paragraph 5.12.

6. TRAILER INSTALLATIONS

6.1 The protection of station installation in house trailers and mobile homes presents certain problems not encountered in permanent buildings. As in other station installations, it is desirable for access reasons that the station protector be installed outside the trailer. However, mounting of a protector on the trailer body is usually objectionable to the owner, and other methods must be employed. (See TE&CM 701 and REA Standard PC-5A).

6.2 Protection for mobile homes involves the use of standard station protectors, preferably of the fuseless type where the provisions of the NEC do not require fused types.

6.3 In the preferred service entrance installation, pairs are extended by buried plant from the main distribution cable to pedestal-mounted terminal housings. A group of indoor-type station protectors or a multipair protector appropriate for the number of trailers to be served should be connected to the protector line terminals, and connectors from the protectors to the station equipment extended in accordance with REA TE&CM 701.

7. TRAILER PROTECTOR GROUNDING AND BONDING

7.1 In all station protector installations, the principle of common grounding (interconnection of the telephone ground with the power ground and local water system) is of prime importance. Because the water pipe system in trailers is frequently isolated from the main grounded water system by hose or other insulating connections, it is necessary to provide a local ground by the use of a ground rod at the protector installation. For safety consideration, the National Electrical Code, Sections 550 and 551, prohibits connection of the trailer frame or the frame of any appliance to the power neutral conductor in the mobile home. Interconnection of the telephone protector ground, trailer body and water supply pipes, and power ground should be achieved as described in the following paragraphs to provide a safe installation which complies with the NEC.

7.2 Each protector ground terminal should be individually bonded to the terminal housing grounding connector with a 12-gauge copper conductor. The terminal housing should be grounded by means of a 10-gauge copper conductor to a water pipe or MGN ground if available. If neither a suitable water pipe nor a MGN ground is available, a ground rod should be driven approximately 61 cm (2') from the pole or pedestal and bonded to the terminal housing grounding connector with a 10-gauge copper conductor.

7.3 The protector ground terminal should also be bonded to the trailer frame by connecting the buried service wire shield to the terminal housing grounding connector and to the chassis of the trailer with a bonding harness arrangement or an equivalent grounding connector terminal mounted with a stainless steel bolt. Details of the recommended installation are included in REA Standard PC-5A.

8. AC POWER SERVICE PROTECTION

8.1 With the ever increasing use of data equipment, key systems, PABX's and other subscriber station equipment powered locally by 60Hz ac, the problem of equipment damage caused by surges on the power line is becoming more serious.

8.1.1 The first line of defense against this type of damage is to provide common grounding and bonding as described in Paragraph 2.3.

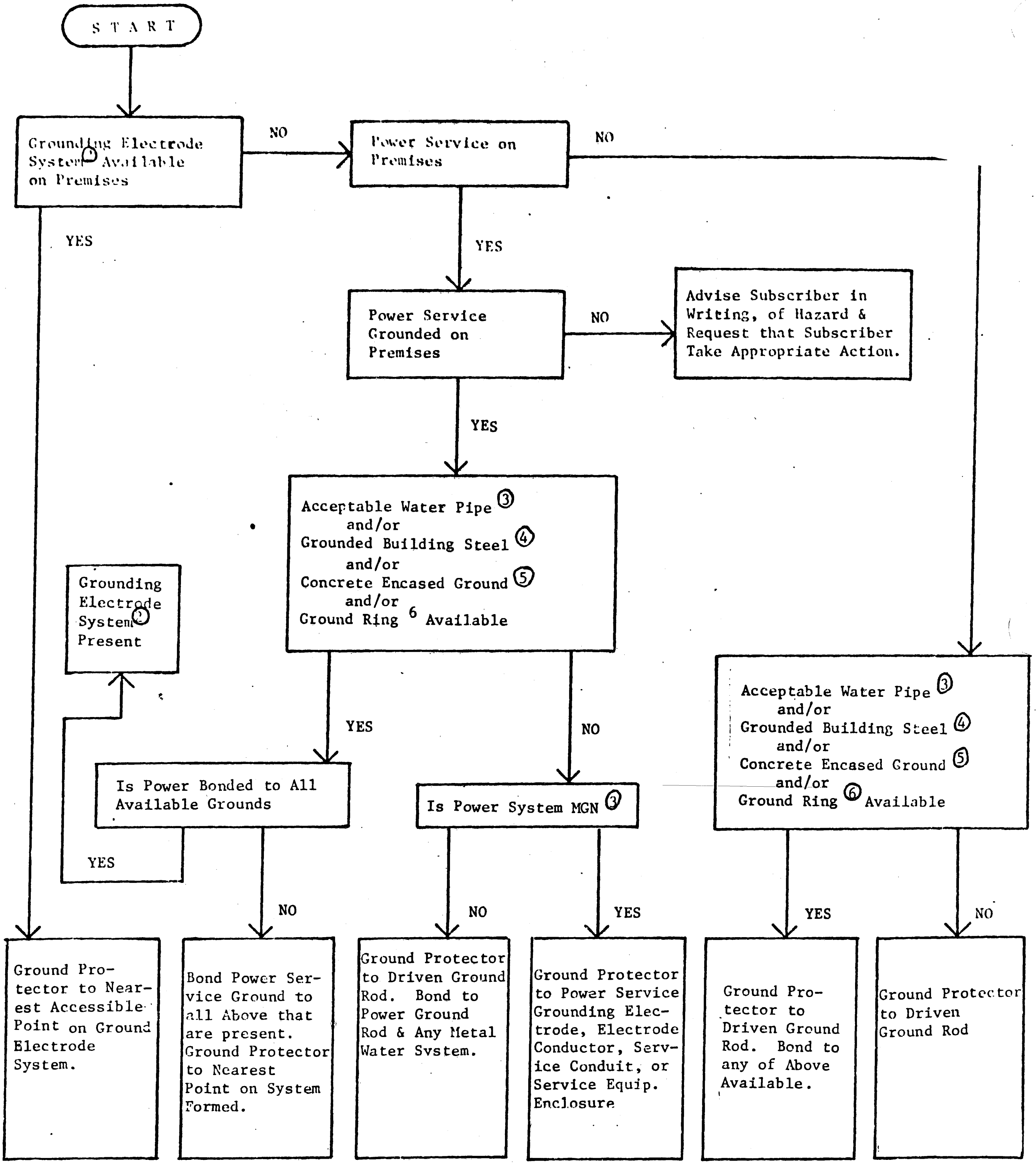
8.1.2 In severe exposure situations, (such as high lightning damage probability areas per TE&CM 801, or locations with a history of power system faults) common grounding and bonding may not provide adequate protection. Protection should then be supplemented by providing a secondary surge arrester on the ac power service to limit the magnitude of surges which can reach the equipment from the power system.

8.2 When protection of ac power service is justified, a two step approach of implementation should be employed.

8.2.1 As the first step, a power service protector, item "gg" on REA's List of Acceptable Materials should be installed. The power service protector should be installed as close to the ac powered telephone equipment as practicable (See Figure 2). The ground terminal of the power service protector should be connected to the power ground as discussed in Paragraph 5, of this TE&CM. Because this unit protects only the telephone equipment, its cost should be borne by the telephone company. If other than the plug-in type of unit is used, the installation should be made by a qualified electrician.

8.2.2 If experience proves the power service protector to be inadequate, consideration should be given to the installation of a secondary power arrester. The secondary arrester should be installed at the service weatherhead on the subscriber's premises. Harmful surges in the power supply are first intercepted by the low voltage gas tube arrester. Surge currents through these tubes develop potentials at the secondary power arrester sufficient to cause the power arrester to break down by virtue of the IA drop over the conductors. With certain types of secondary arresters, a minimum of 6m (20') of steel conduit between the secondary arrester and the branch circuit panel is required to introduce sufficient inductance to cause proper operation of the arrester. The installation of a secondary arrester will protect all electrically powered equipment on the subscriber's premises. As a result, an effort should be made to persuade the subscriber or power company to pay for the installation. The secondary arrester should be installed by a qualified electrician. In no case should telephone company personnel or the subscriber be expected to install the secondary arrester.

8.2.2.1 Power company practices, regarding secondary arresters, vary considerably in different areas. In most cases installation of a secondary arrester at the weatherhead of the subscriber's service would require temporary deenergization of the secondary circuit serving the service. It is, therefore, essential that all installations of secondary arresters be coordinated with the power company involved. In some instances the power company may recommend that the secondary arrester be installed at the customer's load center instead of at the weatherhead. In other instances the power company may recommend the use of aluminum or plastic conduit, or possible no conduit instead of the steel conduit. These alternatives should be approached with caution as many secondary arresters rely on the reactance of the steel conduit to develop sufficient voltage drop to cause the arrester to fire. If the steel conduit is not employed coordination between the secondary arrester and protected equipment becomes more important and should be addressed.



STATION PROTECTOR GROUNDING GUIDE
TABLE 1

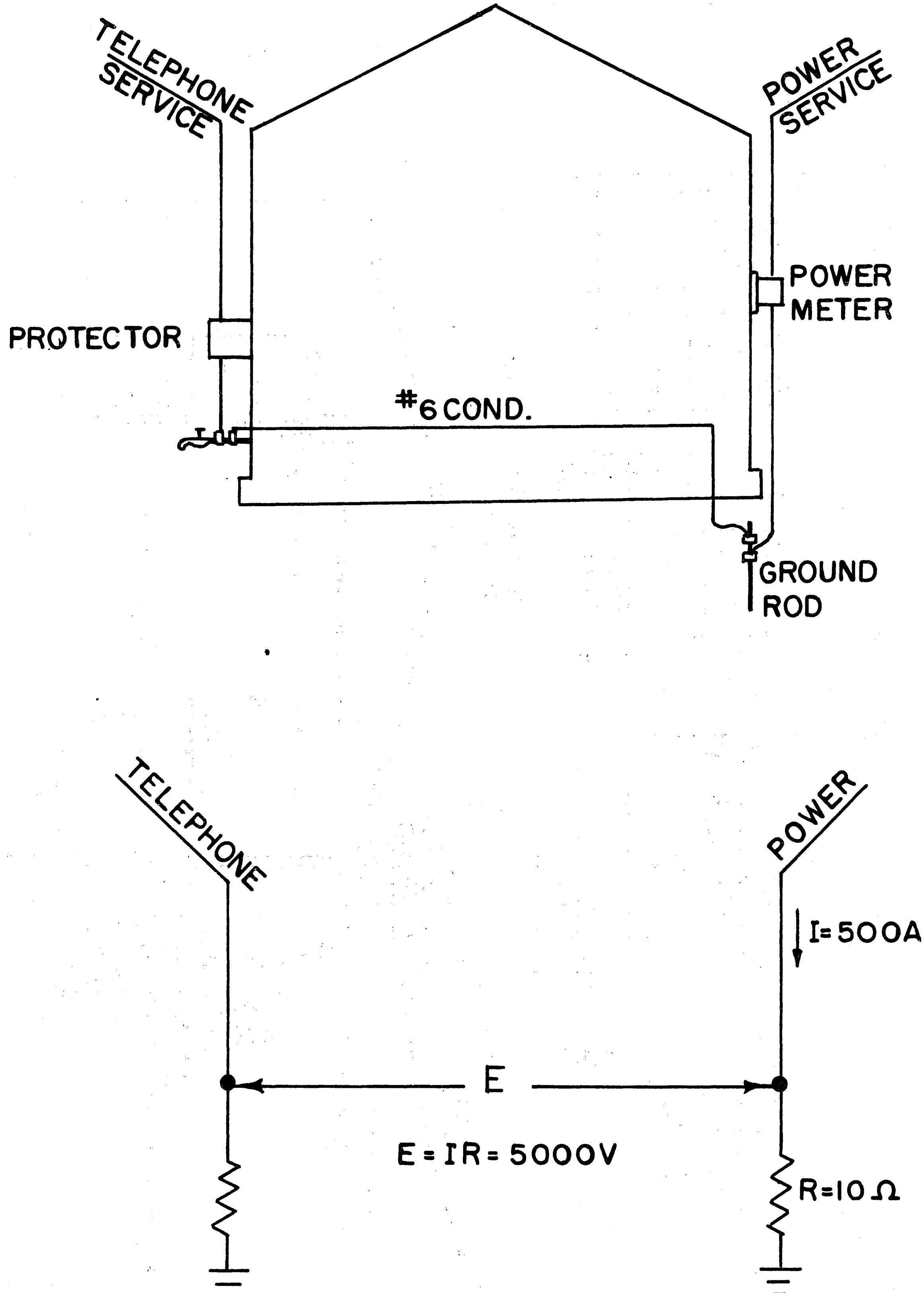


FIGURE 1: ELIMINATION OF HAZARDS BY COMMON GROUNDING

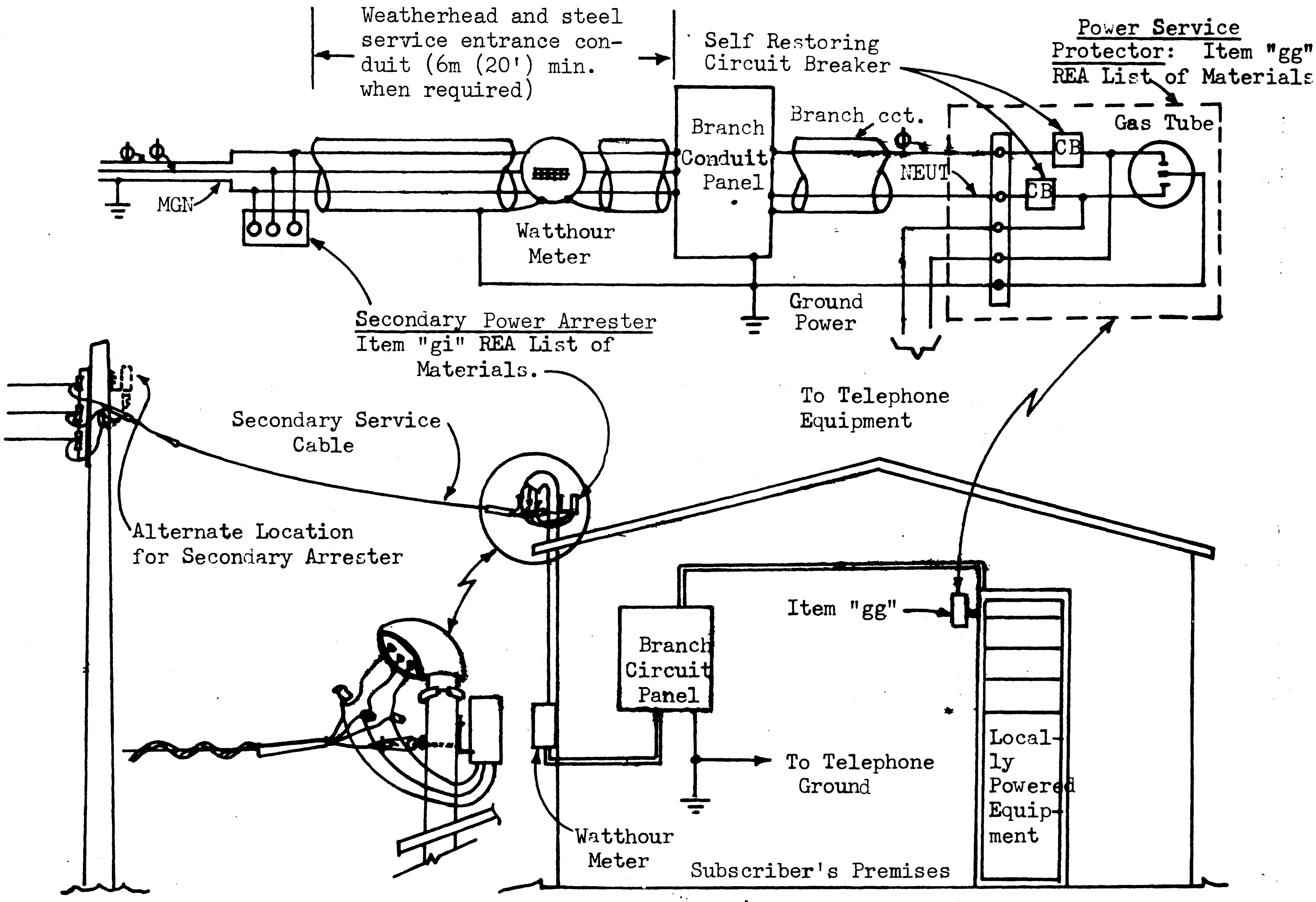


FIGURE 2: TYPICAL INSTALLATION OF SECONDARY ARRESTER AND BRANCH CONDUIT POWER SERVICE PROTECTOR