Customer Substation Manual

09/1/2025

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010.00) General
Within this manual, whenever "Company" is listed, it is in reference to Wisconsin Public Service.

These requirements are applicable to all customer owned substation facilities at which Company supply lines are terminated. For questions of requirement intent, a Company Field Application Engineer will provide an interpretation/clarification and shall be solely responsible for final determination of compliance.

010.00.10) The Customer Substation Manual is a list of Company requirements, not a design guide for a substation. The requirements contained herein are exclusively those of the Company. However, additional requirements applicable to customer substations are set forth in the applicable Wisconsin and Michigan State Electrical Code, IEEE Standards and other codes and ordinances. The Company should be consulted only on matters relative to its specific requirements. Customers and Consultants are advised to communicate directly with appropriate code enforcement authorities for matters which pertain to requirements of the applicable Wisconsin and Michigan State Electrical Codes, and other local codes or ordinances.

010.00.20) The Company's general requirements which follow have been divided into specific sections as an aid to indexing the material covered for reference purposes. The division of the first two parts has been made on the basis of whether the listed characteristic primarily involves electrical or physical design criteria. These parts are Part 1 and Part 2, respectively. Control circuit requirements for service circuit breakers and electrically operated interrupter switches are specified in Part 3.

010.00.30) The general requirements contained herein relative to supply conductor terminations, grounding provisions, service disconnecting means, overcurrent protective devices, surge protection and metering facilities are those deemed necessary to ensure the reliability of the Company's system and the safety of the Company's personnel engaged in the Company's normal operations as the supplying utility; therefore, all customer substation installations must comply and are reviewed and inspected accordingly.

010.00.40) The Company, in its review and inspection, may specify additional requirements relative to the equipment and general design of the substation, as the Company in an emergency situation may be requested to act as the Customer's contractor and operate the substation equipment.

010.00.50) The Customer shall obtain the acceptance of the Company before making any additions or modifications to any existing customer–owned substation. The additions or modifications shall comply with this manual.

010.00.60) The Customer shall contact the Company and schedule a ground grid or duct inspection upon completion of the installation of ground grid or ducts. The ground grid or duct inspection shall be completed by the Company before the Customer is allowed to permanently cover the ground grid or ducts."

010.10) Information Required for the Review of New Customer Substations

Prior to designing or ordering equipment for a customer substation, the Customer or their Contractor shall use section 010.20 for maximum design values for the proposed installation (located near the front of this manual). The Company Service Manager can provide clarification on which system voltage to design for. The Company will provide actual values after Company design is complete. The Customer shall review the entirety of the customer substation manual before providing the following to the Company Service Manager:

- The street address for the proposed installation
- The number, type and size of the transformer(s)
- The anticipated load (present and future)
- The requested service date
- The preferred service location
- The type of service (switchgear line up, rack in breaker style, overhead)
- And any other pertinent data

On completion of the substation design, the Customer shall submit an electronic copy of engineering documents to the Company appropriate service center job owner***. This submittal shall occur prior to ordering any equipment.*** The prints will be reviewed for acceptance by a Company Field Application Engineer. The prints submitted for acceptance shall be details of the actual proposed installation, not typical drawings of a similar installation. These prints shall contain:

Item	Received	Require	Description
1			A one line diagram showing switches, fuses, transformers, surge arresters, interlock schemes, relaying and control schematics, etc.
2			A drawing showing the location and arrangement of the proposed installation with respect to adjacent facilities.
3			The type of equipment with reference to manufacturer and catalog number, electrical ratings, clearances between live parts and to ground, complete dimensions, etc.
4			A drawing showing the location and size of equipment foundations and conduits.
5			A drawing showing the location and provisions for metering equipment – the locations for instrument transformers, the transformer rated meter socket, the cell phone enclosure, the associated conduit runs, etc. See Section 220.
6			A drawing showing the design of the electrical ground system and the provisions for protective grounding. See Section 180.
7			The provisions for warning signs and informational signs. See Section 240.

Note: The switchgear review will not start until a complete set of construction prints showing all of the details listed in item 3 above has been received.

010.20) Company Electrical System Information: Voltage and Fault Duty

For design, system voltage will be provided by Company representative. For Guaranteed Available Short Circuit Current (GASCC), reference chart below.

Voltage	Symmetrical	Asymmetrical
4.16 kV*	10 kA	16 kA
12.47 kV*	10 kA	16 kA
13.8 kV*	10 kA	16 kA
24.9 kV	10 kA	16 kA
46 kV*	10 kA	16 kA

* Legacy voltages, please receive approval from the Company before starting design with these voltages.

Notes:

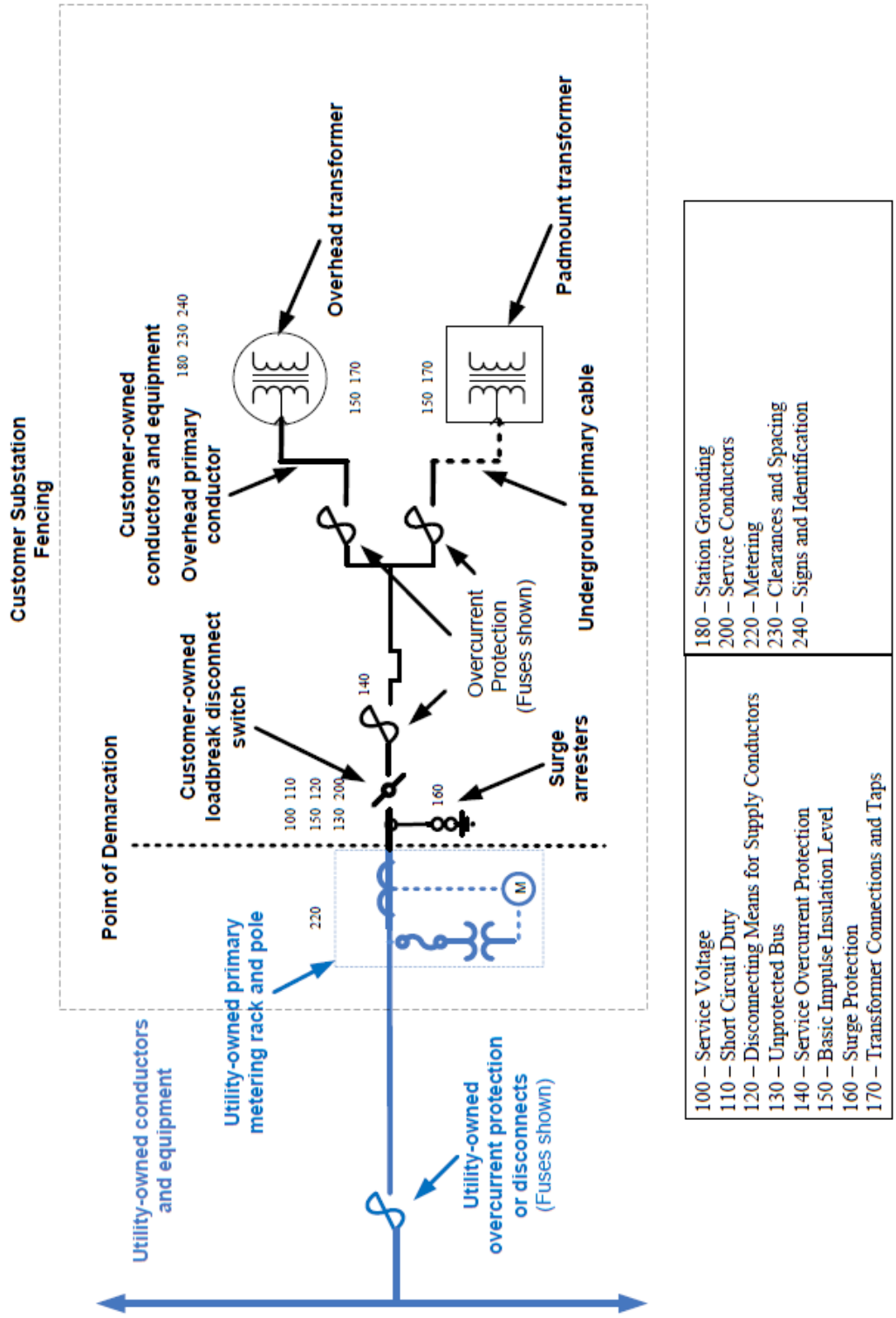
1. Actual fault current will be provided by a Company representative after Company service design is complete.
2. Available fault current may be significantly higher than published above if primary service is required to be fed from a dedicated utility substation.

010.30) Example Sequence of Events

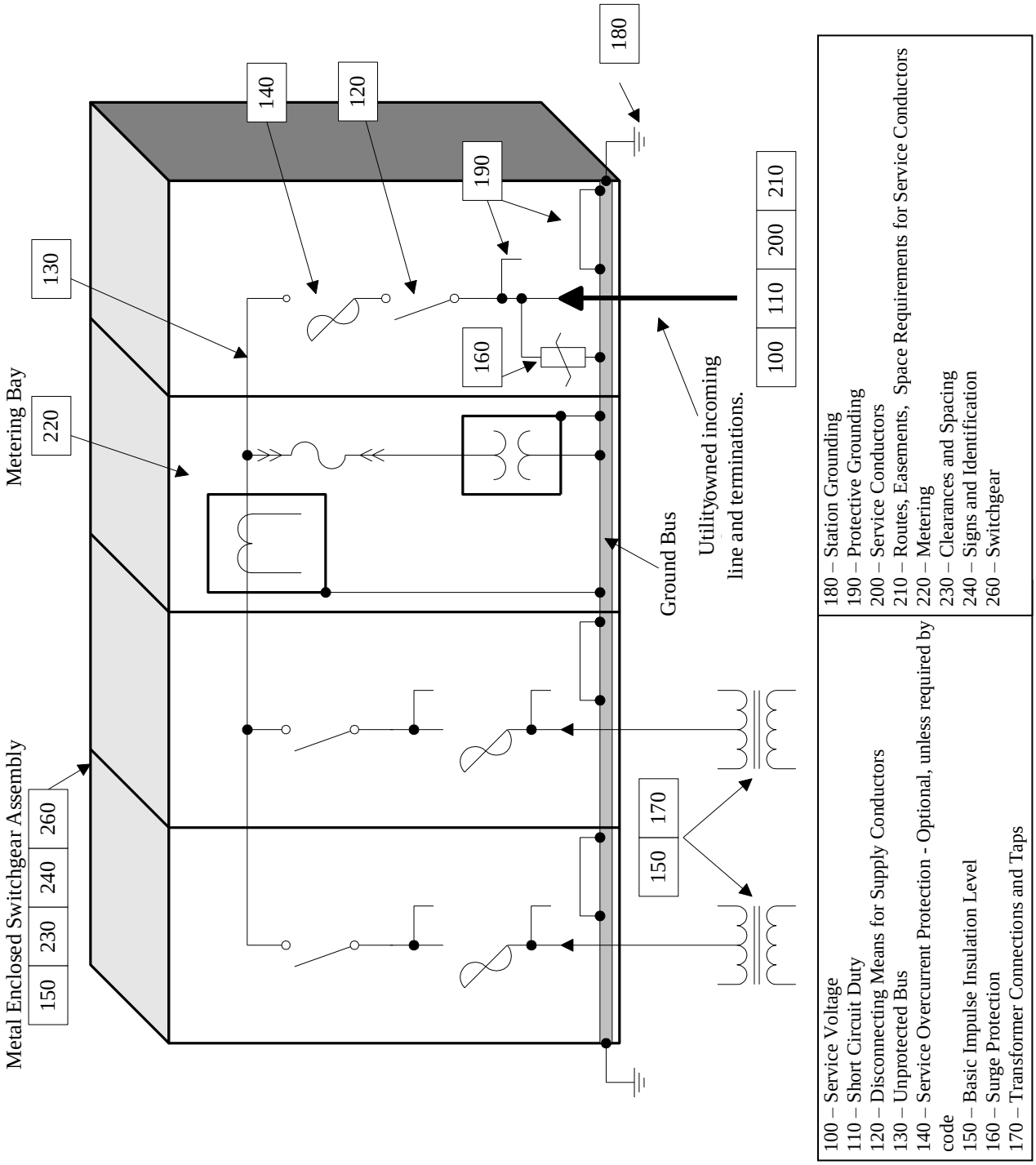
The following typical sequence of events is intended for use as a reference and is likely to vary depending on the specifics of a particular project.

- Customer reviews Customer Substation Manual and applies for service.
- Initial meeting to discuss requirements for customer substation.
- Customer selects proposed location and submits design to the Company for review and acceptance.
- Company Field Application Engineer reviews customer drawings and provides feedback.
- Customer to provide shipping details for metering transformers and associated fuse holders.
- Company Field Application Engineer provides acceptance of customer drawings for release to construction.
- Customer's installer/manufacturer installs metering transformers and associated fuse holders.
- Customer begins construction of customer substation with site prep, excavation, and below grade facilities.
- Company Field Application Engineer inspects ground grid prior to backfilling (minimum of one week notice required) and acceptance is provided.
- Customer Substation is constructed with all major equipment installed with medium voltage cables isolated from switchgear containing metering equipment.
- Customer substation is inspected by the AHJ, Company Field Application Engineer and Company metering personnel. Contact Service Manager for company personnel inspections. Minimum one week notice is required for scheduling of Field Application Engineering inspection.
- The Company installs remaining metering equipment.
- Customer lands medium voltage cables in switchgear containing metering equipment.
- The Company installs primary service facilities.
- Service is energized and loss of phase testing is performed if required.

010.50) Schematic Index for a Typical Overhead Substation with Single Line Feed



010.60) Schematic Index for a Typical Substation
Metal Enclosed Gear with Single Line Feed



100) Service Voltages

Medium voltage service is available for customers with demands over 1000kVA. The Company will specify the service voltage. The Company may specify the use of dual voltage equipment in some areas of its service territory to accommodate planned conversion to a different service voltage. For legacy installations that are being modified, replaced or rebuilt, the Company will specify service voltage for which the equipment will be designed.

110) Short Circuit Duty

110.00.10) The Company will provide the Customer the maximum three phase symmetrical fault current, system X/R ratio and the single phase to ground symmetrical fault current (or the maximum symmetrical and asymmetrical fault currents) for the proposed customer substation in a Fault Current Letter.

110.00.20) Circuit protective device(s) shall have an interrupting rating sufficient for the system voltage and the maximum available fault current at the terminals of the device as listed in the table in section 010.20.

110.00.30) Circuit protective devices will be restricted in size and timing to coordinate with existing Company source side devices.

110.00.40) Switching and disconnecting devices shall have a fault close rating sufficient for the maximum available fault current at the terminals of the device as listed in the table in section 010.20.

110.00.50) All devices shall have a momentary withstand rating sufficient for the maximum available fault current at the terminals of the device as listed in the table in section 010.20.

120) Disconnecting Means for Supply Conductors

120.00.10) The Customer shall provide quantity one (1) disconnect device to isolate each set of Company supply circuits from the Customer substation equipment.

120.00.20) The disconnect device(s) shall be located at the nearest point of connection to the Company owned supply conductors.

120.00.30) The disconnect device(s) and their control shall be readily accessible. The disconnect device(s) shall be located near a door or gate providing egress from the substation. Other substation equipment shall not be located between the door or gate and the operator/control of the disconnect device(s).

120.00.40) Disconnect devices which are accepted by the Company shall consist of one of the following types of equipment in 120.00.40.a through 120.00.40.c:

a) A three phase group–operated load interrupter switch. The device shall conform to the requirements of 120.00.50, 120.00.60, 120.00.70, and 120.00.80.

b) Non draw–out type circuit breakers or circuit reclosers when associated with disconnect switch(es) located on the source side of the circuit breaker or recloser. The disconnect switches shall conform to the requirements of 120.00.50.

c) Draw–out type circuit breakers. A ground-test device must be provided, maintained and readily accessible to allow for a ground cable connection to a ground detail for customer grounds. Grounding provisions must be provided above the utility cable terminations for utility grounds.

120.00.50) The switch or disconnect shall provide a visible break of all circuit phases. The visible break shall be observable from the source side of the circuit breaker or recloser. Line Tension Disconnects shall not be used to meet this requirement.

120.00.60) The switch shall be operated by a handle mechanism without exposing the operator to contact with live parts.

120.00.70) The operating handle shall have provisions for locking in the open and closed position. The customer shall lock the switch in the proper position, and provide a mechanism to allow Company personnel to operate the switch. This is typically accomplished by providing a key to the customer lock, or by providing a shackle which has an opening at either end (this allows the customer to install a lock at one end, and Company to install a lock at the other end).

120.00.80) An insulator shall be installed in the operating pipe of any switch installed on a pole/structure. This insulator shall be rated to withstand the phase to phase voltages on the system it will ultimately be served from and shall be located at an elevation of 10’ to 12’ above the operating handle for the switch. This insulator shall not be made of porcelain.

130)Unprotected Bus/Conductor

An unprotected main bus/conductor may only be installed when the following conditions are met:

130.00.10) The design of the bus/conductor and all materials used in its construction shall be approved by the Company.

130.00.20) All taps from the bus/conductor shall be protected by a Company accepted overcurrent device with a visible break disconnect. This disconnect shall be between the unprotected bus/conductor and the overcurrent device.

130.00.30) Insulated/Shielded cable is not allowed within the unprotected zone. Short sections of properly supported insulated cable for control/instrument transformers may be allowed with Company Field Application Engineer approval.

130.00.40) The circuit length of unprotected bus/conductor shall not exceed 25 feet without Company Field Application Engineer approval.

140) Service Overcurrent Protection

140.10) Fuses
Fuse requirements are listed below.

140.10.10) Fuse Curves
The Customer shall provide Company information, including the manufacturer, type and family of time versus current curves for the proposed fuse type. After review and acceptance of customer substation equipment design and completion of service design, the Company will then specify the maximum fuse size that will be allowed at the particular substation location.

140.10.20) Fuse Mountings
All outdoor fuse mountings installed in Customer Substations for service protection shall be of the disconnecting type and shall be removable using an insulated operating tool.

140.20) Circuit Breakers
Circuit breaker requirements are listed below.

140.20.10) Relays

a) The Company will specify the type and maximum setting of overcurrent relays. The Customer shall provide Company certified test reports verifying relay settings and calibration.

b) The current transformers to which the overcurrent relays are connected shall be located on the supply side of the main circuit breaker.

140.20.20) Control Supply Battery
The Customer shall provide, install and maintain a stationary storage battery of sufficient capacity to ensure tripping. Minimum recommended battery capacity is 24 hours. Capacitor or similarly designed tripping schemes that avoid the use of a battery are not acceptable.

140.30) Circuit Reclosers
Recloser requirements are listed below.

140.30.10) Operating Curves
The Customer shall provide the Company information including manufacturer, type and operating curves. The Company will then specify the maximum trip current or control settings.

140.30.20) Recloser Operation
The recloser must be equipped and set for single non–reclosing operation. *Automatic reclosing of Customer service protective devices is not permitted.*

150) Basic Impulse Insulation Levels and Maximum Continuous Operating Voltages

150.00.10) All high–voltage equipment installed by the Customer on the line side of the service overcurrent protection devices shall have a BIL rating and rated maximum continuous operating voltage not less than that stated in 150.10.

150.00.20) All service overcurrent protection devices shall have BIL ratings and rated maximum continuous operating voltages not less than that stated in 150.10.

150.00.30) For installations without main service overcurrent protective devices, the main bus insulation systems and the overcurrent protective devices connected to the main bus shall have minimum BIL ratings and rated maximum continuous operating voltages not less than that stated in 150.10.

150.10) BIL Levels and Maximum Continuous Operating Voltages for Substation Equipment

Nominal System Voltage (kV)	Maximum Continuous Operating Voltage (kV)	Maximum Phase–to–Ground Voltage During Faults (kV)	Equipment Rated Maximum Continuous Operating Voltage	Equipment BIL (kV)	Notes
4.16Y/2.4	4.4Y/2.54	3	5	60	**1**
12.47Y/7.2	13.2Y/7.62	10	15	95	**1**
13.8	14.52	14.5	27	125	**1**
24.94Y/14.4	26.4Y/15.24	18	27	125	
46	50.6	39	72/138	250	**1**

Notes:
1. Legacy installations only, for maintenance and informational purposes. Please contact the local Company office before designing for these voltages.

160) Surge Protection

160.00.10) The Customer shall install surge arresters on all circuit phases on the line side of the main service disconnect(s). These surge arresters shall be polymer body MOV arresters and require acceptance by the Company.

160.00.20) If the Customer's distribution system is overhead and operates at the service voltage provided by the Company (no transformation), the Customer shall install surge arresters on all circuit phases on the load side of the Company metering instrument transformers.

160.00.30) The application of the appropriate surge arrester class shall be determined based on the maximum fault duty provided in section 010.20 “Company Electrical System Information: Voltage and Fault Duties”. This information shall be used in conjunction with sections 160.10 and 160.20 to determine the appropriate arrester for the each site.

160.00.40) Arrester pressure relief/short circuit withstand rating shall meet or exceed the maximum fault duty quoted, plus any calculated contribution from customer owned generation or rotating loads (motors) and shall meet or exceed the switchgear rating.

160.00.50) Arrester expulsion elements shall not be used inside metal enclosed or metal clad switchgear assemblies.

160.10) Surge Arresters

NOMINAL CIRCUIT VOLTAGE (V)	SURGE ARRESTER		Notes
	Duty Cycle Voltage Rating (kV)	MCOV Rating (kV)	
4,160Y/2,400	3	2.55	**1**
12,470/7,200	10	8.4	**1**
13,800	15	12.7	**1**
24,940Y/14,400	18	15.3	
46,000	39	31.5	**1**

Notes:

1. Legacy installations only, for maintenance and informational purposes. Please contact the local Company office before designing for these voltages.

170) Transformer Connections and Taps

170.10) Acceptable Transformer Connections for Company Systems.

Row	Nominal System Voltage	Acceptable Transformer Connections			
		3 Wire Secondary		4 Wire Secondary	
		Primary	Secondary	Primary	Secondary
1	*13,800V 3 Wire *46,000V 3 Wire	Δ	Δ	Δ	GND Y
		Δ	Y		
		Y	Δ		
2	*13,800V 3 Wire ***See 170.10.a.***	Δ	Y	Δ	GND Y
3	*12,470/7,200V 4 Wire 24,940/14,400V 4 Wire ***See 170.10.b***	GND Y Triplex Core Only	Y	GND Y Triplex Core Only	GND Y
4	*12,470/7,200V 4 Wire 24,940/14,400V 4 Wire ***Transformer must be 1000kVA or larger and be protected as described in 170.10.b.2.***	Δ	Δ	Δ	GND Y
		Δ	Y		
		Y	Δ		
5	*12,470/7,200V 4 Wire 24,940/14,400V 4 Wire ***Transformer must be protected as described in 170.10.b.2.***	GND Y	Y	GND Y	GND Y

*By special permission only. Please contact the local Company office before designing for these systems.

170.10) (continued)

a) On the 13,800V 3 wire system, it is recommended that the Customer install three single phase transformers connected phase–to–phase. When the Company distribution system is converted to 24,940/14,400V 4 wire operation, the transformers may be reconnected in a grounded–wye configuration (taking advantage of the high voltage taps as well).

b) On the 12,470Y/7200 volt and 24,940Y/14,400 volt systems, transformer installations shall have grounded–wye primary winding connections, and three phase triplex core and coil design with grounded–wye or ungrounded–wye secondary winding connections. These restrictions are designed to avoid ferroresonant conditions and eliminate tank heating phenomena under all abnormal system operating conditions.

b.1) Exception 1: When banking single phase transformers connected in a grounded–wye to grounded–wye configuration or grounded–wye to ungrounded–wye configuration.

b.2) Exception 2: When transformer(s) are protected with dedicated relaying which sense the loss of source voltage by measuring primary voltage magnitude and phase angle, and will simultaneously disconnect all phases of the high voltage supply to the transformer(s) in the event of a loss of phase condition. Company preferred method for voltage sensing is through potential transformers. If voltage sensors are used, they shall be high accuracy and be of capacitive divider style design. *Contact the local Company Field Application Engineer for acceptability of this exception before proceeding with this exception and verification of the proposed equipment. See Section 340 for more details.*

b.3) Exception 3: Where a customer presently owns and operates a system and is replacing transformation, the transformer connections on the existing equipment may be acceptable for the new equipment. Company approval is required.

170.20) T–Wound Transformers

T–Wound transformers shall not be utilized by the Customer at the Company supply voltage.

170.30) Transformer Taps

Each transformer shall have five full capacity primary taps with one at nominal system voltage, and two taps at 2 1/2% above, and two taps at 2 1/2% below nominal system voltage. *Customers installing transformers supplied by Company 13,800 volt and 46,000 volt distribution system shall contact Company for specific tap requirements prior to ordering the equipment.*

180) Station Grounding

180.10) General

180.10.10) All substation grounding shall comply with the applicable State Electrical Codes and local ordinances. The goal of a substation grounding system design is for the preservation of human life and the protection of equipment through the control of local potential.

180.10.20) This section defines the minimum Company requirements for a grounding system; however it is not a design guide. The customer is responsible for the complete design. The following requirements are regarded by Company as minimum standards that must be met before Company personnel will enter and operate a customer substation, but do not in themselves guarantee that the design is adequate. A Company representative may add to the requirements and recommendations according to site conditions.

180.10.30) The size of the ground conductor shall be appropriate for the magnitude of the available fault current, the operating time of protective devices, and for sufficient mechanical ruggedness. The minimum conductor size for the ground grid and connections to the grid, ground rod and equipment cases shall be #1/0 copper.

180.10.40) All substation grounding grids shall be inspected by Company Field Application Engineer before permanent covering for compliance with Company rules. Consult Company Service Manager for scheduling at least one week in advance of planned inspection date.

180.20) Indoor Substations (requires Field Application Engineer review and approval)

Due to the added complexity and restricted access indoor customer substations are not preferred. Indoor customer substations may be allowed after review and approval of the Field Application Engineer.

180.20.10) Basement Level Substations

a) A 1/4" x 1–1/2" copper bar shall be installed along all inside walls of the vault to form a closed loop. The height of the copper bar shall be a minimum of 18” above the floor and installed to minimize grounding conductor length.

b) Five–eighths (5/8) inch diameter copperweld ground rods shall be driven at all vault corners and approximately equally spaced along vault walls. Single 8–foot long rods at each rod location are adequate. Install as many ground rods as space permits, maintaining 6–foot typical separation between rods. Do not locate ground rods under doorways or in any other position where they will be hazardous to people walking in the vault. All ground rods are to be connected to the ground bus.

180.20.20) Above Basement Level

a) A 1/4" x 1–1/2" copper bar shall be installed along all inside walls to form a closed loop. The height of the copper bar shall be a minimum of 18” above the floor and installed to minimize grounding conductor length.

b) The ground bar referred to in 180.20.20.a) shall be bonded to building steel in at least four places spaced as evenly as is practical. The frames of all major equipment shall be bonded to building steel.

180.30) Outdoor Substations (Preferred installation)

180.30.10) A grid is required under the entire area substation, consisting of bare–stranded copper cable buried 18 to 24 inches below the soil rough grade. The grid conductors shall be placed to minimize step and touch potential per IEEE 80. Maximum separation between grid conductors shall not exceed 15 feet even if calculations show a larger separation is acceptable. Calculations shall be provided with the approval drawings per IEEE 80. A 4–ft by 2-ft spaced grounding conductor grid is acceptable in the absence of these calculations. When required to limit step and touch potential to operators, an appropriately sized and interconnected supplemental mesh must be installed on top of the rough grade, just under the crushed stone layer or concrete. Within the grid, cables connecting ground rods should be laid in parallel lines and uniformly spaced. They should be located, where practical, along rows of structures or equipment to facilitate the making of ground connections. These rows are to be interconnected at various points including the peripheral cable to form a grid. Interconnecting conductor size should not be less than that of the ground bus or grid.

180.30.20) Five–eighths (5/8) inch diameter copperweld ground rods shall be driven to a depth of 8 feet or more at all ground grid corners and approximately equally spaced along the grid perimeter. The space between the ground rods shall not exceed 8 feet without documentation from grounding study showing further separation is acceptable. All ground rods are to be connected to the grid conductors.

180.30.30) A layer of gravel or crushed stone (minimum 6 inches in depth) shall be placed over the entire grid to establish the finished grade. Gravel resistivity should exceed 2 megaohms/meter.

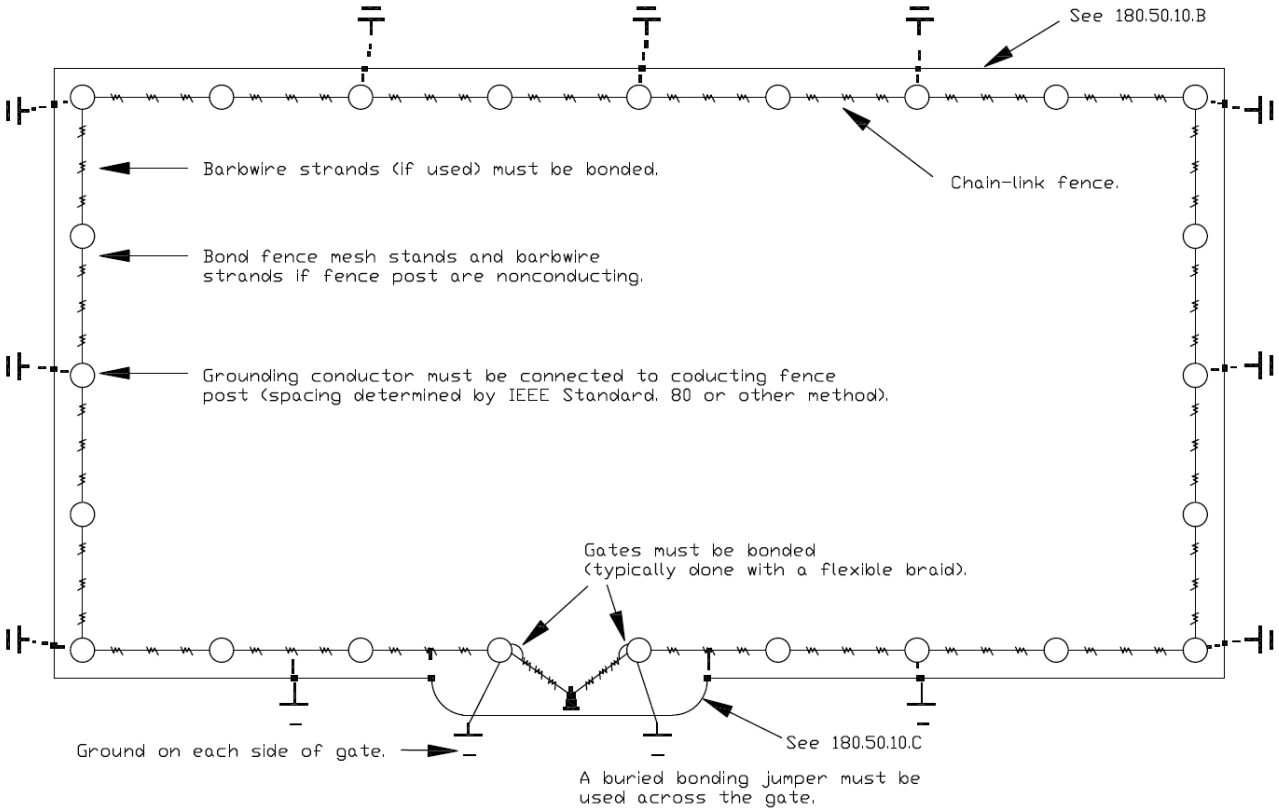
180.30.40) A buried ground conductor shall encircle all switchgear and transformers within 18 inches of the edge of the equipment enclosure, at a burial depth of at least 18 inches but less than 24 inches.

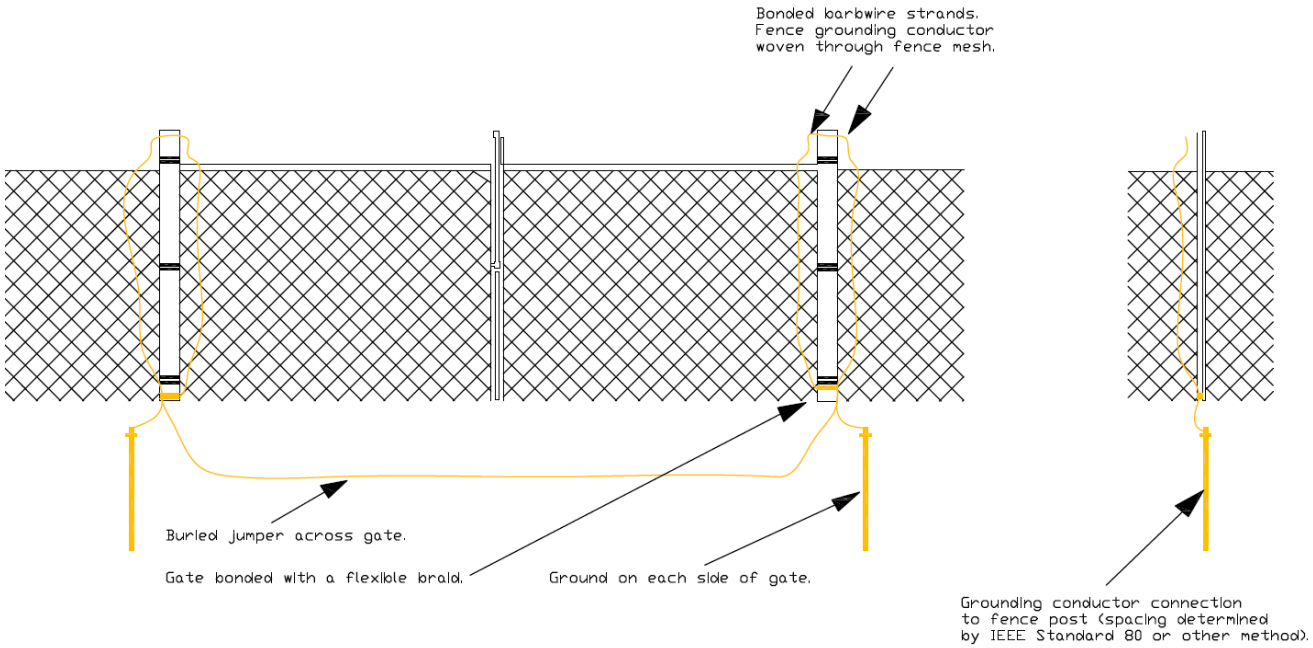
180.40) Equipment and Structures – Indoor and Outdoor Stations

All noncurrent–carrying metallic parts which might accidentally become energized or statically charged (such as switchgear enclosures, metal structures, building steel, transformer tanks, metal railings, housings, and guards, oil circuit breaker tanks and circuit neutrals) shall be connected to the grid or ground bus in a minimum of two locations at opposite ends of equipment by conductors of adequate capacity and mechanical ruggedness. The grid or ground bus should also be connected to any metallic water pipe, metallic drain or sewer pipe located in the station area. Connection shall be made at two points on the pipe at least 20 feet apart and shall consist of a conductor not less than the size of the ground bus. Grid connections shall be irreversible crimp, cad-welded, or other non-removable code compliant means. Split bolt connections are not acceptable for equipment connections.

180.50) Substation Fences

The metal fence surrounding an outdoor open–type substation shall be grounded in accordance with all applicable electrical codes. Of primary concern in the design of a fence grounding system is the reduction of potentials which could prove hazardous to persons within the fence enclosure or approaching from outside.





180.50.10) Fence Ground Interconnected With Station Ground Grid

a) Consideration shall be given to interconnecting the station ground grid with the fence grounds at frequent intervals.

b) The station ground grid shall be extended 2 feet beyond the substation fence. All corner and gate posts, as well as fence posts shall be connected to the grid.

c) All metallic fence parts that might accidentally become energized or statically charged must be metallically connected together. At each entrance gate a buried ground conductor loop connected at each end to the perimeter fence ground conductor shall be placed so as to form a rectangle which encompasses an area extending at least 18 inches beyond the gate swing.

180.50.20) Fence Ground Isolated From Station Ground Grid

a) If the Customer elects to isolate the fence ground system from the station ground grid, a potential difference may be present between the station equipment and the fence during fault conditions.

b) Under this condition, a minimum separation of 6 feet shall be maintained between the fence and the nearest station ground conductor, grounded equipment, or structure.

180.60) Property Fence

180.60.10) Where a conductive property fence is attached to, or passes within 6 feet of a substation fence, it becomes an extension of the substation fence and must be treated accordingly.

180.60.20) Metal property fences installed on the Customer's property shall be grounded to ground rods installed one foot inside the fence at corner posts, gate posts, and at posts on each side of an overhead transmission or distribution line crossing. No connection with the substation ground system is necessary where a minimum separation of 6 feet is maintained between the substation fence and conductive property fence. A buried conductor connecting gateposts is recommended. Fence isolation sections may be utilized to electrically isolate extended sections of property fence from the substation.

180.70) Outdoor Group–Operated Switches
In outdoor stations utilizing load break switches mounted on poles or structures, a three–foot by four–foot metallic grating shall be installed on the surface where a person stands when operating the switch. This section of grating shall be connected to the ground grid and the switch operating linkage as close as is practical to the handle using a minimum #1/0 copper conductor.

190) Protective Grounding

190.10) General

The following requirements shall be used as a guide for determining when and where provisions are needed for the attachment of temporary grounds.

190.10.10) Protection of personnel and property is the primary reason for the attachment of temporary grounds. Hazardous potential differences can exist between apparently de–energized electrical conductors or current–carrying parts of equipment and some other point. These potential differences may exist if the conductor is either accidentally energized or becomes charged because of its proximity to other energized conductors. Proper grounding and bonding will effectively eliminate such hazards.

190.10.20) Wisconsin and Michigan's State Electrical Codes and company operating practices dictate that de–energized conductors and other current–carrying equipment parts shall be grounded during the time construction or maintenance work is being done on them. Such grounding is generally accomplished by connecting a temporary ground cable assembly between the conductor and some grounded point. Under certain conditions, special provisions for the attachment to equipment such as grounding switches may be required where the use of individual ground cables would be impractical or hazardous.

190.10.30) The customer shall install grounding provisions in each customer substation that are adequate for the electrical and mechanical stresses seen during fault conditions to provide protection of Company personnel.

190.10.40) The Company requirements which follow do not cover every situation where grounds might be needed. However, by using the specific requirements included herein as a guide and with an understanding of the hazards involved if grounds are not applied, "adequate provisions" can be made at locations not specifically covered. Each potential source shall be isolated by a visible open from the work area. In addition, safety grounds shall be installed between the visible open and the work area. This document is intended to describe the equipment to meet those criteria.

190.10.50) In some substations grounds can be attached directly to the equipment or conductors. However, because of the limitation in ground clamp range and physical clearances required for safe installation of such clamps, special provisions (ground attachment details) must be made in certain cases for the attachment of ground cable assemblies. Such special provisions (ground attachment details) are also required for bus conductors of special shapes, such as rectangular bar, angle, channel, etc., and at certain locations to make the application of grounds more convenient.

190.10.60) All grounding provisions installed by the customer shall be located so as to render them accessible for safe and convenient application of ground cable assemblies.

190.10.70) The Customer shall provide and install Company–approved grounding provisions for each incoming line (overhead service conductor or underground service cable). Refer to drawing 190.910.

190.10.80) Unless otherwise specified or permitted, such grounding provisions shall consist of a ground attachment detail permanently attached to each incoming line conductor at a conveniently accessible point on the line side of the Customer's main disconnect and ground bracket(s) located within the incoming line section and permanently connected to the station ground bus.

190.10.90) Refer to drawings 190.920, 190.930, and 190.940 for material specifications on the ground details and brackets.

190.20) Grounding Provisions for Specific Equipment
Applications for which basic requirements for line grounding provisions differ from those indicated above are outlined in the following paragraphs:

190.20.10) "Draw–out" Circuit Breakers

a) When "draw–out" circuit breakers are used for service switching and overcurrent protection at customer substations, the customer shall provide a three–pole ground/test device.

b) The ground test device is racked into a compartment in place of the circuit breaker, providing access to the completely insulated switchgear bus conductors for line grounding, bus grounding, low–voltage phase identification, and live–line phasing. Ground cable assemblies and ground brackets are used to complete the connections between the line or bus conductors and the substation ground system. An additional ground/test device may be required in some configurations.

c) Ground test devices shall allow for the connection of Company ground cables from the device to a ground detail.

d) Grounding provisions must be provided in the incoming line bay for utility grounds. The provisions must be placed such that terminations can be accessed (installed, removed, or otherwise modified) while utility grounds are installed.

190.20.20) Stationary–Mounted Circuit Breakers
In all customer substations using stationary–mounted circuit breakers for service protection, the Customer shall install ground attachment facilities on both line and load side of the breaker. These facilities can generally be installed on the breaker bushings or isolation disconnect switches. Ground brackets connected to the station ground bus are required for each set of attachment facilities.

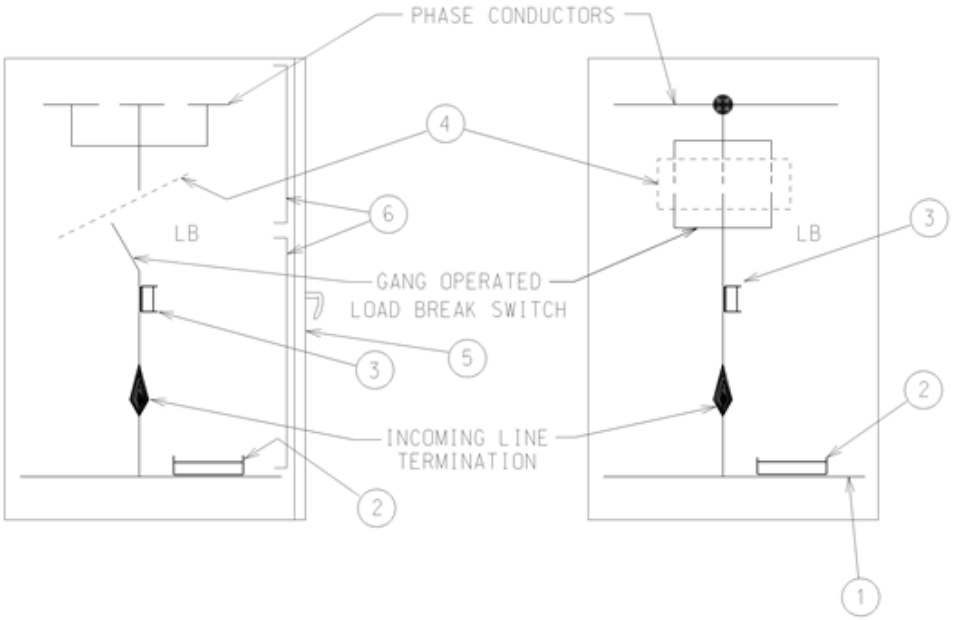
190.20.30) Instrument Transformers
There shall be grounding provisions provided on the bus on each side of the CTs for installation of protective grounding for metering personnel. Further, the metering bay shall contain ground brackets totaling a minimum of 18".

190.20.40) Power Fuses
The customer equipment shall accommodate grounding on both supply and load side of power fuses which cannot be replaced by means of a switch stick (due to weight, lack of accessibility, or the style of the fuse mount). These accommodations shall consist of ground attachment details installed on the supply side and load side terminals of each fuse mounting. Further, the fuse bay shall contain ground brackets totaling a minimum of 18". The ground brackets shall be connected to the station ground bus. These details are to accommodate safe and expeditious fuse replacement.
Exception: Supply side grounding details are not required if the equipment has slide in isolating barriers for the fuses (or switch – if located in the same compartment).

190.30) Grounding Cable Assemblies
All ground details shall be usable with Company large duckbill clamp. Customer supplied ground cables cannot be used.

190.910
Grounding Facilities in Metal–Enclosed Switchgear Service Conductor Entrance Bays

ITEM	DESCRIPTION
1.	SWITCHGEAR GROUND BUS
2.	12-INCH GROUND BRACKET (SEE 190.940)
3.	3½" GROUND ATTACHMENT DETAIL (SEE 190.930)
4.	SLIDE-IN ISOLATING BARRIER: REQUIRED FOR SUBSTATIONS SUPPLIED BY TWO OR MORE LINES.
5.	HINGED DOOR PER 260.20
6.	HINGED SCREEN DOOR(S) PER 260.50



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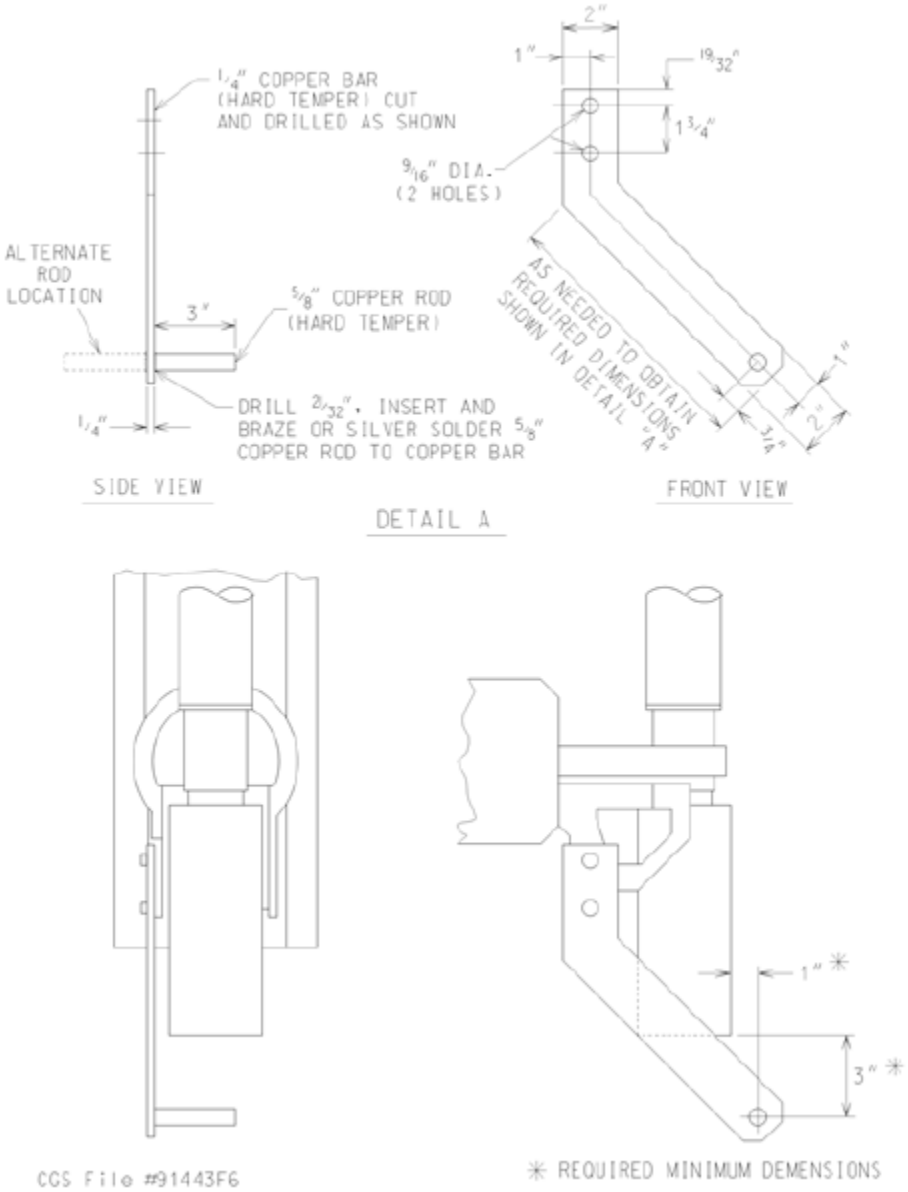
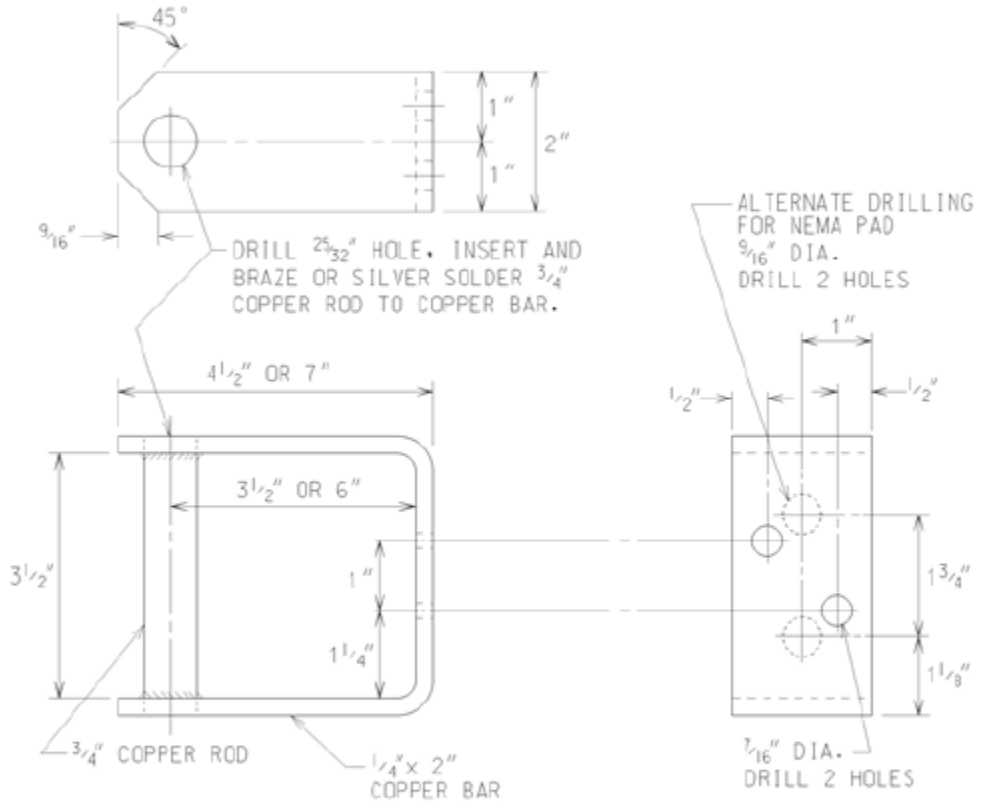
190.920
Power Fuse Ground Attachment Detail



190.930

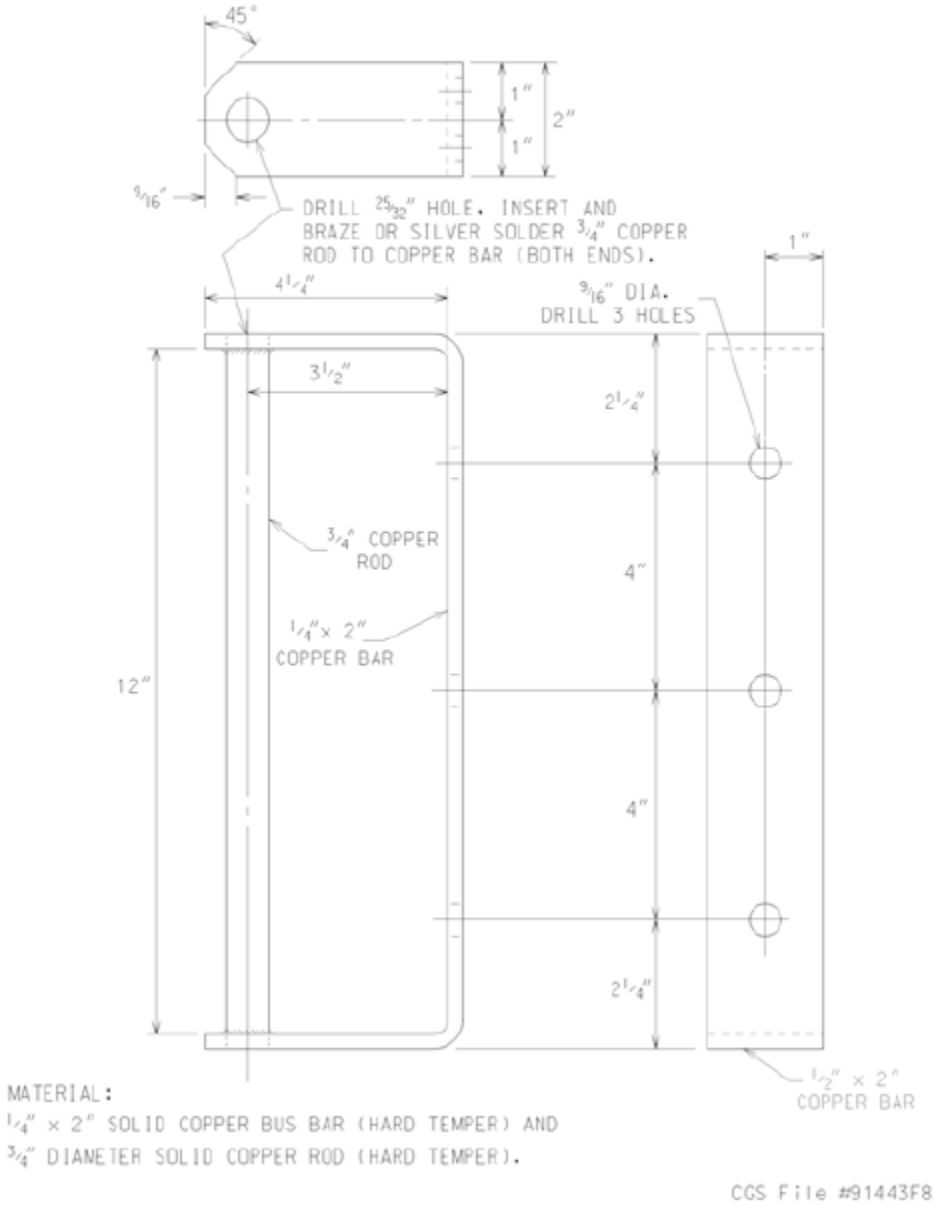
3–1/2" Ground Attachment Detail, 4–1/2" Depth and 7" Depth



NATERIAL: 1/4" x 2" SOLID COPPER BUS BAR (HARD TEMPER) AND 3/4" DIAMETER SOLID COPPER ROD (HARD TEMPER).

CGS File #91443F7

190.940
12" Ground Bracket



195) Capacitors

195.00.10) The installation of shunt capacitors for power factor correction in customer substations can have undesirable effects upon Company supply and customers distribution system. Care should be taken when specifying capacitors. During off peak conditions, or very low load conditions, an excessive voltage rise or a leading power factor can occur. Operation of a shunt power capacitor may subject other system equipment to excessive phase-to-phase overvoltages, especially delta-connected transformers. If the capacitors are switched, a voltage dip, light flicker, high frequency ringing, etc. are possible. Switching can also result in over and under voltages which can cause variable speed drives to shut down. Energizing a capacitor bank and lightly loaded transformer together can cause excessive overvoltages that affect the transformer, capacitor, fuses and arresters. In some applications, capacitors may provide a low impedance path for harmonics which may result in operation of protective devices. Harmonics may contribute to a "loss of life" for capacitors. It is suggested that customers have some knowledge of their harmonic levels, or pursue a harmonic analysis prior to specifying capacitors. No general limitations on capacitor size can be made, since the factors which produce these effects vary with the location of the customer's substation, characteristics of the customers load, etc.

195.00.20) The customer shall obtain approval from the Company for the installation of shunt capacitors. The Company may place restrictions on the use of these capacitors with respect to voltage regulation, telephone interference or other factors. Capacitors operating at lower voltages which are switched with individual loads are exempt from any restrictions.

195.00.30) Shunt capacitors connected to three–phase, three–wire systems are not grounded to:

- avoid possible interference with telephone equipment,
- obtain better compensation for unbalanced voltages.

It may be necessary, however, to ground shunt capacitors installed at certain locations on the three–phase, three–wire systems to obtain proper coordination of protective devices.

195.00.40) Shunt capacitors installed on 13,800 volt and 46,000 volt, three–phase, three–wire systems shall be wye–connected for ungrounded operation.

197) Parallel Generation

The Customer shall contact the Company for specific requirements concerning power quality, relaying, liability and safety.

200) Service Conductors

200.10) General

200.10.10) For the purpose of this section, service conductors are the electrical supply line(s), overhead or underground, which are installed, owned, and maintained by the Company between its distribution system and the Customer's substation. These conductors are installed, owned, and maintained by the Company even though in some cases the Customer may be required to make a financial contribution toward their cost.

200.10.20) The following paragraphs are intended to provide the Customer with general information relative to the Company's requirements for termination of service conductors and to designate a point at which division of ownership occurs. The Company will provide additional supplementary details as required, especially where underground services are involved.

200.20) Overhead Service Conductors

200.20.10) Overhead service conductors are terminated on a dead-end structure provided by the Customer. The Company will provide the following data for each overhead service to a substation to assist the Customer in the design of an appropriate dead-end structure.

a) Approximate heavy loaded tension for each conductor associated with the service.

b) Required conductor spacing and configuration at point of attachment.

c) Minimum attachment height necessary to provide adequate clearance for service conductors.

200.20.20) Customer shall provide and install a dead-end structure of adequate size and structural strength consistent with data furnished by the Company.

200.20.30) Where such dead-end structures are constructed of wood, the Customer need not provide additional termination details. The Company will drill the necessary holes and furnish and install all required attachment hardware.

200.20.40) Where dead-end structures are employed where holes cannot be drilled by the Company, the Customer shall furnish and install suitable attachment provisions.

200.30) Underground Service Conductors

The Company will generally provide, install and terminate the incoming service lateral cable(s) when the supply to a Customer substation is underground. The following paragraphs outline specific Company requirements for representative installations:

200.30.10) Cubicle–Type Substations Consisting of Metal–Clad or Metal–Enclosed Switchgear Supplied Via Single Conductor Direct Burial Service Lateral Cable
The Customer shall furnish and install the following facilities for entry and termination of underground service lateral(s):

a) Terminal pad with NEMA standard two–hole drilling on which service lateral cables are to be terminated. The Company will connect service lateral cables to Customer's terminal pad with a NEMA standard two–hole cable lug. Such terminal pads shall be located no less than 25" for 24,940 Volts (and below) above terminal compartment floor or bottom of cable trench (where present). These dimensions assume the conduits are located directly below each termination.

b) Where service lateral cables are to be terminated six feet or more above the bottom of the cable trench or cubicle compartment floor, a structural member shall be provided, securely fastened to the terminal compartment walls complete with appropriate drilling to receive service lateral cable clamps. Cable clamp supporting member shall be located three feet minimum and four feet maximum below the center line of cable termination pads. Refer to 200.40.20 to determine required cable clamp drilling.

c) Station ground bus to be extended to the vicinity of cable termination. The Company will furnish and install the materials necessary for bonding the service lateral concentric strands or lead sheath to the station ground bus.

d) Access to the service lateral termination compartment(s) shall be by hinged door(s) with screen doors at the front or rear of the switchgear. The Company will provide the necessary padlock(s).

e) An 8’ working space in front of cable termination shall be clear of all obstructions. This working space is for the installation and maintenance of the de–energized termination. Equipment mounted in front of the termination point shall be removable to permit proper installation of service lateral cables.

f) Service lateral conduits shall enter switchgear from the bottom. *Top and side entrances are not permitted.*

g) Indoor Substation Application Only

g.1) Cable pulling anchors (see 200.40.30 and 200.40.40) shall be installed by the Customer at the locations specified by the Company.

g.2) Customer substations located below grade shall be provided with a 12–inch wide by 6–inch (minimum) deep cable trench in the floor as specified by the Company. Depth of trench required for specific installation shall be such as to meet the requirements of item

(a) above. Only the Company's incoming line cables shall be allowed in this trench. If multiple lines feed the customer substation, each line shall be installed in a separate trench. Exposed portions of this trench shall be covered with removable "checker plate" consistent with conditions encountered. Size requirements for opening in basement or foundation walls are shown in 200.30.50.

g.3) Customer substations located at grade level shall be provided with service entrance conduit as specified by the Company.

g.4) When indoor customer substations are not located adjacent to an outside wall or not at or below ground level, the Customer shall furnish and install the required service lateral conduit encased in concrete as specified by the Company.

h) (Outdoor Substation Application Only) The Customer shall furnish and install, according to Company specifications, that portion of the service lateral conduit which is beneath the switchgear foundation or pad.

200.30.30) Outdoor Substation Constructed on Open Framework and Supplied Via Direct Buried Service Lateral Cable.

The Customer shall furnish and install the following facilities for entry and termination of underground service lateral(s):

a) A pothead support consisting of a structural framework complete with appropriate drilling capable of supporting the weight of the pothead and the service lateral cable. The pothead support shall be located at the height above final grade specified by the Company. Potheads shall be as specified by the Company based upon the size and type cable to be used.

b) Working space in front of pothead mounting provisions shall be clear of all obstructions for a distance of four feet.

c) Station ground bus shall be extended to the vicinity of pothead mounting. The Company will furnish and install materials necessary for bonding of service lateral cable sheath to the ground bus.

d) Structural framework complete with appropriate drilling to receive service lateral cable support bracket(s) at a point 4'6" below center line of pothead mounting provisions. Refer to drawings 200.40.10 and 200.40.20 to determine the required cable support drilling. One cable support for each service lateral cable will be provided and installed by the Company.

e) Connecting leads from pothead aerial lug terminals to substation bus.

f) When slab–type structural foundations are to be used, the Customer shall furnish and install, as specified by the Company, that portion of the service lateral conduit which is beneath the foundation.

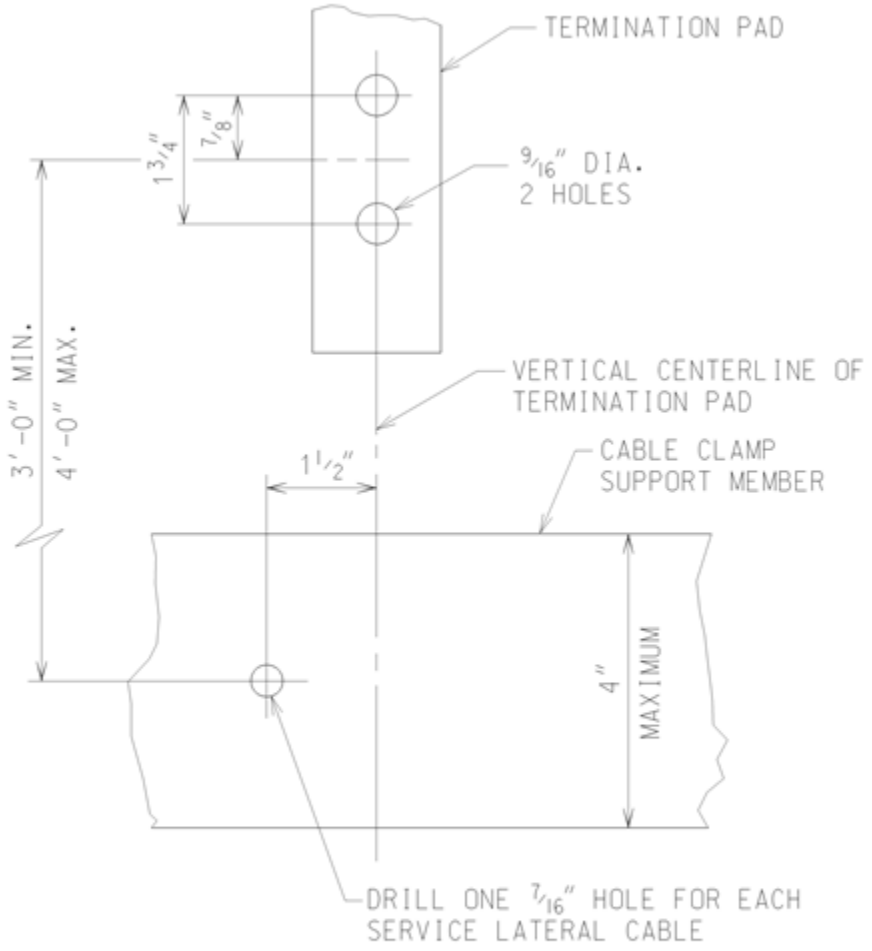
200.30.40) Special Equipment or Construction

The Company shall be consulted to obtain specific requirements for equipment and construction which cannot be classified in any of the above categories.

200.30.50) Size requirements for openings in basements or foundation walls.

Number of Ducts	Vertical Size of Wall Opening	Horizontal Size of Wall Opening
1	12"	12"
2	12"	18"
3	18"	18"

200.40.20
Cable Support Drilling Detail for Direct Buried Cable



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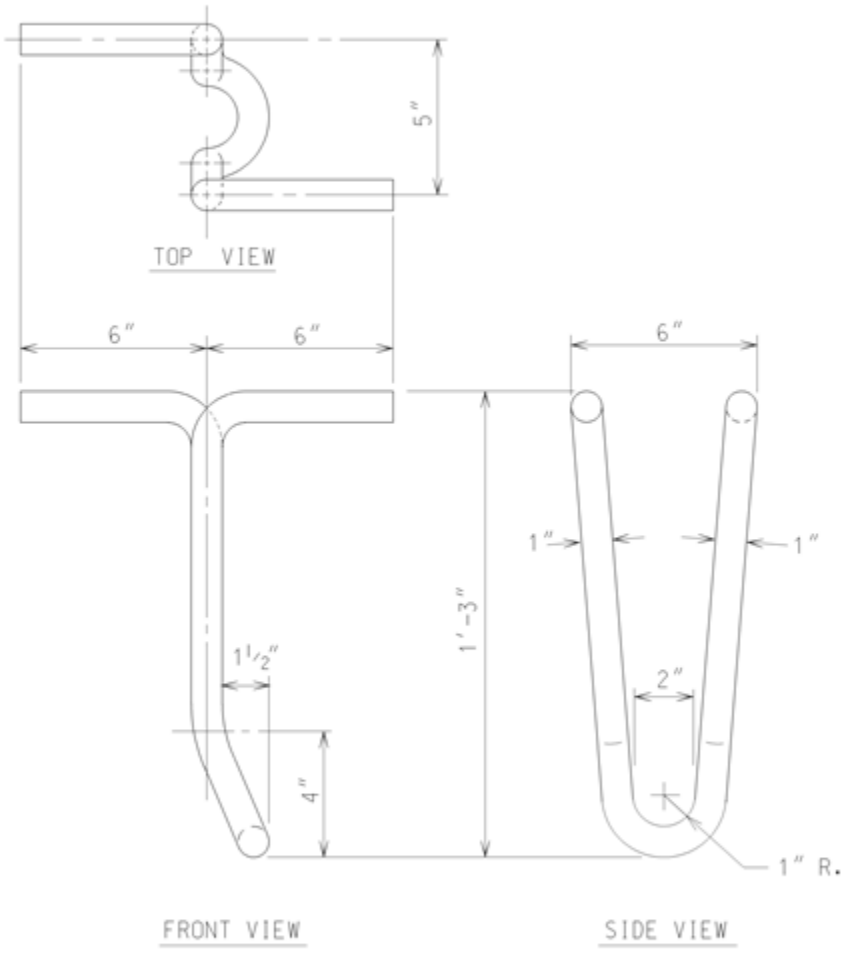
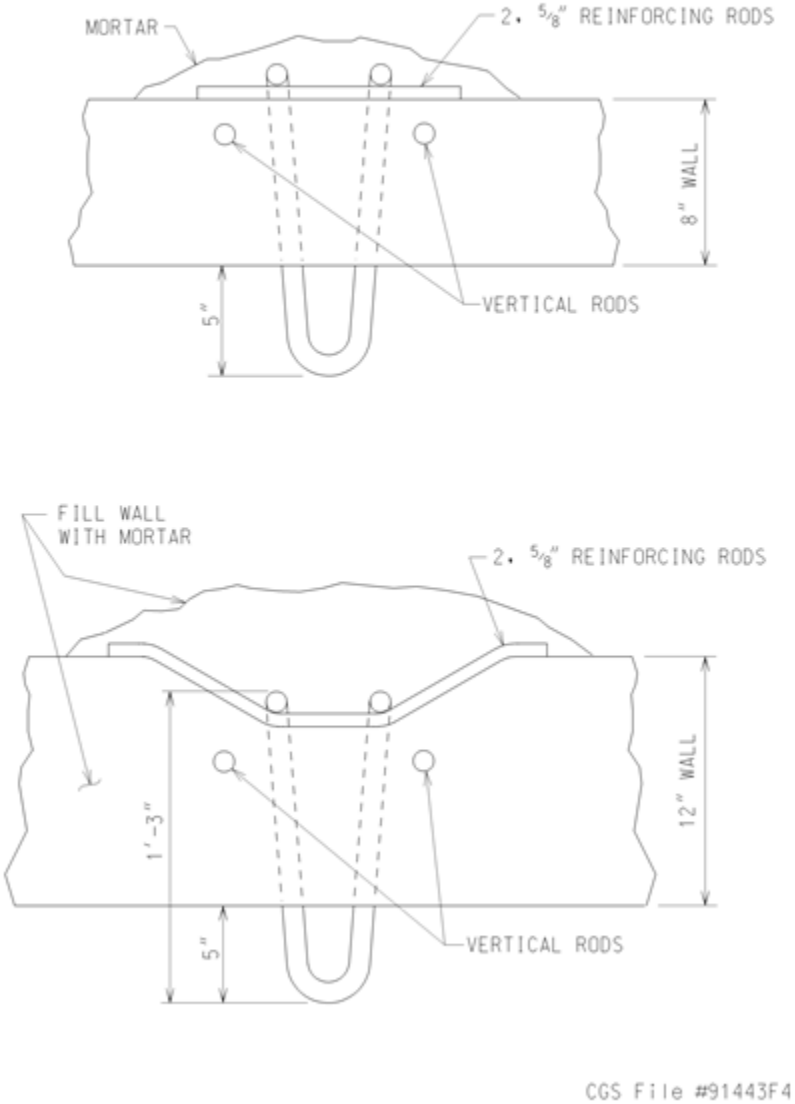
200.40.30
Cable Pulling Anchor Detail



NOTE: MATERIAL, 1" ROUND STEEL, THOROUGHLY GALVANIZE AFTER BENDING. DEVELOPED LENGTH - 40½".

CGS File #91443F3

200.40.40
Installation of Cable Pulling Anchor



210) Routes, Easements and Space Requirements for Service Conductors

210.00.10) When a Customer's substation is remote from Company distribution circuits, the service conductors are extended across private property to the Customer's service entrance equipment located either outdoors or within a building.

210.00.20) It is important in planning the route for incoming circuit(s) to avoid conflicts with the Customer's operations and existing or future underground or overhead structures.

210.00.30) The Company will select the route over which service conductors will traverse between its distribution system and the Customer's substation.

210.00.40) This will generally be the most direct, practical and readily accessible route available consistent with existing conditions.

210.00.50) The Customer shall furnish the necessary easement and tree trimming rights to enable the Company to construct, operate and maintain the service entrance conductors in accordance with its specifications. (Easement documents and associated exhibits will be prepared by the Company for the Customer's signature.)

220) Metering

220.10) General

The appropriate method and location of metering facilities will be determined by the Company on an individual basis. This determination will be based on overall installation cost, reliability, and the Customer's future plans for revision and expansion. Please contact the Company to determine whether high voltage (primary) or low voltage (secondary) side metering will be used.

220.20) Metering at Service Voltages Above 600V

220.20.10) Metering Instrument Transformers

a) Instrument transformers supplied by the Company shall be mounted by the Customer with the exception of primary metering racks for overhead metering installations. In addition, the Customer shall make all necessary primary and grounding connections to such devices. If subsequent replacement of these devices should become necessary because of equipment failure, the Company will perform the mounting and connection operations. The instrument transformers shall be oriented such that the secondary connection compartments face the door of the switchgear compartment or towards meter socket in open-type stations. If necessary, reverse polarity installation may be used to accomplish this requirement.

b) Where indicated in the illustrations, the grounding terminals of voltage and current transformers shall be grounded. For voltage transformers, the neutral (N2) conductor shall not serve as a ground. A separate conductor, #1/0 copper minimum, is required.

c) The metering current and voltage transformers shall be connected on the load side of the Customer's main service disconnect.

d) The voltage transformers shall be connected on the line side of the metering current transformers.

e) Outdoor metering installations involving the use of instrument transformers at 24,900 volts require primary voltage transformer fuses.

f) When separate primary fuses or current limiting fuses are required for metering voltage transformers, they shall be installed and connected by the Customer. The Company will provide these fuses and their mountings, and will furnish specific guidelines for the proper placement of these fuses.

g) The instrument transformers shall not be used to support the bus bars or as a bus insulator.

h) The Company will forward metering equipment (instrument transformers and fuse holders) to the manufacturer/installer. Customer instructions for such an arrangement shall be directed to the local Company service center as early as possible. This allows the Company to reserve specific transformers for the job, thereby allowing the manufacturer to design the metering cubicle accordingly. Instructions shall include the following:

- Name of the switchgear manufacturer/installer
- Specific address of plant to which units are to be shipped
- Name and title of the individual to whom the units are to be directed
- Customer's purchase order number (for reference)
- Approximate date by which units will be required at factory

The Company will exercise every effort to assure prompt and safe delivery of instrument transformers to the manufacturer, but will not assume responsibility for delays caused by loss or damage of such equipment in transit.

220.20.20) Associated Metering Equipment

a) The Customer shall provide and install suitable meter mounting devices as specified below. The meter mounting devices and conduit shall be bonded and grounded in accordance with the Wisconsin or Michigan State Electrical Codes and applicable local ordinances. All conduit shall be galvanized rigid or galvanized intermediate. Meter mounting devices shall be located and mounted in accordance with the Company's Metering Requirements Manual.

b) The company will provide a Transformer Rated Meter Socket to the customer for installation.

c) The Customer shall install 1¼" galvanized rigid or galvanized intermediate conduit between the meter mounting devices and the instrument transformer location. The conduit run shall be exposed where practical and may be up to 40 feet in length without approval from the Company.

d) All required revenue meters, metering conductors or cables, test switches, relays and other equipment not previously mentioned will be furnished and installed by the Company.

220.20.30) Metering Cubicle Unit for Metal–Clad or Metal–Enclosed Switchgear Applications

a) The Customer shall furnish and install a Company approved metering cubicle unit where Company metering instrument transformers are to be mounted. This unit shall be specifically designed for metering equipment only. No devices other than those required for support, installation/replacement rigging provisions, and connection of metering instrument transformers will be permitted.

b) The metering cubicle shall have rigging provisions (such as a bar, pulling eyes, or similar) to facilitate installation/replacement of metering instrument transformers. The rigging provisions shall be able to support a minimum of 500lbs. Switchgear enclosure surfaces shall not be used as physical support for metering equipment or any other items unless specifically designed for that purpose.

c) For cubicle–type installations with remote meter enclosures, the required meter conduit shall be terminated inside the cubicle containing instrument transformers with an appropriate conduit bonding bushing. The Company preferred location for this conduit is the front third of the metering cubicle compartment in an unobstructed area. Contact the switchgear manufacturer for a more precise location for this conduit.

d) The Customer may choose to provide meter mounting space (within the metering cubicle). This compartment shall have minimum dimensions of 44” high x 30” wide x 14” deep. This space shall be completely separated from all high voltage equipment by hinged screen doors.

220.20.40) Metering Instrument Transformer Arrangement for Outdoor, Open–Type Substations 24,940 Volts and Below

a) Where the substation design utilizes a wood structure, the required 1¼" meter conduit shall be terminated on a vertical column (pole) of the structure on which metering instrument transformers are located. The conduit shall be installed from the metering enclosure to the metering PTs and CTs.

b) Where the substation design utilizes a steel structure, 1" minimum conduit shall interconnect the secondary terminal boxes of all metering instrument transformers. 1¼" minimum size metering conduit shall be used between the meter enclosure and the first conduit body junction point.

c) Terminations for meter wiring on meter instrument transformers shall be orientated to face same side.

d) See 220.40 for additional requirements.

220.30) Loss Compensated Metering

220.30.10) At installations where secondary side metering is chosen by the company, the revenue meter will be programmed to electronically compensate for the Customer's transformer and line losses. For these applications, the Customer shall be required to provide the Company with a certified test report of the power transformer to ensure accurate compensation.

220.30.20) All requirements for installations metered at 600 volts or below are detailed in the *Electric Service Manual*.

220.40) Illustrations

220.40.00) The following illustrations show examples of typical metering instrument transformer installations in Customer-owned metal enclosed or metal clad substations and in Customer–owned outdoor open–type substations for all Company system voltages.

220.40.10) Metering switchgear units for application on 3 phase 4 wire system voltages of 5000 Volts and below.

220.40.20) Metering switchgear units for application on 3 phase 3 wire and 3 phase 4 wire system voltages above 5000 Volts up to and including 13,800 Volts.

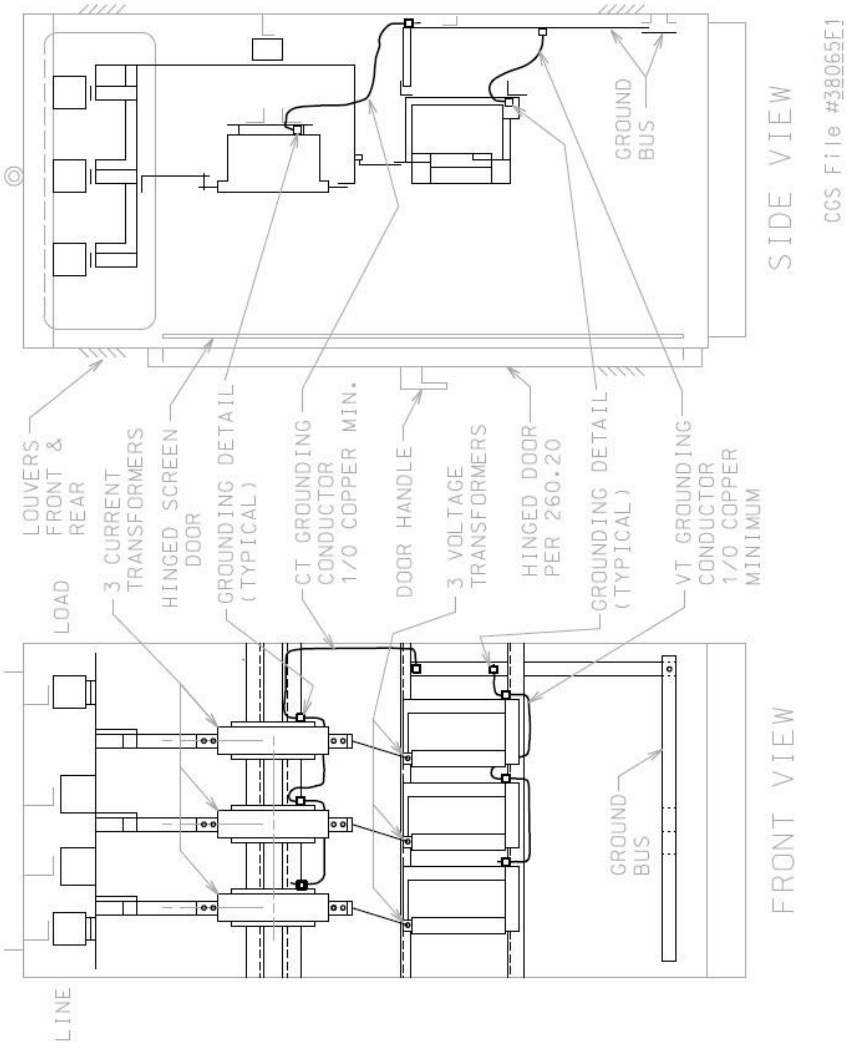
220.40.30) Metering switchgear units for application on 3 phase 4 wire distribution system voltages above 13,800 Volts, up to and including 24,900 Volts.

220.40.60) Outdoor metering structure for 3 phase 4 wire distribution system voltages 15kV and below

220.40.70) Outdoor metering structure for the 24.9kV 3 phase 4 wire distribution system.

220.40.10
5kV Metering Switchgear Unit
3–Phase 4–Wire Services — Typical Arrangement

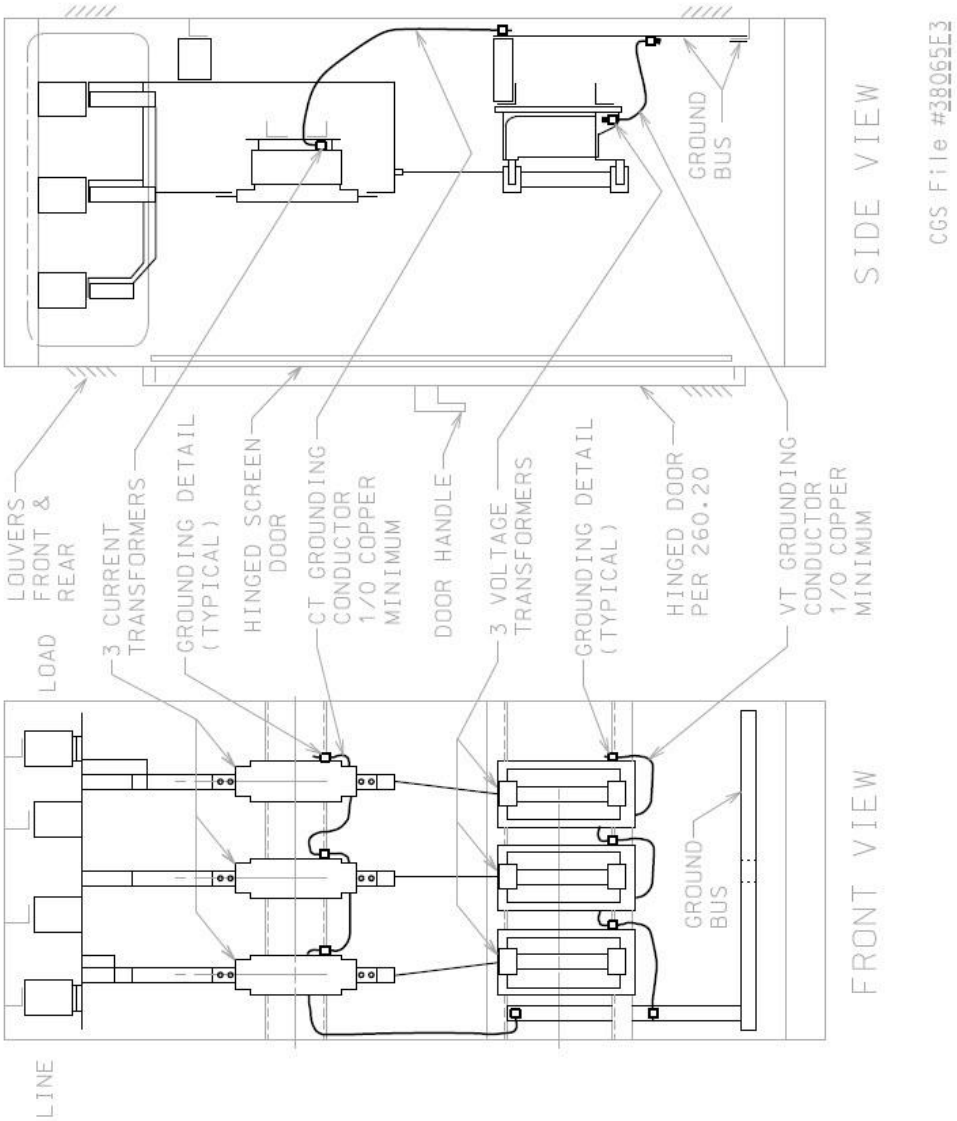
Grounding details on the **current** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Grounding details on the **voltage** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.



5kV Metering Switchgear	60kV BIL
Required Minimum Clearances	
Phase to Phase	4.5 Inches
Phase to Ground	3.0 Inches
Phase to Barrier	2.0 Inches

220.40.20
15 kV Metering Switchgear Unit
3–Phase 3–Wire and 3–Phase 4–Wire Services — Typical Arrangement

Grounding details on the **current** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Grounding details on the **voltage** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.

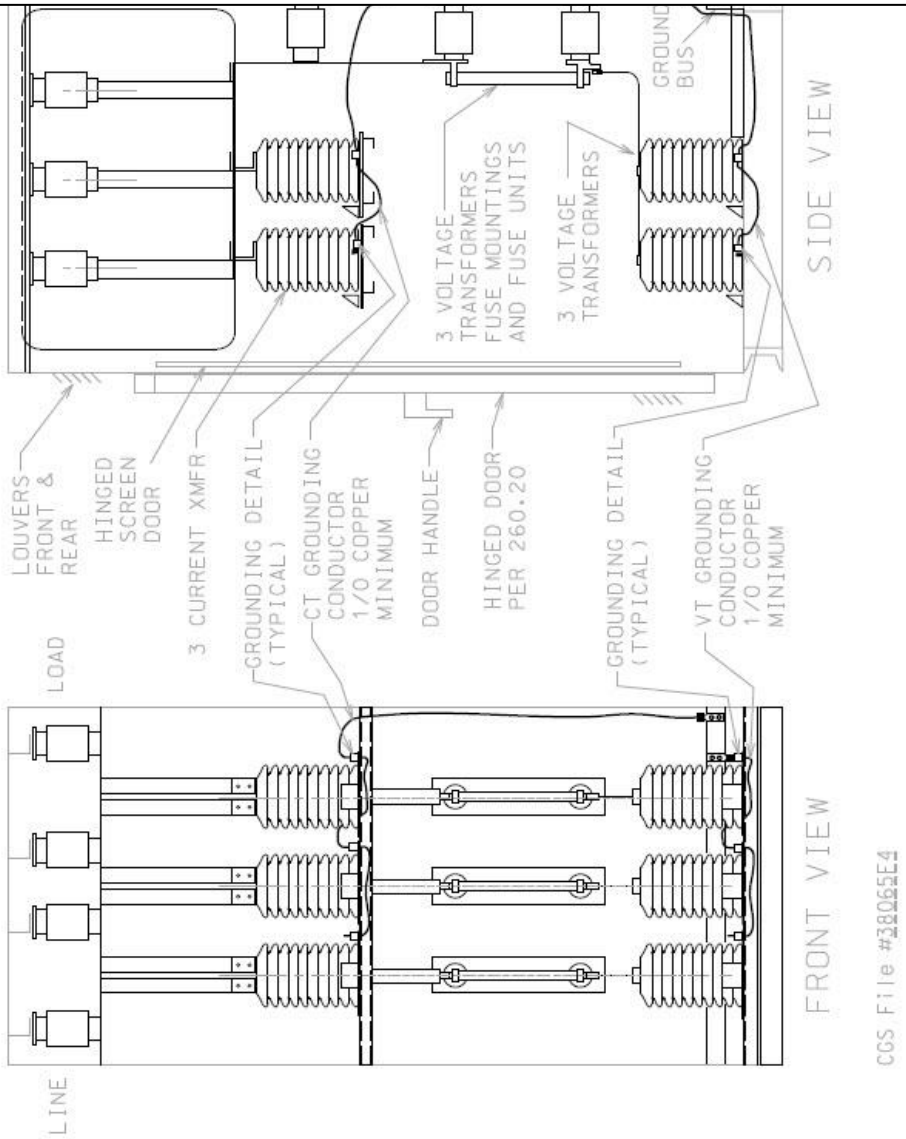


15kV Metering Switchgear	95kV BIL	110kV BIL
Required Minimum Clearances		
Phase to Phase	7.5 Inches	9.0 Inches
Phase to Ground	5.0 Inches	6.5 Inches
Phase to Barrier	2.0 Inches	2.0 Inches

220.40.30

25 kV Metering Switchgear Unit
3–Phase 4–Wire Services — Typical Arrangement

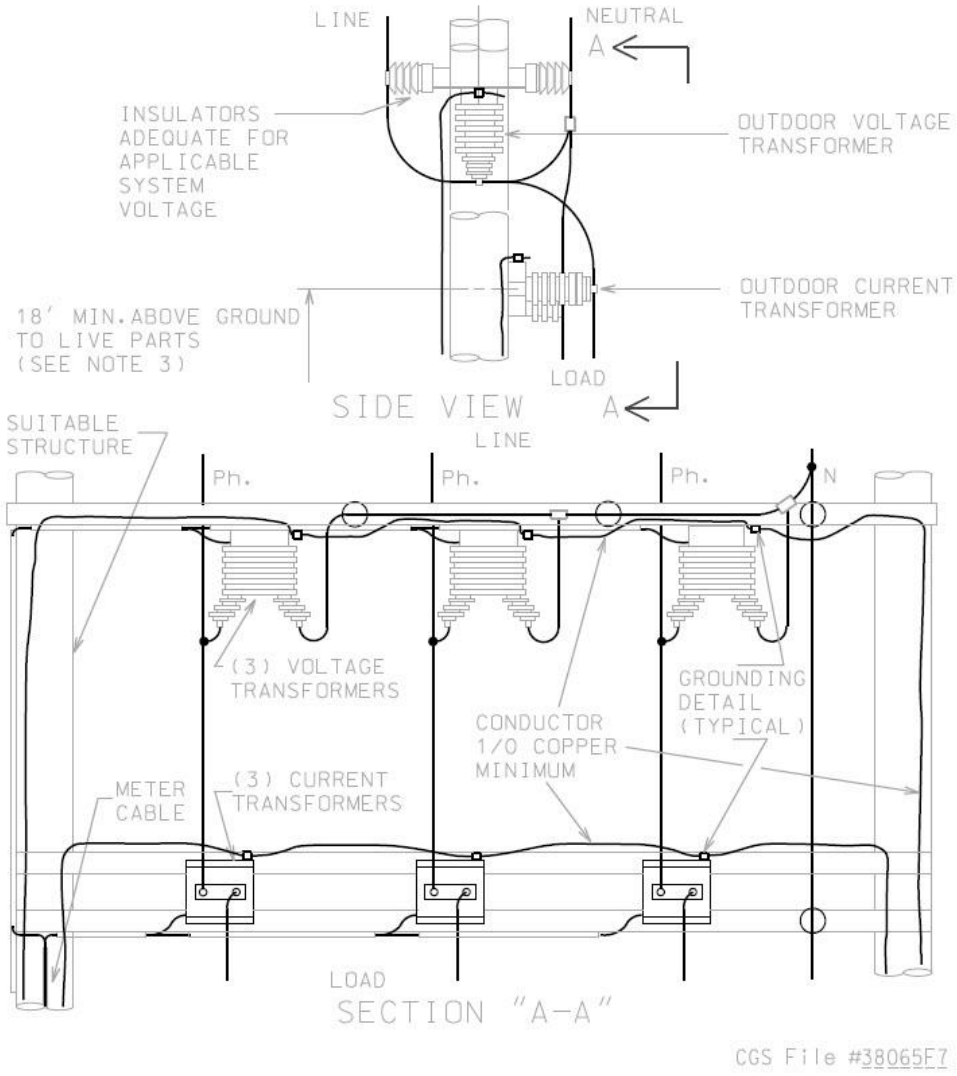
Grounding details on the **current** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Grounding details on the **voltage** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.



24.9kV Metering Switchgear	
Required Minimum Clearances	125kV BIL
Phase to Phase	10.5 Inches
Phase to Ground	7.5 Inches
Phase to Barrier	2.5 Inches

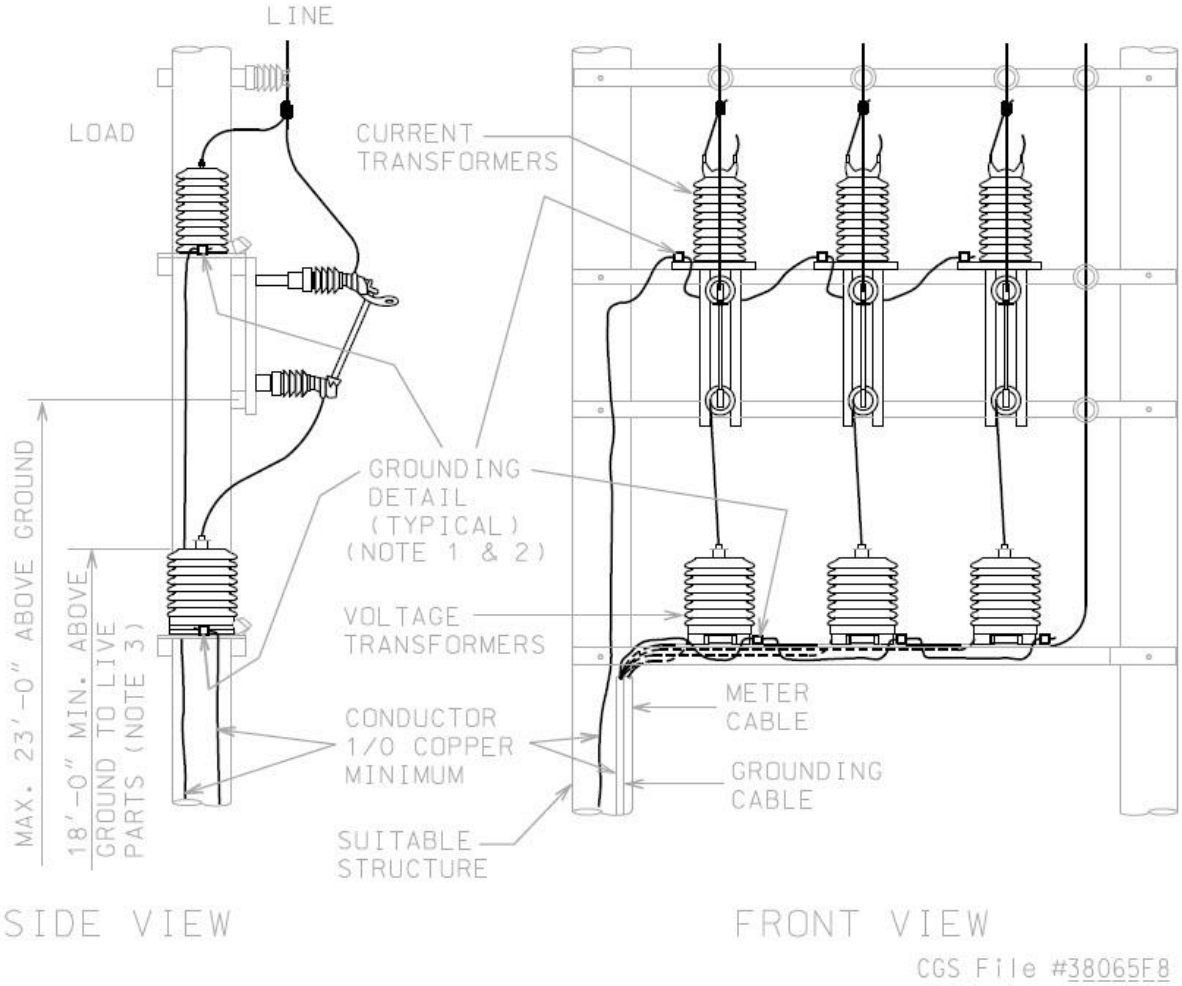
220.40.60
System Voltages 15kV and Below: 3–Phase 3–Wire and 3–Phase 4–Wire Services
Primary Metering Structure for Outdoor Open Style Substations — Typical Arrangement

Note 1: Grounding details on the **current** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Note 2: Grounding details on the **voltage** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Note 3: This clearance may be reduced to 9'0" if the installation is within a substation enclosure as described in Section 250.



220.40.70
Distribution System Voltages 25kV and Below 3–Phase 4–Wire Services
Primary Metering Structure for Outdoor Open Style Substations — Typical Arrangement

Note 1: Grounding details on the **current** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Note 2: Grounding details on the **voltage** transformers shall be interconnected and grounded using a minimum conductor size of 1/0 copper.
Note 3: This clearance may be reduced to 9'6" if the installation is within a substation enclosure as described in Section 250.



230) Clearance and Spacing

230.10) General

Customer substations shall be constructed in accordance with the requirements of the applicable Wisconsin or Michigan State Electrical Codes (all volumes) and applicable local codes or ordinances with respect to live part clearances, spacing of equipment and conductors, and working space. This includes meeting all minimum clearances for live parts as listed in NEC 490–24.

230.20) Operating Space for Open–Type Fuse Installations

For metering voltage transformer fuses, the customer shall provide inside the substation a clear, level area, which extends three feet outside each outboard fuse mounting and a minimum of six feet out from the face of the mounting structure. In addition to the space required to operate the fuses, the substation design shall provide an area adjacent to the fuse structure in which to assemble, raise, and lower the switch stick. The switch stick should be two feet shorter than the distance from grade to the lower support point or lower hinge point of the fuse. The clear area shall be four feet wide and four feet longer than the switch stick, both in ground area and in the path of the stick as it is raised.

240) Signs and Identification

240.10) General

240.10.10) The Customer shall provide a schedule of nameplates and signs for Company acceptance prior to construction of substation. Such schedule shall clearly indicate the inscription of each sign or nameplate, and specify the intended location of each.

240.10.20) To cover unusual installations, the Company may require additional signs and markings at the time of installation.

240.20) Location

240.20.10) Signs used to identify equipment are mounted either directly on the equipment or on the station structure close to the equipment identified.

240.20.20) Signs shall not hinder the operation of equipment, reduce electrical clearances or in any way present a hazard.

240.20.30) Danger and Caution signs shall be located so that there is sufficient time to read the warning before encountering the hazard.

240.20.40) Signs giving operating instructions shall be conspicuously located at the operating point either on or near the equipment involved.

240.30) Minimum Sign Requirements for Typical Customer Substations

Before the substation is placed in service, the Customer shall furnish the signs for the style of substation listed in 240.30.10 or 240.30.20.

240.30.10) Signs for Outdoor Open Type Substations:

DESCRIPTION	LOCATION
No Admittance	Outside face of all entrance gates or doors in station fence or enclosure.
Danger High Voltage	Outside face of station fence or enclosure spaced not more than 40 ft. apart.
Phase Identification Letters **A**, **B**, and **C**	Adjacent to deadend attachment or potheads of all incoming lines.
CAUTION: Do Not Open Any Disconnect Switches When Carrying Load or **CAUTION: Do Not Open Any Disconnect Fuses When Carrying Load**	On structure near disconnect switches or disconnecting type fuses in a conspicuous place.
Incoming Line Loadbreak Switch or Incoming Line Circuit Breaker	On or near service loadbreak switch operating handle or service circuit breaker.

240.30.20) Signs for Indoor or Outdoor Substations Consisting of Metal–Enclosed Switchgear With Loadbreak Switches and Fuses, or With Draw–Out Circuit Breakers

DESCRIPTION	LOCATION
NOTICE: Keep This Doorway Free of Obstructions At All Times	Outside face of each gate or door specifically provided as an entrance or exit from station enclosure or vault.
DANGER: High Voltage	On all doors which give access to high voltage components.
Incoming Line Termination	On door which gives access to an incoming line termination.
Incoming Line Loadbreak Switch	Center of front door on all incoming line compartments which contain the designated equipment.
Service Fuses	Center of door on compartment which contains the designated equipment.
WPS Meters	Center of door on compartment which contains the designated equipment.
WPS Metering Transformers	Center of door on compartment which contains the designated equipment.

250) Enclosures, Fences, and Surfacing – Outdoor Open Type Substations

250.00.10) Customer shall furnish and install a suitable fence or enclosure for outdoor, open–type substations in accordance with the requirements of the applicable Wisconsin and/or Michigan State Electrical Codes (all volumes) and/or applicable local codes and ordinances.

250.00.20) Initial fence construction and final grading shall be done carefully so as to close all voids between the bottom of fence or gate and final grade which may jeopardize the integrity of the enclosure. Also, reasonable maintenance shall be performed, as required, to close such voids which appear after the initial installation due to settling or erosion.

250.00.30) The Customer shall provide and install crushed limestone surfacing outside the substation fence when the fence ground is interconnected with the station ground grid as directed in Section 180.

260) Metal–Enclosed and Metal–Clad Service Entrance Switchgear

260.10) General

Metal–enclosed or metal–clad switchgear assemblies are required for underground service and shall be constructed in accordance with the latest revisions of applicable ANSI, IEEE and NEMA Standards and appropriate electrical codes.

260.20) Doors

260.20.10) All compartments containing Company cables, terminations and metering equipment shall meet the ANSI C57–12.28 latest revision #14 AWG wire tamper resistance provision.

260.20.20) All compartments shall be equipped with hinged access doors. All doors shall be fitted with concealed hinges and be secured by a sturdy 3–point latching mechanism operated by a single padlockable handle.

260.20.30) Doors handles on compartments in which Company supply cable terminate, compartments containing service switch or breaker and compartments containing Company metering transformers shall, in addition to the above requirements, accept a standard Company padlock with 21/64 inch shackle and include a single captive recessed penta–head bolt. The door handle and penta–head bolt provision shall be designed so that:

a) The padlock shall block access to the penta–bolt.

b) The door handle cannot be operated until the padlock is removed and the penta–bolt is loosened.

c) The padlock cannot be installed until the handle is closed and the penta–bolt tightened.

260.20.40) Doors on compartments in which Company supply cable terminate, compartments containing service switch or breaker and compartments containing Company metering transformers shall not be secured by key or mechanical interlocks. The service switch or breaker may have a key cylinder interlock that releases keys for downstream devices but does not interfere with the operation of the compartment door.

260.30) Windows

Inspection windows shall be provided in the door of each compartment that contains a switch so that the open and closed positions of all switch blades are readily discernible from the exterior of the enclosure.

260.40) Detachable Panels

260.40.10) Detachable panels on compartments in which Company supply cables terminate, compartments containing service switches or breakers, compartments containing Company metering transformers, and compartments containing unprotected bus shall be secured so they cannot be removed from the outside of the compartment. The locking provisions shall not be circumvented.

260.40.20) Panels secured by external fasteners using specialty drivers such as hex, torx, star or similar do not meet the intent of this requirement.

260.50) Screen Doors

260.50.10) All compartments that contain Company supply cable terminations, service switches, Company metering transformers and feeder fuses shall be equipped with hinged screen doors to isolate all high voltage parts.

260.50.20) Service switch compartments equipped with slide–in isolating barriers shall be provided with hinged split screen doors.

a) The upper screen door shall isolate only the portion of the switch above the slide–in barrier.

b) The lower screen door shall extend from just below the upper screen door to the bottom of the compartment.

c) The arrangement and location of the split screen doors and the isolating barriers shall permit the installation of the isolating barriers when only the lower screen door is open.

d) Feeder Switch/fuse compartments shall be equipped with a hinged screen door isolating only the switch. An additional hinged screen isolating the feeder fuses is required unless the compartment door is interlocked to the feeder switch operating handle so that the main door can be opened only with the switch open.

260.50.30) All compartments that have access to medium voltage equipment shall be equipped with hinged screen doors to isolate medium voltage parts.

260.60) Company Cable Termination Isolation

260.60.10) The service switch compartment(s) shall be equipped with provisions to isolate the Company cable terminations from live parts whenever the switchgear main bus can be energized from more than one source (i.e. multiple Company feeders or a Company feeder

and customer owned generator feeder). For disconnect switches, slide-in barriers are preferred.

260.60.20) The slide-in barriers shall insert on insulated rails and slide between the stationary and movable contacts of the disconnect switch.

260.60.30) Slide-in barriers shall be installable using a shotgun type insulated operating tool.

260.60.40) Slide-in barriers shall be fabricated from fiberglass board material.

260.60.50) When installed, the barrier shall not contact live parts.

260.60.60) Provisions to store these barriers, when not in use, shall be provided on the outside of the screen door or on the inside of the compartment door.

260.60.70) Storage of slide-in barriers shall not obstruct the viewing window.

260.70) Insulators

260.70.10) Requirements for insulators apply to all insulators on unprotected bus which support:

- **a)** Interrupter switches
- **b)** Fuse mountings on the source side of the fuse
- **c)** Switch push rods
- **d)** Interphase insulators

260.70.20) Skirted insulators of appropriate ratings shall be used between any connection of a live part and a grounded surface or between live parts of different phases.

260.70.30) Insulators shall be installed so that water will not pool on the skirts.

260.70.40) Insulators may be made of porcelain, cycloaliphatic epoxy resin or silicone rubber.

260.75) Clearances
The minimum clearance of live parts within metal enclosed switchgear shall be as specified below in 260.75.10. Minimum clearance between live parts and insulated barriers shall be as specified below in 260.75.20. For metal clad switchgear this requirement only applies to the Company cable terminations and metering compartment.

260.75.10) Minimum Clearance of Live Parts (From Table 490–24 of the NEC).

Nominal Voltage Rating (kV)	Impulse Withstand B.I.L. (kV)	Minimum Clearance of Live Parts	
		Phase–to–Phase	Phase–to–Ground
		Indoors/Outdoors	Indoors/Outdoors
	Indoors/Outdoors	Inches	Inches
2.4–4.16	60/95	4.5/7	3/6
7.2	75/95	5.5/7	4/6
13.8	95/110	7.5/12	5/7
14.4	110/110	9.0/12	6.5/7
23	125/150	10.5/15	7.5/10
46	200/250	18/21	13/17

260.75.20) Minimum Clearances from Live Parts to Barriers.

System Class (kV)	Impulse Withstand B.I.L. (kV)	Minimum Phase–to–Barrier Clearance (Inches)
5	60	2.0
15	95	2.0
15	110	2.5
25	125	2.5
46	200/250	4.5

260.80) Momentary Current Rating

The integrated switchgear assembly (interrupter switches, breakers, power fuses, primary bus and enclosure) shall have a momentary current rating equal to or greater than the maximum available short circuit current at the point of application.

260.85) Protective Grounding

All compartments shall be equipped with protective grounding facilities as described in Sections 180 and 190.

260.90) Potheads and Other Cable Terminations

Adequate space shall be provided in the incoming line terminal compartments for the installation of potheads or other terminators (see Section 200.30 for additional detailed termination requirements).

260.95) Accessibility to Outdoor Switchgear

Outdoor switchgear installations equipped with a weatherproof operating and maintenance aisle shall include provisions to secure at least one entrance door with two padlocks. Removal of either padlock shall be sufficient to gain entry. One of the two padlocks will be furnished and installed by the Company. The second padlock shall be provided by the Customer.

Exception: When Customers provide the Company keys to their padlock. These keys will be kept in key boxes furnished and installed by Company on the Customer's premises near the switchgear.

270) Indoor Substations

270.10) General

270.10.10) Each aisle or work space about substation equipment shall have a suitable means of exit which shall be kept clear of all obstructions. If the plan of the vault and the character and arrangement of equipment are such that an accident would close or make inaccessible a single exit, a second exit shall be provided.

270.10.20) All personnel doors shall swing out and be equipped with full width panic bars that are normally latched but open under simple pressure for quick escape in the event of trouble. Von Duprin catalog number 99NL–F or functional equivalent shall be used.

270.10.30) The customer shall furnish and install sufficient lighting fixtures to provide a minimum illumination intensity of 10 foot candles. If the room temperature is to be maintained above 40°F, fluorescent light fixtures may be used. The lighting fixtures shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The lighting circuit shall be supplied from a back-up generation source, if present.

270.10.40) Only metal–enclosed equipment will be allowed in areas accessible to unqualified persons. This equipment must conform to the switchgear requirements listed in section 260. All other equipment must be located in an area where access to which is controlled by a lock.

270.10.50) Customer shall provide Company personnel 24–hour per day access to indoor vaults for the purpose of switching and maintenance.

270.20) Vaults for Company Cable and Equipment.

270.20.05) These indoor **v**ault requirements apply to a room in the customer's facility in which the Company will install and own electrical distribution cables and/or equipment. The customer is responsible for the structure and the environment and the Company is responsible for the electrical distribution equipment. For vaults containing a transformer please contact the Company, as additional requirements apply.

270.20.10) Indoor vaults shall be located so as to be easily accessible by Company personnel to facilitate moving and operation of utility electrical distribution equipment for both initial installation and future replacements. The customer must provide floors, doorways, passageways and/or elevators having structural strength and clearances adequate for the transportation, installation and replacement of equipment. It is highly desirable that a hatchway, lift off slab, equipment well or doorway on an outside wall or ceiling of the vault will be provided such that the equipment can be installed directly from the outdoors.

270.20.20) The size and shape of the vault in which Company equipment is to be installed must be sufficient to safely operate the installed equipment, perform maintenance on such equipment, and remove and replace such equipment, should that become necessary. The minimum vault size and shape will be specified by the Company Field Application Engineer.

270.20.30) The vault shall be constructed according to the requirements of the Wisconsin State Administrative Code, SPS 316 & PSC 114 or Michigan State Electrical Code. The room shall meet the requirements of all local inspectors and local ordinances.

270.20.50) In addition to the requirements listed in Section 270.10.20, the vault will be secured with a Company supplied and installed high security cylinder lock in each door. The cylinder may be either a rim or mortise type.

270.20.60) Pipe or duct systems foreign to the electrical installation shall not enter or pass through a vault except with written permission of the Company Field Application Engineer. No system will be approved if it contains appurtenances that require maintenance.

270.20.70) Ventilation openings shall be covered with durable grating and screens or louvers in order to avoid unsafe conditions and to restrict entrance of snow and rain. Gratings shall be ¼ to ½" mesh and made of copper, stainless steel, or heavy gauge galvanized steel.

270.20.80) The walls and roofs of vaults shall be constructed of masonry materials which have adequate structural strength for the conditions with a minimum fire resistance of 3 hours. The floors of vaults in contact with earth shall be concrete not less than 4 inches thick, but when the vault is constructed with a vacant space or other rooms below it, the floor shall have adequate structural strength for the ultimate load and a minimum fire resistance of 3 hours.

270.20.90) The use of materials which are subject to rot and/or mold growth in the presence of moisture or which are readily flammable are not acceptable for use inside or as part of the vault structure. Such materials include, but are not limited to: wood, drywall, foam insulation, and plastics. PVC conduit, insulated wiring such as THHN, and plastic equipment housings are acceptable when used as part of a system required by this manual.

270.20.100) Windows, glass panels, or glass blocks are not permissible.

270.20.110) The customer shall provide non-combustible exterior doors and fireproof interior doors suitable for the required size of the doorway. All doors shall swing out of the vault. The Company Field Application Engineer will specify required doorway size(s) and location(s).

270.20.120) Where a doorway connects the building and vault, the fire resistance rating of the door shall be a minimum of 3 hours. A minimum 3.5" concrete sill or curb shall be provided

under each vault interior doorway to contain within the vault the oil from the largest piece of oil containing equipment, unless the floor of the vault is at least 4" inches below the adjacent area.

270.20.130) The customer shall provide drainage to carry off any accumulation of water via one of the two methods below.

a) Floor drain(s): The entire floor shall be pitched to the drain(s) at a slope of 1-2%. Sump crocks and pumps associated with vault floor drains shall be located outside of the vault so they can be maintained without entry to the vault. The customer shall consult with local sewerage district to determine what if any provisions are required to prevent oil entry into the local sewer system in the event of a leak. The customer is responsible to install any required oil stop provisions.

b) Gravity directly to the outside of the building: The entire floor shall be pitched to the exterior doorway(s) at a slope of 1-2%. A small gap of ¼ to ½ inch shall be provided in place of a door sill. The drainage path shall be free of curbs or other obstructions. The vault floor elevation must be above adjacent grade.

270.20.140) In addition to the lighting circuit, the customer is required to furnish and install one 20 ampere, 120 volt circuit in the vault. This circuit shall be supplied from a back-up generation source, if present.

270.20.150) The customer shall only provide a fire suppression system (automatic sprinkler) if required by local ordinances. The fire suppression system shall be a type that is not damaged or activated by freezing temperatures. Heads and associated piping shall not obstruct replacement of cables or equipment.

270.20.160) The customer shall be responsible for all maintenance to the:

a) Vault Structure – Walls, floors, ceiling, doors, fire proofing materials, and any conduits that penetrate the structure.

b) Ventilation System – Louvers, screening, duct work, fans, motors, motor controllers, thermostats, etc.

c) Drainage System – Drains, piping, sumps, pumps, etc.

d) Lighting Systems – Bulbs, fixtures, switches, outlets, conduit and wire.

e) Fire Suppression System – Sprinkler heads, piping, etc.

270.20.170) The Wisconsin State Administrative Code, PSC 114, and Company policy do not allow customers access to vaults containing Company equipment. The Company will inform the

customer of any required maintenance, or at the request of the customer will escort the customer through the vault for the purpose of inspection.

270.20.180) Any required maintenance will be performed by the customer or his contractor in the presence of a Company inspector/escort. Costs associated with a Company inspector/escort for this purpose shall be chargeable to the customer.

270.20.190) The customer may be held liable for any and all costs associated with repair or replacement of Company equipment resulting from failure to perform required maintenance for which they have been notified. This includes but is not limited to damage from flooding due to clogged drains or failed sump pumps.

270.30) Vault Agreement

Prior to energizing any services fed from a vault the customer shall sign a vault agreement stipulating compliance with all items in section 270 above**.**

300) Introduction

300.00.10) The design and construction of control circuits have a major effect upon the proper operation of the service circuit breakers and interrupter switches with which they are associated. The Company has a vital interest in circuits which influence the ability of Customer–owned service equipment to perform switching and fault clearing functions. The design and construction of control circuits often receive less attention than the related power circuits, but a power system can operate only as effectively as permitted by its control circuits.

300.00.20) All control circuits for service circuit breakers and electrically operated interrupter switches shall be constructed in accordance with the requirements listed in Part 3. The Company will specify the type, range, and settings of overcurrent relays and the associated current transformer ratios.

310) Control Circuit Practices

Circuit breakers or automatic switches should open for overcurrent conditions as specified by the Company.

310.10) Control Circuit Relays

310.10.10) Standard device function numbers shall be assigned to identify the functions of all relays. Device function numbers may be found in American National Standard C37.2.

310.10.20) Relays shall be connected to provide proper operation and phasing for the intended application.

310.20) Control Circuits

A means shall be provided to disable the control package for purposes of securing a hold off position.

310.30) Bus Fault Detection

310.30.10) A bus fault detection system shall act to detect a fault and then open all incoming line switches or circuit breakers.

310.30.20) The alternate supply switch or circuit breaker shall be blocked from closing after operation of bus fault detection system.

310.30.30) Bus fault protection requirements may vary with equipment insulation medium, construction, proximity of protective device, unprotected bus exposure, system application, interrupting duty, etc.

310.40) Instrument Transformer Connections

310.40.10) Each current or potential transformer secondary circuit shall have only one ground connection, constructed so that it can be conveniently removed without disturbing the circuit. The ground connection is to be located at the terminal block of the relay electrically nearest the instrument transformer.

310.40.20) All current transformer secondary circuit connections shall be made with copper #12 AWG gauge minimum stranded wire, containing no rotary switches, receptacles for test plugs, or tee joints. All connectors shall be of proven reliability.

310.40.30) All potential transformer secondary circuits shall be fused. Indicating lamps or alarm relays shall be provided to monitor all potential transformer secondary circuit fuses, unless the circuit contains relays which always cause a trip operation upon loss of voltage.

310.60) Miscellaneous Devices

Additional control circuit requirements are as follows:

310.60.10) All indicating lamps shall be color coded to indicate the functions of the lamps, as specified below:

Color	Function
Red	Close
Green	Open
Blue	Alarm
Orange	D–C Potential
White	A–C Potential
Clear	Ground Detection

310.60.20) All circuit breaker trip circuit fuses shall be monitored with indicating lamps or alarm relays.

320.10.10) Switch Operators and Breakers

a) The switch operators or breakers must be provided with a method to mechanically (manually) operate, which is not dependent upon the control package electrical system.

b) The switch operators or breakers must be a stored energy type so that one operation to open can be done after loss of supply voltage.

c) The switch operators or breakers must have targets to indicate its position (open/closed) and the operator status (charged/discharged and coupled/decoupled).

d) For equipment with a manual close button, a protective cover shall be installed to prevent the manual closing of the equipment in order to defeat the interlocking scheme.

320.10.20) Switchgear Only Requirements

a) Switch operators must have a provision for padlocking in both open and closed positions.

b) The switch operator must be capable of being manually decoupled. The decoupled state must be visibly evident through some mechanically altered condition.

c) The door to the service switch bay for live front equipment must be interlocked to the switch operator so that automatic and manual operation is blocked if any of the doors are open.

d) It must not be possible to couple the operator to the switch if both are not in the same open/closed position, in such a manner that the position of either operator or switch indicates incorrectly.

320.30) Sensing

320.30.10) If installed on the 12.47kV system or 13.8 kV subtransmission system, over/under voltage sensing must be adjustable to compensate for future conversion of primary voltage from 12.47kV system or 13.8 kV subtransmission to 24.9Y/14.4 kV distribution.

320.30.20) Potential transformers supplying control power or voltage sensing must have removable high and low voltages fuses. They must be Company approved devices since they are directly connected to Company lines.

340) Loss of Phase Protection

340.00) A loss of phase protection scheme protects transformer(s) and equipment against a loss of source voltage on one or more phases.

340.00.10) The loss of phase protection scheme shall measure primary voltage magnitude and phase angle, and will simultaneously disconnect all phases of the high voltage supply to the transformer(s) in the event of a loss of phase condition.

340.00.20) The loss of phase protection scheme must detect the loss of phase condition and de-energize the transformer(s) as soon as practical, not to exceed 10 seconds. The loss of phase protection scheme time delay shall be determined by evaluating the equipment temporary overvoltage damage curves.

340.00.30) The loss of phase protection scheme shall prevent energization of transformer(s) when a loss of phase condition exists. This includes any means of energization (manual/automatic, local/remote, physical/electrical, etc.).

340.00.40 The Company's preferred method for voltage sensing is utilizing potential transformers. If voltage sensors are used, they shall be high accuracy and be of capacitive divider style design. Use of voltage sensors requires acceptance by the Company.

340.10) The Company Field Application Engineer may require loss of phase protection due to certain types of customer owned equipment interconnected to the Company's distribution system. Loss of phase protection is intended to minimize the potential for ferroresonance causing damage to both The Company and Customer's equipment during the loss of one or more phases.

340.20) If loss of phase protection is required, the Company will test the loss of phase protection Scheme**.** Loss of phase testing will consist of the Company creating a loss of phase event on the Customer's service by dropping voltage to each phase, one phase at a time. The Company encourages the use of load banks on transformers during loss of phase testing events to prevent customer equipment damage. The Company assumes no liability for damage to the Customer's equipment during the loss of phase testing. A successful loss of phase scheme operation shall be demonstrated to Company Field Application Engineer on each phase before the Company will leave the Customer's service energized. This testing can be scheduled with the Company Service Manager and is subject to availability depending on Company workload.