

Chapter 6 – General Specifications for a Customer-Owned 69 kV Outdoor Substation – Table of Contents

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Chapter 6 – General Specifications for a Customer-Owned 69 kV Outdoor Substation

1. Introduction

PSEG is committed to providing a safe environment for our employees and safe, adequate and reliable electric service to our customers.

These General Specifications are provided to assist the customer and their agents in developing the necessary detailed substation specifications for acceptable operation on PSEG's 69 kV electrical system.

The Addendum to these General Specifications show typical one-line substation configuration ([Figure 6.1](#)) that is acceptable for operation on PSEG's 69 kV electrical system. Not all configurations are shown. Preliminary discussions with PSEG are recommended to determine what substation configurations might best serve the customer's requirements.

In accordance with Section 5.1 of the *Standard Terms and Conditions of PSEG's Electric Tariff* B.P.U.N.J. No. 15, the customer's 69 kV bus is considered part of PSEG's distribution system for operational purposes, and system power may flow through the customer's bus with no remuneration to the customer by PSEG.

2. General

The following general requirements apply to customer substations:

1. PSEG requires that all customer substations supplied from the 69 kV electrical system shall be designed for 69 kV operation with 350 kV BIL minimum insulation rating unless otherwise specified.
2. The 69 kV system is operated with its neutral solidly grounded at the supply station.
3. Prior to purchasing any equipment, PSEG shall be contacted for details on types of equipment and relays suitable for the substation design selected by the customer.
4. Customer shall submit to the Division 69 kV Planner two copies of the conceptual one-line (electronic version in PDF format) as part of the first contact with PSEG. The one line shall clearly indicate all proposed relay protection (function/make and model) and all equipment ratings. One copy shall be addressed to the Division 69 kV Planner and the other to the Electric Meter Supervisor.
5. Interior and exterior lighting is required, per National Electrical Safety Code (**NESC**) requirements.

3. Reviews and Approvals Required

The following are requirements for the review and approval of the customer's substation.

1. Five sets of the final substation plans, and an electronic version in PDF format, shall be submitted to PSE&G for its review so as to ensure that the design satisfies PSE&G's technical requirements. PSE&G's review must be completed prior to the fabrication of apparatus and the supporting structure.
2. Specifically, the drawings submitted should cover the following items:
 - a. Single-line diagram of the substation including secondary connections to the main transformers, bus and feeder breaker arrangements and connections.
 - b. Written procedure on how the customer substation will be operated.
 - c. DC and AC (three line) schematic diagrams of the relaying and control of all 69 kV automatic apparatus.
 - d. A plot plan showing the location of the substation with regard to all structures within 100 ft thereof.
 - e. A manhole and conduit drawing representing incoming lines and instrument transformer secondary circuits used for revenue metering and control.
 - f. Electrical plan and elevation plan views of the substation.
 - g. A listing of the major equipment and materials, including their electrical characteristics and the manufacturer's description, unless these are detailed on the drawings.
 - h. The location and arrangement of metering, indication and control panels. See [Section 9](#). Number 8. for Distribution SCADA and Number 12. for ESOC interface requirements and details.
 - i. The substation grounding plans, details and calculations.
3. PSE&G's review of the above final plans and drawings is for general arrangement acceptance and to ensure conformity with PSE&G's technical requirements only, and does not indicate safe or faultless design. By review of the final plans or drawings, PSE&G is indicating that the design is compatible with PSE&G's equipment and service. Responsibility for proper design, operation, maintenance and safety of the customer's installation rests solely with the customer. In addition, all work and equipment must conform to municipal and all other applicable codes and requirements, including applicable provisions of the National Electrical Code (**NEC**) and the NESC in effect at the time of construction.

Note



PSE&G will not be liable for damages or for injuries sustained by customers or by the equipment of customers or by reason of the condition or character of customer's facilities or the equipment of others on customer's premises. PSE&G will not be liable for the use, care, or handling of the electric service delivered to the customer after same passes beyond the point at which PSE&G's service facilities connect to the customer's facilities.

4. Final acceptance by PSE&G before introducing service to the completed installation is dependent upon the customer obtaining approval from the electrical inspection authority having jurisdiction, and provision by such inspection authority to the local Electric Distribution Division Wiring Inspection Department of an original cut-in card.
5. Unless otherwise specified, PSE&G requires a minimum of 3 weeks after notification of completion of the customer's work and its walk through or inspection of the customer's installation, to test and set relays, breakers, meters and/or other associated equipment, including developing final cut-over procedures or other documents or procedures required for the customer. Further, any corrective items noted by PSE&G during the final walk through or inspection of the customer's site must be completed prior to PSE&G beginning its final commissioning work noted above.

4. Frequency and Voltage Regulation

The following are general voltage and frequency conditions on PSE&G's system that the customer should consider in its substation design.

1. The frequency of PSE&G's system is normally regulated at 60 Hz (cycles per second) and under usual conditions the variations are limited to 0.1 cycle above or below 60 Hz.
2. The voltage of PSE&G's 69 kV system under normal conditions will be within a range of 105% to 98% of nominal voltage with a maximum variation of 6%. Under emergency conditions the voltage can be within a range of 105% to 95% of nominal voltage with a maximum variation of 8%. If this regulation is not satisfactory for the operation of the customer's plant, it is the customer's responsibility to install suitable voltage regulation equipment. If the cost to supply service to the customer at these voltage ranges could be substantially reduced by operating outside these limits, PSE&G may render service with different limits under the terms of a special agreement with the customer.
3. It should be noted, that during fault conditions, short term voltage fluctuations of up to 0.5 seconds may occur on PSE&G's system which could result in abnormally low voltage and/or unbalanced voltages. This effect should be considered in the design of the customer's relaying. In addition, operation of certain types of customer's utilization equipment will adversely affect the power quality of the supply voltage. If the customer has installed critical computer or electronic equipment requiring continuity of service or exceptional service quality, it is the customer's responsibility to install any necessary uninterruptible power supply and/or a power conditioning device that may be required for this application.
4. It is also recommended that time-delay protective devices be installed on important motors and other critical equipment. This will permit the customer to avoid unnecessary outages during faults or surges on PSE&G's system or from the customer's in-plant facilities.

5. Short Circuit Duty

The maximum available three-phase symmetrical short circuit current on PSE&G's 69 kV system is 40 kA (Short Time Symmetrical 2 Seconds) / 63 kA (Momentary 10 Cycle Asymmetrical) / 104 kA (Peak). The construction of PSE&G's 69 kV system is dynamic and subject to change as required for the safe, adequate and reliable operation of the system. PSE&G recommends that the customer design its substation for the maximum short circuit current available.

6. Circuit Breakers

The following are general requirements for circuit breakers:

1. All circuit breakers on the high-voltage side of the customer's transformers shall meet the most recent edition of Electrical and Electronics Engineers (**IEEE**) Standard C-37 for 72.5 kV maximum rated voltage equipment. Line circuit breakers shall have a minimum of 1,200 A continuous current rating. Bus tie breakers may require higher current ratings depending on the substation configuration.
2. PSE&G requires all circuit breakers on the high-voltage side of the customer's transformers have short circuit interrupting duty of 40 kA (Short Time Symmetrical 2 Seconds) / 63 kA (Momentary 10 Cycle Asymmetrical) / 104 kA (Peak).
3. The line side of the service entrance or transformer circuit breaker shall be provided with a bushing-type, five tap multi-ratio American National Standards Institute (**ANSI**)/IEEE standard current transformer in each terminal. The current transformer shall be relay accuracy class C-800 or better on full tap, and its current rating shall be compatible to the continuous current rating of the breaker.

7. Fuses

PSE&G's preference is for the use of circuit breakers, but in some cases fuses may be utilized on the high-voltage side of the customer's transformers in lieu of transformer primary circuit breakers. This is only allowable for transformers of up to 10 MVA rating. If fuses are used, the voltage rating shall be greater than or equal to the system line-to-line operating voltage. The fuses shall meet the following requirements:

1. The fuses shall coordinate with PSE&G's source line(s) relaying and with the transformer secondary fuse, breaker or recloser. If the primary fuse is of the expulsion type, the minimum melting time shall be corrected for "preloading". The selection time between primary and secondary protection for a customer's transformers shall be a minimum of 0.5 seconds.
2. The fuses shall have an interrupting capacity equal to, or greater than, the maximum asymmetrical short circuit current available on the system at the fuse location, 40 kA.
3. The current rating shall be greater than or equal to the transformer manufacturer's nominal nameplate full load emergency rating. The customer shall submit its proposed fuse type to PSE&G's System Protection Department for approval prior to energization of the substation.
4. The fuses shall meet the requirements of the most recent editions of IEEE Standards C-37.46 and C-37.48.

8. Battery

A storage battery or other reliable DC source, shall be provided to supply DC voltage for automatic tripping of the circuit breaker(s). The latest editions of IEEE Standards 484 and 485 provide guidance in calculating the appropriate battery size and for installation design and procedures. IEEE Std. C37.06-2009, Table 18 provides the control voltage range required at the circuit breaker(s).

The battery shall be equipped with an automatic charger, a voltmeter and a low voltage alarm. The low voltage alarm shall be either an audible alarm that will provide a response, or a remote alarm to a manned location. Likewise, if another DC source is utilized, it shall be alarmed to indicate loss of voltage.

The battery shall be sized for minimum of an 8-hour discharge rate.

9. Relays and SCADA Interface

The following are general requirements for relaying and SCADA equipment:

1. Specific PSE&G requirements will be provided for relays and their associated equipment, as required for the operation of circuit breakers and/or motor-operated disconnecting switches.
2. All proposed relay designs involving the protection of the 69 kV equipment, including single line diagram, relay and instrumentation diagrams, tripping tables, etc. must be reviewed and approved by the PSE&G System Protection Group prior to purchasing the equipment. Additionally, please contact PSE&G for approved relay types prior to the design of the protection scheme. The customer will be responsible for applying certain relay settings provided by PSE&G using an approved third party testing company at the customer's expense. Written relay test results must be provided to PSE&G for the initial installation, and provided every 4 years thereafter, when the settings are verified by an approved testing company.

3. All protective relays shall have provisions for isolating the relays for testing or replacement purposes while the equipment is in service. Relay isolation shall be accomplished by using switches such as the ABB FT-1. Test switches in AC current circuits shall be equipped with test jacks for test connections.
4. The current and potential transformers supplying the relays shall not be used for any other purpose.
 - a. All CTs for relay protection shall adhere to ANSI/IEEE Standard MRCT, C800 class or better.
 - b. 69 kV breakers shall be equipped with two sets of three-phase CTs on both sides to provide overlapping zones of protection for incoming PSE&G lines, the customer's 69 kV bus and 69 kV transformers, unless it is not possible to fit in two sets due to space limitations, in which case the relay and Current Transformer (**CT**) arrangement and accuracy class must be submitted to PSE&G for approval of the configuration.
 - c. Each incoming 69 kV line shall be provided with three line-side single phase Potential Transformers (**PTs**), with a 69000/ 3-69:69 V ratio, wye-connected on both the primary and secondary sides.
5. It is recommended that the customer consider the installation of differential relaying for the protection of large power transformers.
6. If differential relaying is installed, the overcurrent relays associated with each service entrance breaker shall be connected to the bushing-type current transformers on the source side of each service entrance breaker. If CTs are not available on the source side of the entrance breaker, load side CTs may be used.
7. To facilitate maintenance and eliminate the possibility of vibration damage/inadvertent operation, the relays for tripping high-voltage circuit breakers shall be installed in a separate weatherproof enclosure or on the rack in the control house or control room.
8. Basic Distribution SCADA functionality should be considered for all customer subs. For small 69 kV customers a standard Mini SCADA box may be used. The box has only dry contact inputs for indication enabled. Standard prints for this class and coded NEMA 4 Mini SCADA box are 311336, 311337, and 311338. This SCADA box is PSE&G class and coded with code W930001 and is usually kept in stock by PSE&G. Please contact PSE&G design group for standard prints to be used in designing point to point diagrams and review of proposed design. PSE&G Design should be contacted for direction and final review of the design.
 - a. PSE&G shall require approximately 48 in. x 48 in. of open wall space to install a distribution SCADA RTU for monitoring of the station. The RTU itself is approximately 30 in. x 30 in. x 12 in.
 - b. 125 V DC from station batteries is required available at the SCADA RTU for power.
 - c. 120 V AC is required as a back-up source of power. This is also used for the heater and AC convenience outlet.
 - d. This RTU takes up to 16 dry contact inputs and provides a wetting voltage to the field contact with the power supplied.
9. Recommended indications/alarms shall be as follows if available and should be wired in this order. If the specific alarm is not available, a spare input shall be left in its place. The points listed here are suggestions and of course every site will have slightly different points to be submitted and approved by the local operations and Relay groups. Specific text can be modified in the Master. As a rule of thumb, Station Alarm (as described elsewhere in the alarm bus portion of the spec.), Station Control handle in Auto, Breaker / motor operated disconnect indication, DC System trouble, Station L&P fail are the most basic. The customer must supply a dry contact and wiring to the RTU cabinet for each available point.
 - a. Common Station Alarm (If Available and Applicable)
 - b. Station Control Handle (If Available and Applicable)
 - c. Fire Alarm (If Available and Applicable)

- d. Station Battery System Trouble (If Available and Applicable)
 - e. Station Light and Power Fail
 - f. L1 Breaker Status (Any Line Breaker MOC “A” and TOC in Series)
 - g. L2 Breaker Status (Any Line Breaker MOC “A” and TOC in Series)
 - h. SEC. 1-2 Breaker Status or Motor operated disconnects
 - i. Transfer Auto/Manual
 - j. SPARE
 - k. SPARE
 - l. SPARE
 - m. SPARE
 - n. SPARE
 - o. SPARE
 - p. SPARE
10. A standard dial-up phone line, otherwise known as a Plain Old Telephone Service (**POTS**) line and normally ordered and maintained by the customer, is to be terminated at the location of the Distribution SCADA RTUs. The customer agreement with the operating division shall define who orders and maintains the line.
11. If a standard energized POTS line is not available from the telephone service provider and a fiber optic connection is provided, the customer shall provide an uninterruptable power supply to the router or other interface device. The router or other interface device shall be powered in such a fashion, so that if power to the facility goes down the communications system shall be kept “live” for a minimum of at least 8 hours.
12. ESOC RTU needs to be installed to provide a required control, status indication and telemetering points as follows:
- a. Output for transformer LTC 5% voltage reduction control (raise/lower)
 - b. Status indication to monitor 69 kV circuit breaker (open/close)
 - c. Analog input to measure three-phase line currents and voltages
13. The following requirements need to be met to support the installation of ESOC RTU:
- a. PSE&G shall require approximately 48 in. x 48 in. of open wall space to install the ESOC RTU. The RTU itself is approximately 24 in. x 24 in. x 12 in.
 - b. 125 V DC from station batteries is required available at the ESOC RTU for power.
 - c. 120 V AC is required as a back-up source of power. This is also used for the heater and AC convenience outlet.
14. PSE&G shall designate, select and specify the equipment and subsequent telecommunications devices to be used for interface with ESOC by means of fiber optic cable, digital data links and/or analog signals to be installed at the facility.
15. Corresponding communication circuit to be terminated at ESOC RTU should be ordered and maintained by the customer.

16. Please contact PSE&G design group for standard prints to be used in designing point to point diagrams and review of proposed design for ESOC. PSE&G Design should be contacted for direction and final review of the design.
17. The presence of any type of generation running in parallel with the service may result in additional specific protection, SCADA, and ESOC RTU design requirements. The customer engineer is required to identify any generation and obtain direction and approval from PSE&G Design Group based on the specific planned install.
18. PSE&G shall designate, select, specify and purchase the equipment required for Distribution SCADA and ESOC purposes. The applicant shall receive the devices from PSE&G and install the equipment at its facility. If necessary, PSE&G will install any other SCADA and ESOC equipment required at its facilities, at the applicant's expense. The applicant shall pay PSE&G for all costs associated with SCADA and ESOC equipment.
19. Two copies of each relay instruction book for all line and bus relays shall be provided to PSE&G 2 months prior to the expected service date.
20. Note that some multifunction microprocessor relays may be used with the prior approval of PSE&G's System Protection Group.
21. Relays required for the protection of a sub-transmission line or a transmission line, are very specific to the application and are based on the line configuration, impedances, etc. Those requirements are not in the scope of this document. The PSE&G System Protection Group in Newark must be contacted for specific recommendations. At that time, sample AC and DC schematics will be provided by PSE&G.
22. For other applications (i.e. bus differential protection discussed in item 5 above) the same System Protection Group in Newark must be contacted for specific relay recommendations.

10. Disconnecting Switches

The following are guidelines for disconnecting switches:

1. Guidelines for the application, installation, operation and maintenance of disconnecting switches are described in the latest editions of IEEE NESC C2-2012, Sections 173 and 216, as well as the latest editions of IEEE C37.30, C37.32 and C37.35.
2. The line disconnecting switches shall be horizontally mounted, three-pole, gang-operated, vertical break devices with arcing horns. One three-pole, gang-operated line grounding switch shall be installed as part of each line disconnecting switch, and shall be mechanically interlocked in such a way that the line grounding switch cannot be closed when the line disconnecting switch is in the closed position, and the line disconnecting switch cannot be closed when the line grounding switch is in the closed position. The line disconnecting switches and the line grounding switches shall be so arranged that they can be padlocked in any position desired. The Ground Switch shall be of 72.5 kV Class, withstand 350 kV BIL in the open position and have a withstand rating of 40 kA (Short Time Symmetrical 2 Seconds) / 63 kA (Momentary 10 Cycle Asymmetrical) / 104 kA (Peak) and meet all applicable operational and test parameters for service in 69 kV systems.

Note



ANSI Standards do not require ground switches to have a fault close rating since proper operating practice requires the circuit be tested de-energized before closing the ground switch. It must have a momentary rating of 63 kA.

3. Disconnect switches shall be 350 kV BIL, and have a Withstand / Fault Make – Latch rating of 40 kA (Short Time Symmetrical 2 Seconds) / 63 kA (Momentary 10 Cycle Asymmetrical) / 104 kA (Peak).
4. Line disconnecting switches and any line breaker bus disconnecting switches or bus sectionalizing switches shall be rated 1,200 A. Bus sectionalizing switches may require higher current ratings depending on the customer's substation configuration.
5. Where a circuit breaker is not used as the primary side disconnecting means for a main power transformer, then the primary side disconnecting switch shall be capable of interrupting the magnetizing current of the transformer and be rated at least 1,200 A load break capability and be tested and capable of at least five full load interruptions at an operating voltage of 72.5 kV minimum.
6. Any disconnecting switch mounted vertically shall be hinged at the bottom to prevent accidental closing.

11. Revenue Metering Equipment

The information listed below pertains to Revenue Metering Equipment.

1. PSE&G will furnish two PTs and two CTs for revenue metering, the secondary control cable and test switches for each metering point.
2. PSE&G will not permit the connection of any customer equipment to the metering transformers used for its revenue metering. No device other than those used for automatic tripping, or those supplied or required by PSE&G, shall be placed on the line side of the billing meters. The revenue metering transformers shall be installed after the customer's main breaker(s), fuse(s) or disconnect(s). In stations with multiple incoming lines, the metering transformers shall be on the load side of the common bus.
 - a. The customer shall install instrument transformers in an approved manner, and on suitable foundations or structural support members. To support change or maintenance of instrument transformers, switches or other means of visible disconnect shall exist on the line and load side of instrument transformers. The customer shall wire the high-voltage side and the equipment ground connection. The instrument transformer equipment ground shall be 350 MCM minimum, copper wire or equivalent. The closely spaced primary connections to metering transformers shall not exceed a length of 3 ft.
 - b. The primary connections shall be made so that the PTs are connected on the line side of the CTs. These connections shall be direct and shall not be fused. 250 kcmil is the maximum size wire that can be terminated on the PTs, #2 AWG is the minimum size that may be used.
 - c. A 12 in x 12 in. x 5 in. pull box will be installed on the metering transformer structure. The box shall have provisions for locking and shall be NEMA 3R or 4X as required by PSE&G. Conduit runs from these transformers to this pull box may be made with 1-1/2 in. weatherproof flexible conduit, or threaded rigid galvanized steel conduit using Erickson or equivalent type fittings.
 - d. A 1/2 in. Everdur or equivalent type stud projecting 1-1/2 in. inside and outside the box with double nuts on both sides shall be provided for secondary grounding connections, with an external tie-in to the ground bus. Metering transformers, the transformer secondary's grounding stud, and conduit shall be solidly connected to the station ground bus by direct copper connections of not less than 350 MCM or flat copper bar 2 in. x 1/4 in. in cross section.
 - e. The mounting arrangement for the CTs shall be designed for GE JKW-350 CTs. These CTs will be used for 25/50:5 through 1500/3000:5 ratios. CTs shall not be considered to be bus supports. The bus shall be properly supported and braced without the CTs. For details of current transformers see *Meter and Wiring Manual* (Rev. 1, 3/15/11) Figure 10.38 as well as attached [Figure 6.3](#).
 - f. The mounting arrangement for the PTs shall be designed for GE JVT-350 PTs. For details of potential transformer see *Meter and Wiring Manual* (Rev. 1, 3/15/11) Figure 10.47 as well as attached [Figure 6.4](#).

12. Insulators, Conductors, Connections and Clearances

The following are general requirements for insulators, conductors, connections and clearances.

1. Specific detail requirements for bus supports and insulators rated for 200 kV BIL minimum and corresponding clearances are described in the latest editions of IEEE Standards C37.32, and ANSI/NEMA C29.8 and C29.9.
2. All 69 kV bus shall consist of rigid bus construction, and such bus and flexible connections shall be in accordance with the guidelines of the latest edition of ANSI/IEEE Standard 605. The length of flexible connections should be kept to a minimum and in no case should the length exceed 6 ft. The closely spaced connections to metering transformers should be limited to 3 ft in length.
3. Bus construction shall have 1,200 A capacity in the line positions. The main bus between positions may require higher current ratings depending on the customer's substation configuration. The bus must be tubular copper or aluminum.

13. Transformers

Transformers shall comply with the general requirements and installation guidelines of latest edition of IEEE Std. C57.

Transformers shall be delta connected on the 69 kV side.

14. Surge Arresters

PSE&G recommends the installation of surge arresters. If surge arresters are to be installed, they shall meet the following requirements:

1. Surge Arresters shall be installed in accordance with the guidelines and standards of the latest edition of ANSI/IEEE Std. C62.
2. Single-phase, station class, Metal Oxide Varistor (**MOV**) type surge arresters shall be installed on the 69 kV side of each transformer and shall be readily disconnected for maintenance. The arresters for transformers of 69 kV class shall be rated at 66 kV Station Class.
3. Single-phase MOV type surge arrester protection shall be installed on the line side of each line disconnecting switch. The arresters shall be 60 kV Station Class arresters, and shall be readily disconnected for cable fault location purposes.

15. Grounding

The following are general requirements for grounding:

1. Specific detail requirements for grounding are described in the latest editions of the NEC, NESC and IEEE Standards 80 and 81. The station ground resistance shall be measured in accordance with Section 8 of IEEE Std.81-2012 “IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of the Grounding System” and Section 19.1 of IEEE Std. 80-2000 “IEEE Guide for Safety in AC Substation Grounding”. These standards provide procedures for measuring the earth resistivity, the resistance of the installed grounding system and the continuity of the grid conductors.
2. PSE&G will supply the following values:
 - Maximum ground fault current
 - Maximum fault clearing time
 - Split factor, Sf
 - X/R Ratio
3. The Customer shall supply PSE&G with the following information:
 - Plans and details of the substation that indicate conductor size and typical grounding grid design
 - Calculations as described in IEEE Std. 80-2000, with special attention paid to step and touch potentials.
4. For typical customer’s substation grounding details see [Section 25](#). “Standard Layouts”, [Figure 6.8](#).

16. Location and Structural Arrangement

The following are general requirements for substation layouts:

1. At any location where the following actions may be performed there shall be adequate, safe space available for:
 - Inspection
 - Maintenance
 - Routine removal or replacement of components
 - Routine removal or replacement of power or control cable
2. The customer’s substation site should be selected to provide adequate clearances from existing and future buildings. The clearance between energized equipment and other structures shall meet or exceed the latest requirements of NESC, NEC, and IEEE STD 1427.
3. In no case shall any building be located within 15 ft of energized equipment (except the control house). Where necessary, a parapet guard shall be considered for installation along the building roof adjacent to the substation for safety of personnel.
4. The substation shall be enclosed by a fence at least 7 ft high, (6 ft fence with 1 ft of barbed wire) as described in the Section 110A of IEEE NESC C2-2012. Fences and gates shall be equipped with “Danger High Voltage” signs as required by the NEC and NESC.

5. Substation design should meet requirements of IEEE Std. 979-2014 “IEEE Guide for Substation Fire Protection” or National Fire Protection Association (NFPA) 850, 2015 Edition including as a minimum:
 - a. Construction of oil spill containments for transformers filled with a mineral oil
 - b. Separation of mineral oil containing transformers from each other and substation buildings by distances listed in Table 1 of IEEE Std. 979-2014 or Table 5.1.4.3 of NFPA 850, 2015 Edition. If these distances can't be achieved, 2 h rated firewalls should be constructed designed in accordance with the above-mentioned standard.
6. Substation should have an adequate lightning protection in accordance with the latest revision of IEEE Std. 998 “Guide for Direct Lightning Stroke Shielding of Substations”.
7. If a building wall is used as a part of the substation enclosure, there shall be no windows, doors, fire escapes, vents, drains, down spout openings, or other foreign obstructions in or near such areas of the wall which are bounded by the projection of the substation building; this section of the wall shall be made of a fireproof material type of construction.
8. The substation structure must be of sufficient strength and properly braced to adequately support PSE&G's entering 69 kV lines, each conductor of which may have a maximum tension of 2500 lb and may deviate up to 45 degrees from a direct approach.
9. For personnel safety, lighting of the substation should be provided for walkways and in operating areas as per NESC, Section 111.
10. A telephone shall be provided in the control house for the purpose of switching.

17. More Than One Source

Where the customer's load can be supplied from more than one source, such as the customer's own generation or a duplicate service from PSE&G, the entrance switchgear shall be provided by the customer with a sign stating “Caution – Multiple Power Sources”.

Additional requirements may be specified by PSE&G depending upon the customer's equipment and/or arrangement.

18. Mimic Bus

A Mimic Bus or schematic representation, illustrating the arrangement of the devices and apparatus contained in the HV equipment system, shall be displayed on the front panels of the control racks.

19. Operating Procedures

The following are standard operating procedures for the substation:

1. To provide for security of PSE&G's system and for the safety of PSE&G's and the customer's personnel, PSE&G requires operational control of the following devices at the customer's substation:
 - 69 kV line disconnecting switches
 - Line grounding switches
 - Line circuit breakers and their bus disconnecting switches
 - 69 kV bus sectionalizing switches and breaker(s), if provided

A representative of PSE&G's local Electric Distribution Division will operate these devices as directed by that Division's Service Dispatcher.

2. An authorized attendant of the customer may operate the 69 kV service entrance breaker(s), the breaker isolating switches and all equipment on the load side of the service entrance breaker(s) as desired. The customer's authorized attendant is never to operate the devices listed above in item 1.
3. In the event of an interruption to service, PSE&G will to restore service as soon as possible without notification.
4. Specific operating instructions will be provided to the customer prior to energization.

20. Other Requirements

“**Danger High Voltage**” signs shall be installed in accordance with applicable requirements of the NEC and the NESC in effect at the time of construction.

Approved “Lamicoid” tags shall be furnished by the customer on all switchgear compartments and board-mounted components, and all circuit breakers, transformers and disconnect switches. Tag names shall be identical to the terminology used in the customer's drawings, or as specified by PSE&G at interface points. All tags shall be attached with either stainless steel pins or stainless steel machine screws.

21. Customer Responsibilities for Testing and Commissioning

Normal protocol would expect that all the work listed below is performed when commissioning customer substations. This work is the responsibility of the Customer and is normally performed by the site Electrical Contractor and a Testing Contractor. Testing and commissioning must be performed by a certified National Electrical Testing Association (**NETA**) company.

1. Customer shall perform the following:
 - a. Tightening and torquing of all bolted electrical connections.
 - b. Verification of all external wiring.
 - c. Complete testing of all protection and control circuits using the AC/DC schematics.
 - d. Hi-pot, Doble and Ductor testing of all circuit breakers.
 - e. Timing test for service entrance and bus tie circuit breakers.

- f. Hi-pot and Doble testing of all bus work including arrestors. Ductoring of bus work is also recommended.
 - g. Operational verification of each circuit breaker – electrical, mechanical, safety interlocks.
 - h. Operational verification of each line disconnect and ground switch and keyed interlocks.
 - i. Ratio verification of potential devices.
 - j. “Megger” and ratio tests of all current transformers.
 - k. Setting the ratio of all CTs as per protection requirements – Line Protection CTs shall be set by PSE&G.
 - l. Shortening all unused CTs and winding taps as necessary.
 - m. Calibration of all instruments.
 - n. Verification and adjustment of battery chargers as required – verification of set points of all battery related alarms
 - o. Verification and testing of all alarms to the annunciator.
 - p. Verification of accuracy of Mimic Bus against the One Line.
 - q. Verification of operation of telephone circuits for SCADA and metering.
 - r. Verification of correct taps for transformers.
 - s. All necessary transformer tests before energizing (TTR, Doble, hi-pot, cooling system as required).
2. PSE&G shall:
- a. For service entrance and bus tie circuit breakers, perform operational checks and review results of Ductor and timing tests performed by the Customer.
 - b. Set line relays (bus differentials and breaker failure if used), verify associated instrumentation and perform operational / trip checks of service entry and bus tie breakers.
 - c. Set and test the required ratio of CTs associated with the line relays.
 - d. Verify operation of line disconnects, line grounds and keyed interlocks.
 - e. Install and verify metering and SCADA equipment

22. Construction in Flood Prone Areas

As part of the customer facility design process, the customer or customer’s engineer shall determine if the customer site is prone to flooding by reviewing the latest Federal Emergency Management Agency (**FEMA**) and New Jersey Department of Environmental Protection (**NJDEP**) Flood Maps. If flooding is a possibility, station equipment that may be impacted by flood waters shall be installed at least 1ft above the highest available design flood elevation as determined by:

1. FEMA 100-year Base Flood Elevation (**BFE**)
2. NJDEP Flood Hazard Area Limit (**FHAL**)

This will apply to, but not limited to, metal clad switchgear, circuit breakers, operating mechanisms for disconnects, transformers, batteries, relays, terminal blocks (especially those carry DC current) and other vulnerable electronic devices.

23. Animal Deterrent

It is required to mitigate interruptions and equipment damage resulting from animal intrusion into electric power supply substation by using the means of animal deterrent recommended by the latest IEEE Guide 1264.

24. Arc Flash Hazard Calculation Studies

It is required to performed Arc Flash Hazard Calculation Study in accordance with latest IEEE STD 1584 and NFPA 70E and reviewed by PSE&G.

The arc-flash study report should include the following information as a minimum:

1. Executive summary.
2. Narrative describing the scope and results of the study and the methodology used.
3. Description of modes of operation (power system) and details of the scenarios evaluated.
4. Results of short-circuit analysis listing equipment that is applied above its short-circuit current rating, and recommendations if appropriate.
5. Results and recommendations of time-current analysis, including time-current curves.
6. Arc-flash spreadsheet: A tabulated form including a listing of all equipment that had arc-flash hazard values calculated as part of the study. This listing should include the calculated three-phase bolted fault current, arcing fault current, identity of overcurrent protection device with its opening time, working distance, arc-flash protection boundary, and incident energy.
7. A tabulated form showing the worst case incident energy calculated for each bus and the associated mode of power system operation. Report may include incident energy calculated for each bus for each mode of operation.

Note This may be a part of the arc-flash spreadsheet.



8. Documentation of all study input data, including utility available fault currents; cable sizes, types, and lengths; motor data; breaker types and settings; fuse sizes and types; etc.
9. Up-to-date single-line diagram(s).
10. Documentation of the software manufacturer, exact version of software used, and configuration settings used to do the study.
11. List of assumptions that were made for cable lengths, CT ratios, transformer impedances, etc.
12. Additional information may be included where it enhances understanding of the electrical system and arc-flash study.
13. Advisory statements covering the impact of changes to the power system, including overcurrent protective devices or system operation and potential impact on arc-flash incident energies.

25. Standard Layouts

Figure 6.1: Dual Supply - Dual Transformer (69 kV Ring Bus)

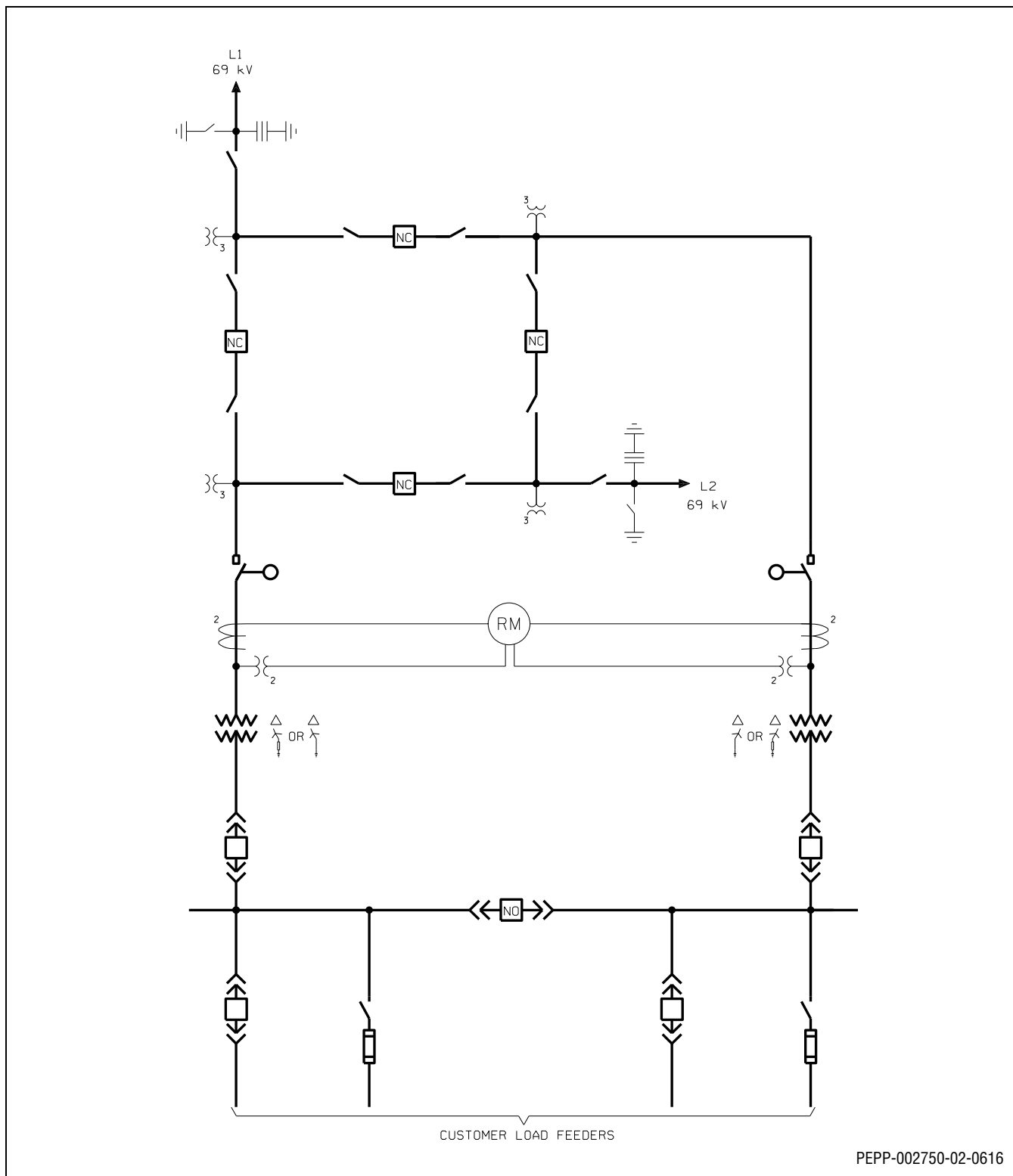
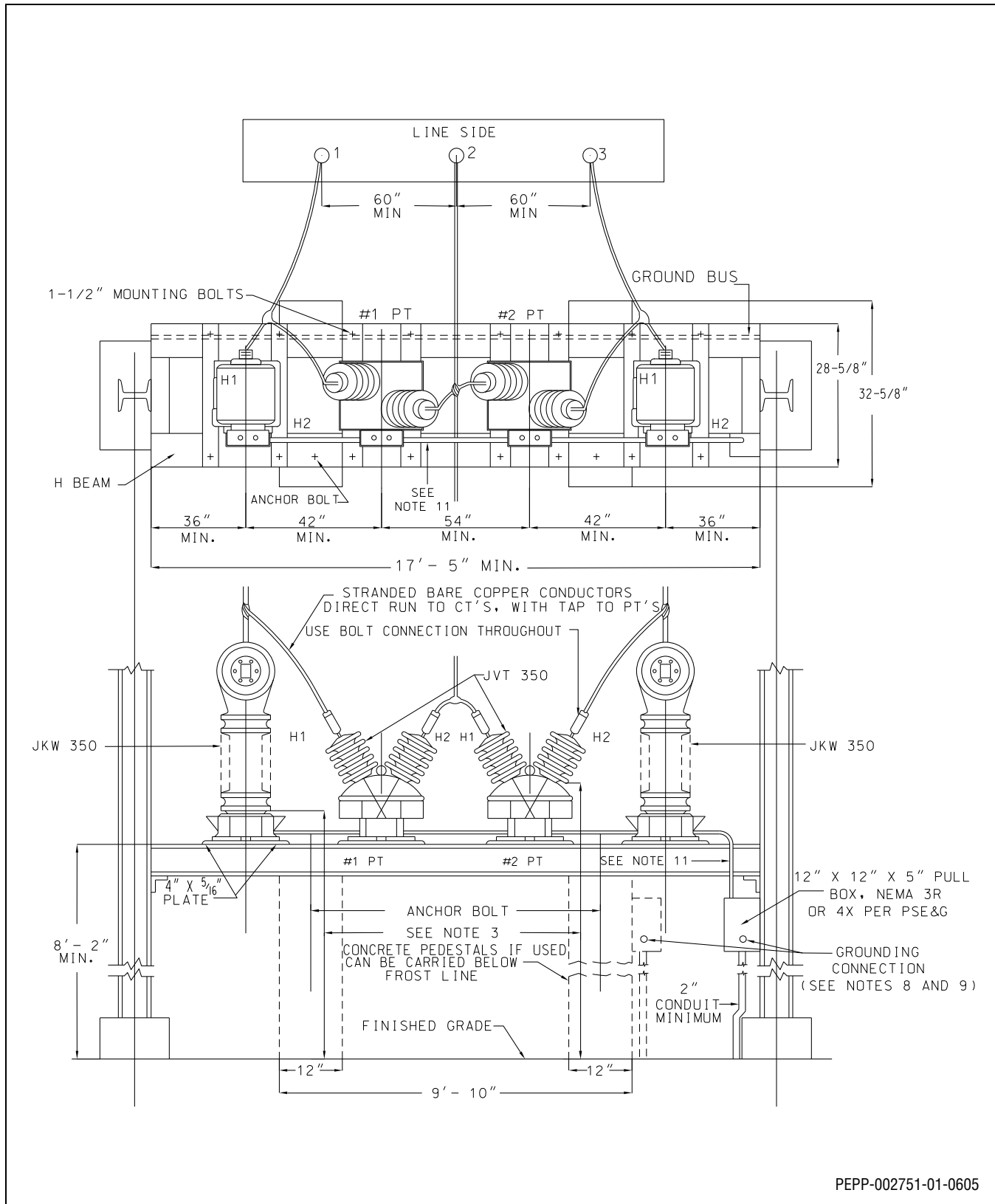


Figure 6.1: Notes:

1. Connections to metering transformer secondary terminals, test switches, meter equipment and meters will be made by PSE&G.
2. PTs and CTs for metering shall be accessible at all reasonable times for the purpose of inspection, maintenance or change-out by PSE&G. If the PTs and CTs are enclosed in switchgear or a transformer cabinet, or compartment where visual inspection is impractical, access is to be limited only to PSE&G personnel by a hinged door having provision for PSE&G barrel locks and seals. Metering transformers, secondary wiring and unmetred primary conductors shall be visible for inspection when the service is energized.
3. Threaded rigid galvanized steel 2 in. conduit shall be used for the secondary control cable runs from the metering transformer pull box to the meter enclosure, and shall be supplied and installed by the customer. PVC conduit is not acceptable.
 - a. Conduits for metering transformers secondary connections shall be dedicated conduit that shall not pass through either trenches, hand holes or manholes. Metering conduits shall be inspected prior to backfill or pouring concrete.
 - b. PSE&G shall furnish the secondary control cables, and the customer shall pull the cables
 - c. Connections to metering transformer secondary terminals, test switches, meter equipment and meters will be made by PSE&G.
4. A meter panel with minimum dimensions of 36 in. wide x 36 in. high is to be supplied by the customer and installed at a height of no less than 24 in. and no more than 78 in. from the floor. However, if two sets or more of instrument transformers are used, this meter panel shall be 4 ft x 6 ft. Please discuss the meter panel layout with PSE&G's local Electric Distribution Division Metering Department. There should be 48 in. of clear space in front of the meter panel to provide space for installation and metering of equipment. This panel shall be located immediately adjacent to the metering cubicle, but in no case shall the length of secondary leads from the metering transformers to the revenue meters exceed 180 ft.
 - a. The station ground shall be extended to the meter enclosure for grounding of the metering circuits and equipment in accordance with the NEC.
 - b. The meter panel and associated equipment shall be housed inside a building or in a weatherproof, heated structure. A metering and control house for housing the metering equipment, relays, control equipment, telephone and storage battery is recommended. A door for entrance to this structure shall be equipped to take PSE&G's standard padlock, and access preferably should be from outside the substation enclosure.
 - c. Painted plywood is recommended for the meter panel. Thickness shall be 3/4 in. and a 1 in. air gap shall be provided behind the wood to enhance dryness. Alternative materials may be used for the meter panel with advanced PSE&G approval.
 - d. Lighting must be available at indoor metering locations for meter readings and inspections.
 - e. If the customer elects to house the meter board in a heated outdoor metal enclosure, such structure requires specific PSE&G approval as to the size, layout and mounting location of the enclosure. A 120 V duplex outlet shall be provided on the meter panel.

- f. Drilling dimensions for the meter enclosure will be supplied by PSE&G's local Electric Distribution Division Metering Department personnel, as will specific details as to the type and size of metering transformers that will be furnished by PSE&G. Refer to figures at the back of this chapter for typical examples:
- [Figure 6.5](#) – Meter Panel for one set of metering instrument transformers
 - [Figure 6.6](#) – Indoor Meter Panel for two sets of instrument transformers
 - [Figure 6.7](#) – Outdoor Meter Panel for two sets of instrument transformers
- g. PSE&G shall provide the revenue meter socket(s), relay enclosures, and any enclosures required for test switches. The local Electric Distribution Division Metering Department will provide an arrangement plan for this equipment. The customer shall mount this equipment on the meter board, and provide the connecting conduits. PSE&G will connect the wiring to the test switches, meters and other associated equipment on the meter board.

Figure 6.2: Customer's 69 kV Outdoor Metering Arrangement for Metering Transformers JKW-350 with JVT-350



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Figure 6.2 Notes:

1. Minimum clearance phase-to-ground 27 in.
2. Minimum clearance phase-to-phase 34 in.
3. Minimum vertical clearance from bottom petticoat of transformer bushing to grade or any other horizontal surface suitable for standing on it (for example, platform) should be 8 ft-9 in. minimum.
4. For outline diagram of potential transformers see *Meter and Wiring Manual* Figure 10.47 and [Figure 6.4](#).
5. For outline diagram of current transformers see *Meter and Wiring Manual* Figure 10.38 and [Figure 6.3](#).
6. Transformers may be mounted to the structure as shown or may be attached to concrete pedestals, (shown as dotted lines).
7. All conduit shall be threaded galvanized rigid steel or weatherproof flexible conduit.
8. A 1/2 in. Everdur or equivalent type stud, projecting 1-1/2 in. inside and outside box with double nuts on both sides, shall be provided for grounding connections, with external tie-in to the ground bus.
9. Metering transformers, pull box grounding stud, and conduit shall be solidly connected to the station ground bus by using direct copper connections of not less than 350 MCM, or flat copper bar 2 in. x 1/4 in. in cross section.
10. All steel bracing in the vicinity of current and potential transformers shall have 27 in. minimum clearance from live parts.
11. When installing #2 PT reverse secondary connections.
12. The conduit between instrument transformer secondary terminal boxes shall be 1-1/2 in. weatherproof flexible or 1-1/2 in. rigid galvanized steel (if flexible conduit, use Erickson or equivalent type fittings).

Figure 6.3: GE Current Transformer JKW-350 Outline Dimensions

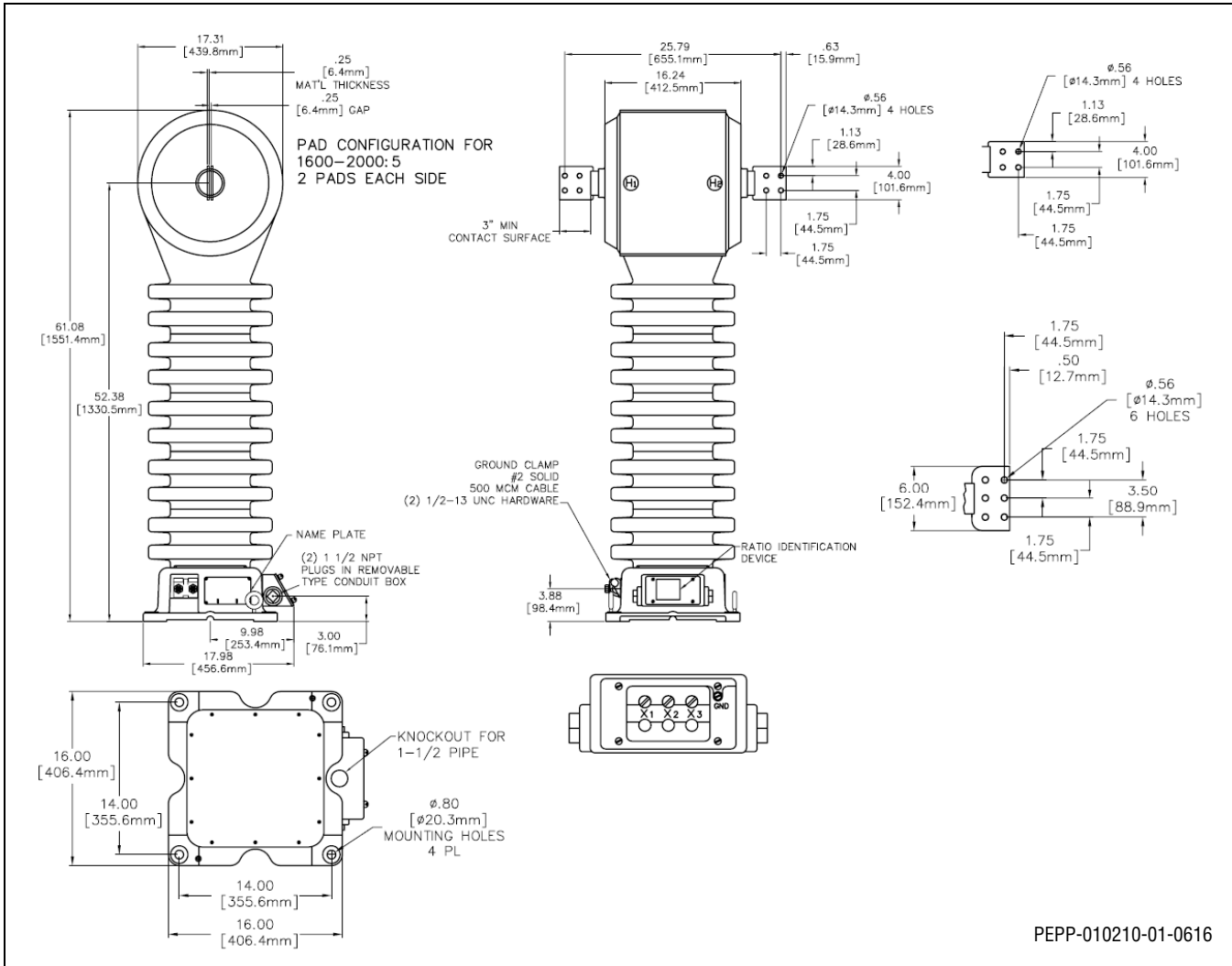


Figure 6.4: GE Potential Transformer JVT-350 Outline Dimensions

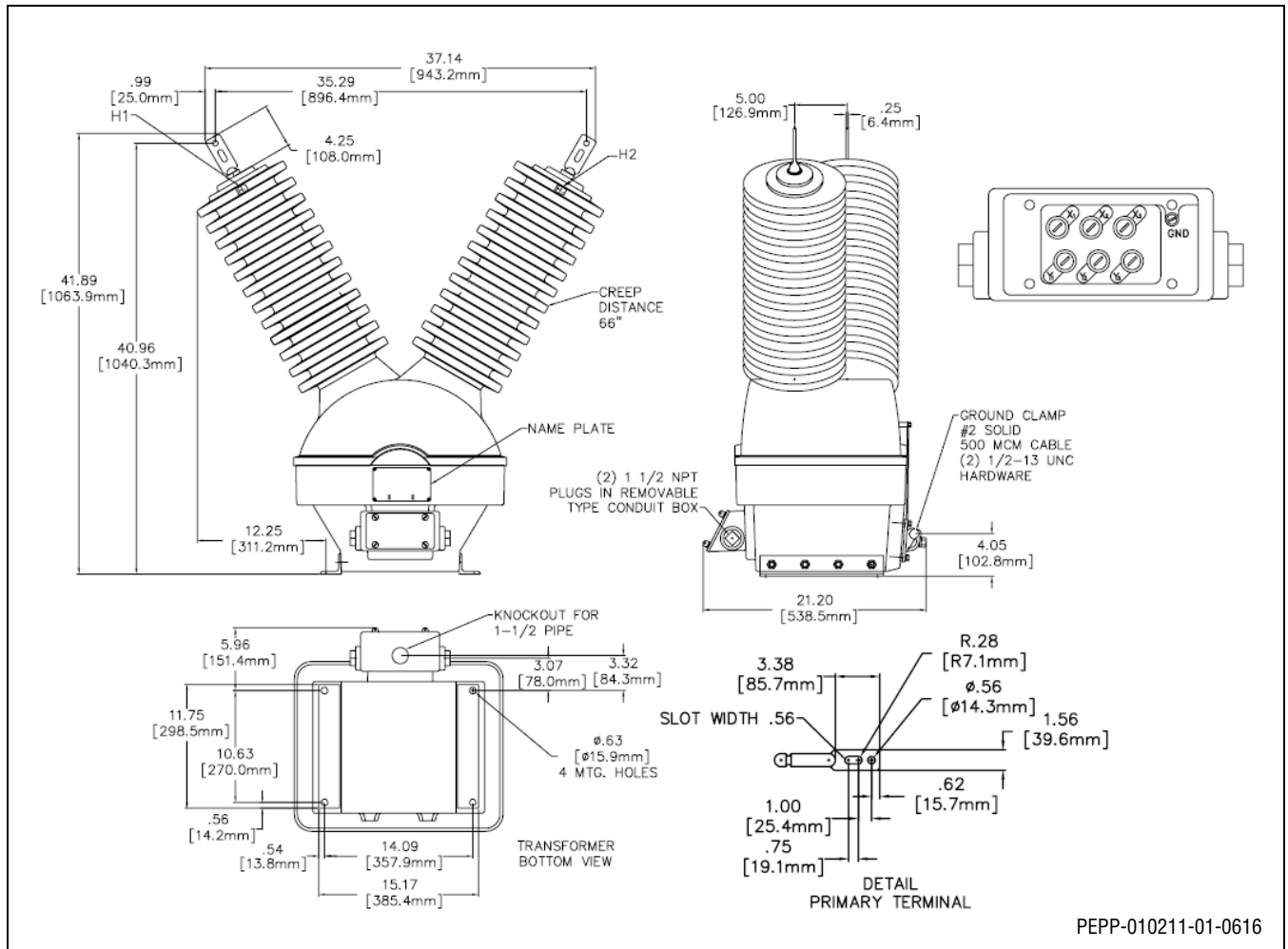


Figure 6.5: Meter Panel – Single Metering Point

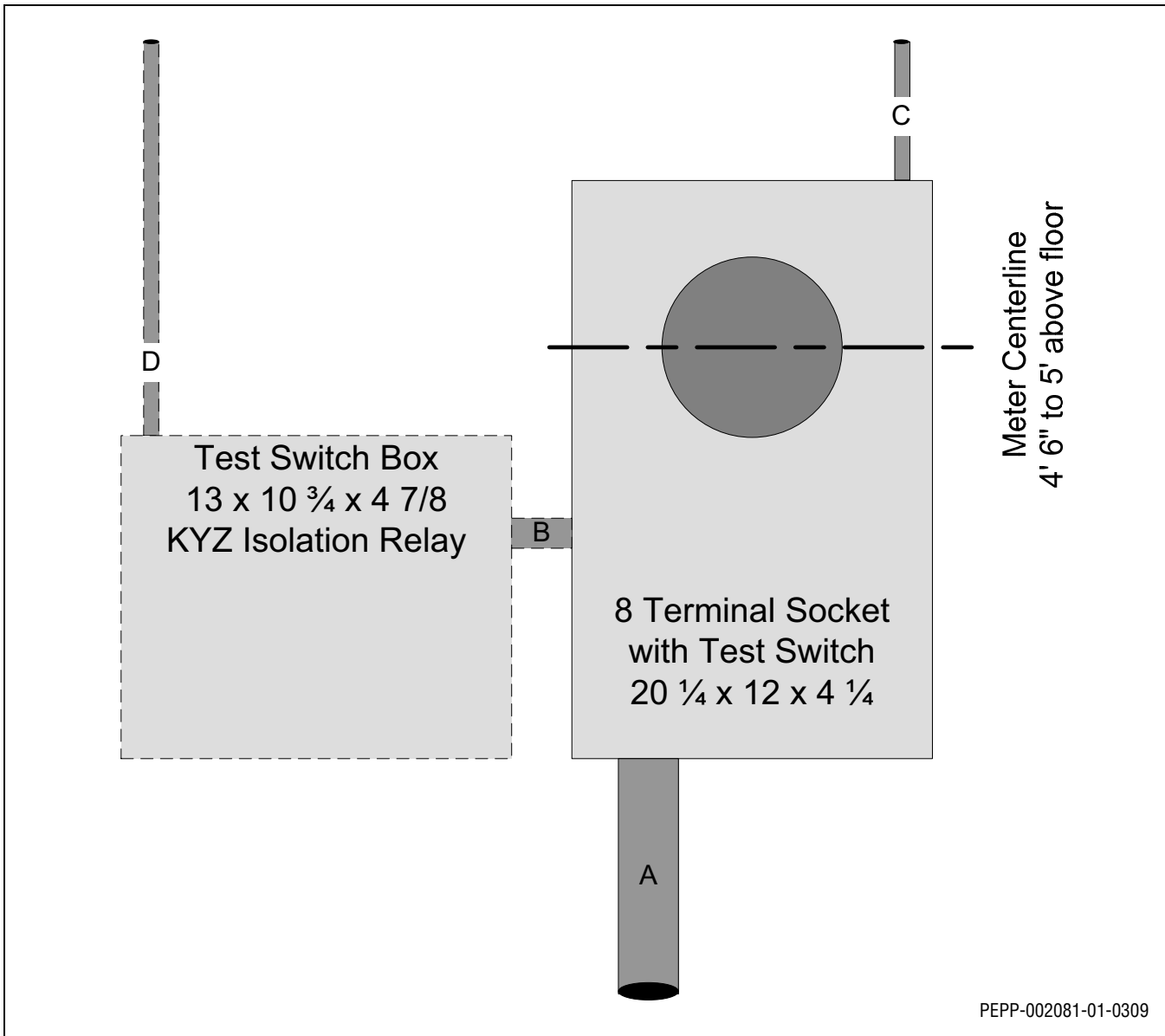


Figure 6.5 Notes:

Note	Conduit	Comment
A	2 in. RGS	For Instrument Transformer Secondary Connections
B	1 in. RGS nipple	With lock nuts and grounding bushings or use lock nuts with piercing screw and plastic bushing, 2 in. min length
C	1/2 - 1 in. EMT, PVC or RGS	Phone line (POTS) - Suggest 4 pair Cat 5
D	1/2 - 1 in. EMT, PVC or RGS	Optional KYZ to Customer Suggest < 10 ohm loop resistance

Equipment to be mounted on 36 in. x 36 in. x 3/4 in. minimum painted plywood attached to the wall to provide an air space behind plywood.

Figure 6.6: Meter Panel – Indoor – Two Metering Points

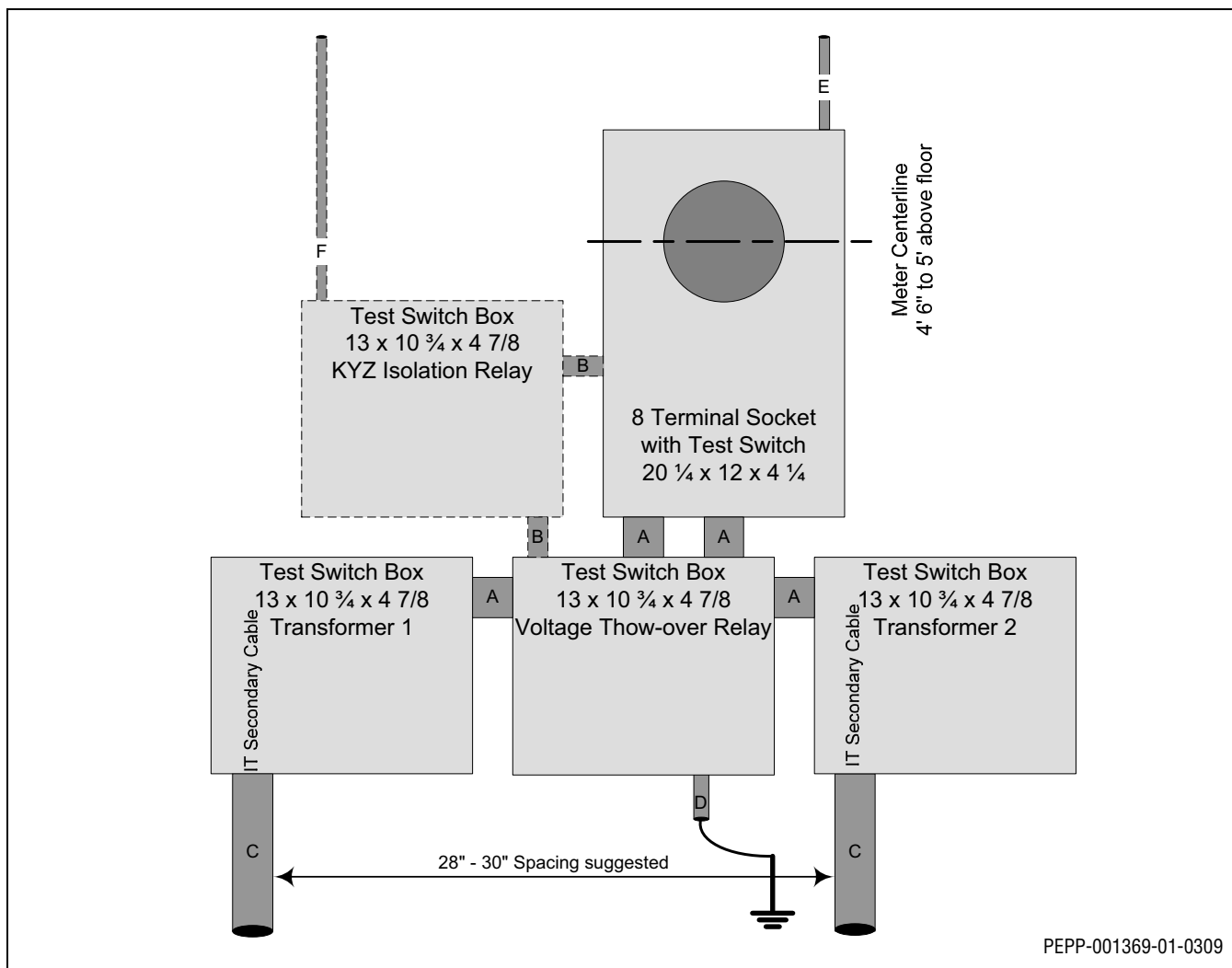


Figure 6.6 Notes:

Note	Conduit	Comment
A	2 in. RGS nipple	With lock nuts and grounding bushings or use lock nuts with piercing screw and plastic bushing, 2-1/2 - 3 in. long
B	1 in. RGS nipple	With lock nuts and grounding bushings or use lock nuts with piercing screw and plastic bushing
C	2 in. RGS	For Instrument Transformer Secondary Connections
D	3/4 in. - 1 in. EMT or PVC	Ground Connection #8 or larger connection to ground bus
E	1/2 - 1 in. EMT, PVC or RGS	Phone line (POTS line) - Suggest 4 pair Cat 5
F	1/2 - 1 in. EMT, PVC or RGS	Optional KYZ to Customer Suggest < 10 ohm loop resistance

Equipment to be mounted on 48 in. x 72 in. x 3/4 in. minimum painted plywood attached to the wall to provide an air space behind plywood.
Boxes shall be mounted and connected to allow doors and covers to open without binding on adjacent boxes.

Figure 6.7: Meter Panel – Outdoor – Two Metering Points

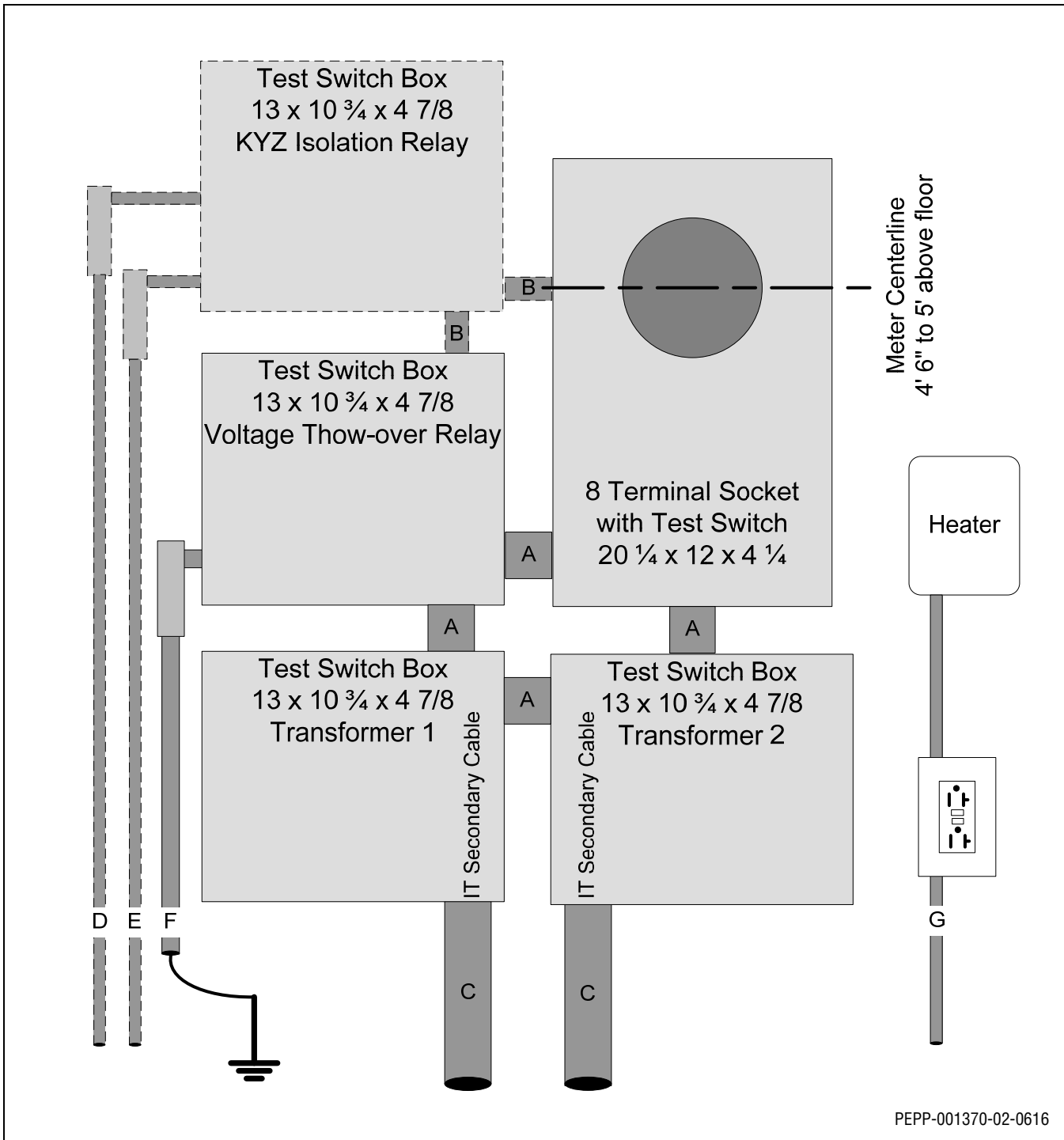


Figure 6.7 Notes:

Note	Conduit	Comment
A	2 in. RGS nipple	With lock nuts and grounding bushings or use lock nuts with piercing screw and plastic bushing, 2-1/2 - 3 in. long.
B	1 in. RGS nipple	With lock nuts and grounding bushings or use lock nuts with piercing screw and plastic bushing
C	2 in. RGS	For Instrument Transformer Secondary Connections
D	1/2 - 1 in. EMT, PVC or RGS	Phone line (POTS line) - Suggest 4 pair Cat 5
E	1/2 - 1 in. EMT, PVC or RGS	Optional KYZ to Customer Suggest < 10 ohm loop resistance
F	3/4 - 1 in. EMT or PVC	Ground Connection #8 or larger connection to ground bus
G	1/2 - 1 in. EMT or PVC	120 VAC, 20 A Station Power
<p>Equipment to be mounted on 36 in. x 36 in. x 3/4 in. minimum painted plywood attached to the wall to provide an air space behind plywood.</p> <p>Boxes shall be mounted and connected to allow doors and covers to open without binding on adjacent boxes.</p>		

Figure 6.8: Typical Customer's Substation – Grounding Details

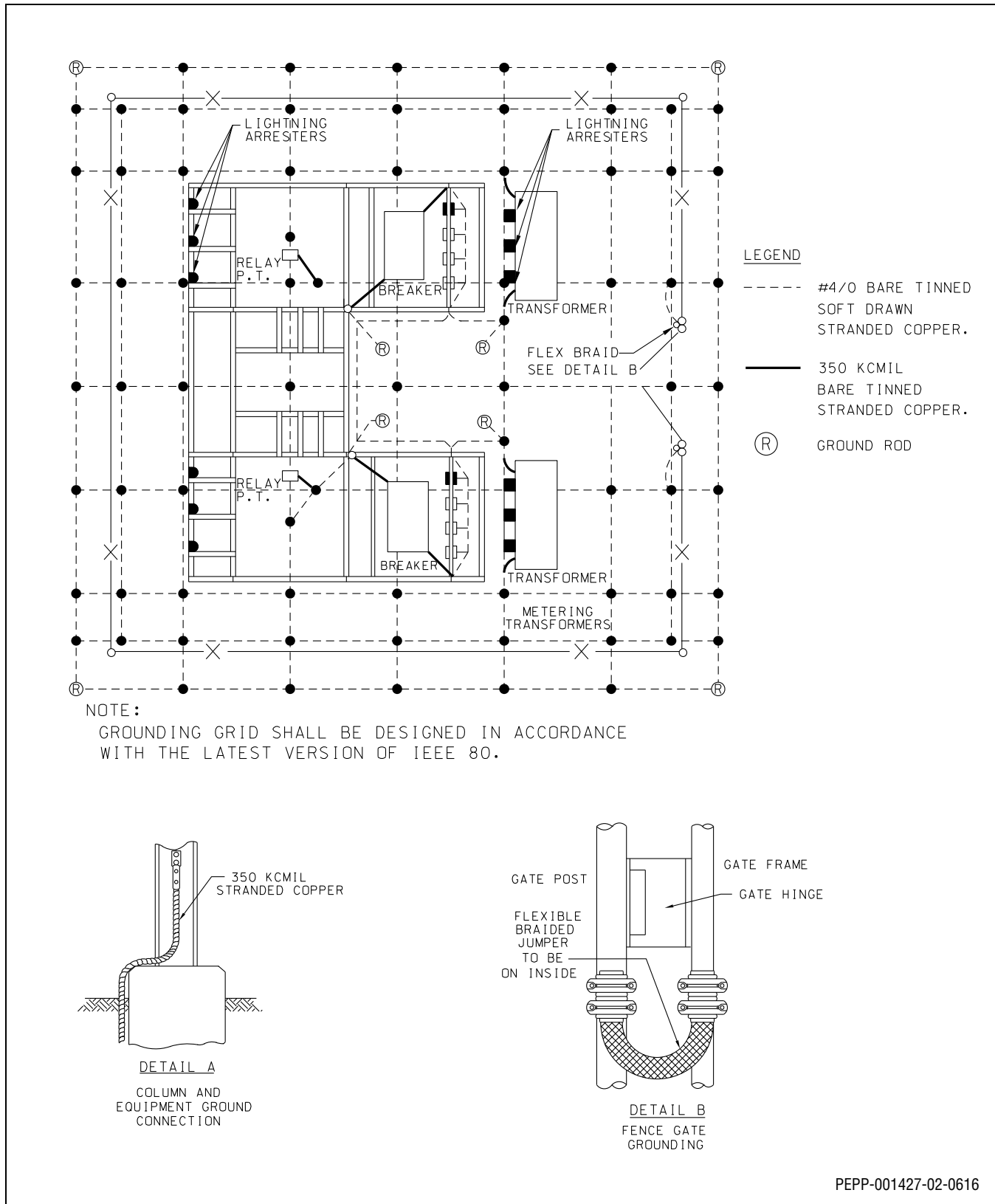


Figure 6.8 Notes:

1. The main station ground grid is to be made of # 4/0 AWG Bare Tinned Stranded Copper (minimum).
2. Connections between the ground grid bus, structure, and various pieces of apparatus are to be direct copper connections of # 350 kCMIL Stranded or 2 in. x 1/4 in. Bar (minimum).
3. Ground connectors may be of the welded, bolted or compression type. Bolted connectors must utilize at least two independent bolts or two U-Bolts.
4. Where connectors are in direct contact with structural steel members surfaces, the surface of the connectors shall be tinned.