MATERIAL AND SERVICE SPECIFICATIONS

TECHNICAL ENGINEERING, PROCUREMENT, AND CONSTRUCTION REQUIREMENTS FOR HIGH VOLTAGE INTERCONNECTION SUBSTATIONS

1. GENERAL

This specification covers the general requirements for the engineering, design, material procurement, construction, installation, and management of a high voltage electrical interconnection customer substation and system upgrade projects. The specific requirements of the substation (project description, physical arrangement, voltage classes, current ratings, protective relaying schemes, metering requirements, etc.) are described in the project contract documentation. High voltage line work is not included in the scope of this specification. The specific individual services required (engineering, procurement, construction, project management), or any combinations thereof or any partial service in one category, are also described in the contract documentation. In all aspects of the project – a commitment to safety shall be first and foremost.

2. DEFINITION OF TERMS

2.1.1. ITO (Interconnection Transmission Owner) - Shall mean the entity, and any of its affiliates or designated agents, granting the option to design, procure, construct, test, and/or manage the installation of a high voltage interconnection substation.

2.1.2. IC (Interconnection Customer) - Shall mean the entity, and any of its affiliates or designated agents, executing the option to design, procure, construct, test, and/or manage the installation of a high voltage interconnection substation.

2.1.3. Supplier – Shall mean any third party entity, and any of their affiliates or designated agents, providing material or services via the Interconnection Customer as needed for the project.

2.1.4. Contract Documents - Shall mean the Interconnection Service Agreement, Construction Service Agreement, Interconnection and Operating Agreement, any interim agreements, any authorized change orders, IC's proposal, ITO's studies, ITO's General Terms and Conditions, this specification, data sheets, all referenced drawings, specifications, standards, files, schedules, and any other documents used to define the work, including all attachments, addenda, exhibits, references, and latest revisions thereof.

3. SCOPE

The scope of work under this specification shall include furnishing all engineering, procurement of all equipment and material, installation of all facilities, and project management, except in those areas listed as being designed, supplied, and/or installed by others per the Contract Documents.

The IC is fully responsible for the design, engineering, fabrication, assembly, and performance of the high voltage substation facilities and all integral components, including compliance with all applicable standards, codes, rules, and regulations of governing bodies having jurisdiction. It is the responsibility of IC to ensure proper operation of the facilities and all equipment components with respect to the correct ratings, sizes, dimensions, arrangements, etc. The ITO's comments or action taken with respect to drawing review, authorization to proceed, and/or field inspection shall not expressly or by implication relieve the IC of the responsibility or obligations for meeting the requirements of the specifications of the Contract Documents unless specifically agreed to in writing by the ITO.

The IC will be provided access to the ITO’s site during the project. The ITO will have a full time inspector on site during the entire construction phase of the project. IC will understand the overall site layout, local conditions, applicable rights-of-way, ITO safety rules, access and parking arrangements, and other factors likely to affect their work and allow for these in their execution of the project. All costs incurred by IC to provide a complete and functional installation will be the responsibility of the IC. These costs include but are not limited to; sub-surface conditions, permitting issues, environmental issues, screening issues, etc.

3.1. <u>Engineering</u> – IC shall provide detailed design drawings and other engineering data that is essential to the ordering of material, constructing of the entire project, and documenting the facility for future reference. IC shall be required to submit drawings and engineering data in accordance with the requirements and schedule specified to assure compliance with the technical specifications, overall construction schedule, and the project in-service date. Submissions shall include all foundation and structural design calculations, any design models, all calculations including station ground grid, fault analysis associated with the equipment supplied, and other related documentation.

In order to gain the economics, safety of operation, acceptable performance, reliability, maximum interchangeability of parts, O&M familiarity, and other benefits obtained from uniform construction, the IC will use the ITO's standard designs related to, equipment, and bus configurations when designing the interconnection substation, unless explicitly stated otherwise in the Contract Documents. Alternate designs, foundations, structures, equipment, or bus configurations may be submitted in writing to ITO in the conceptual design phases for acceptance. If an alternate is approved in writing, the foundations, structures, equipment, and bus configurations must still conform to the applicable ITO AP Material & Services Specifications.

IC shall be responsible to coordinate with the local utility companies and ITO to ensure that the substation design, protective relaying, switchyard components, metering provisions, and communication circuits are in complete agreement with their requirements.

IC shall be responsible for determining whether federal, state, or local permits or approvals are required for the project. IC will prepare all required information, submit all applications, and obtain all requisite federal, state, and local permits and approvals for the project.

3.2 Procurement - IC shall provide all the material and equipment for the complete substation installation such as: concrete, rebar and anchor bolts for foundations; ground grid system above and below grade; perimeter fence and gates; line dead-end structures; bus conductor, insulators, and support structures; power, instrument, station service, and metering transformers; high voltage breakers and switches; metal-clad switchgear equipment (if required); harmonic filter and power factor correction capacitors (if required); power, control, and meter cabling; static wire lightning protection system; surge arresters; substation lighting; SCADA system; control building; telecommunications services; all required miscellaneous hardware; and any other related items. The ITO will provide the revenue metering equipment for the installation. Unless otherwise specified in writing, the IC shall procure all material and equipment using the ITO's AP Material & Service Specifications.

As a basis of quality control, reliability, maximum interchangeability of parts, O&M familiarity, and matching ITO standards, the IC will use the material and equipment manufacturers in the AP Material & Services Specifications and/or Approved Supplier List. Alternate selections of non-approved suppliers may be submitted in writing to ITO in the design phase prior to procuring alternate equipment for acceptance. If an alternate is approved in writing, the material and equipment must still conform to the applicable ITO AP Material & Services Specifications.

3.3 Construction - IC shall provide all the labor, supervision, administration, management, construction equipment, tools, field office, temporary construction utilities, materials and services necessary to complete the installation of the substation under this contract. This shall be provided from site clearing and grading through substructure work to the installation and commissioning of electrical facilities and ending with the clean-up and rehabilitation of the site. IC shall coordinate work performed under the Contract Documents with other work related to the project being performed at the site in the best interests of ITO. The ITO will provide a full time inspector to monitor the quality of work for facilities that will be owned and operated by the ITO.

4. APPLICABLE CODES AND STANDARDS

4.1. General Construction Standards – Each individual component of the substation shall be designed, manufactured, tested, and installed in accordance with the applicable requirements of the latest edition of the following standards:

- American Association of State Highway & Transportation Officials (AASHTO)
- American Concrete Institute (ACI)
- American Iron and Steel Institute (AISI)
- American Institute of Steel Construction (AISC)
- American National Standards Institute (ANSI)
- American Society of Civil Engineers (ASCE)
- American Society of Testing Materials (ASTM)
- Building Officials and Code Administrations (BOCA)
- Illuminating Engineering Society of North America (IESNA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Insulated Power Cable Engineering Association (IPCEA)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)

- National Electrical Testing Association (NETA)
- National Fire Protection Association (NFPA)
- Mine Safety and Health Administration (MSHA)
- Occupational Safety & Health Administration (OSHA)
- Underwriters Laboratory (UL)
- Uniform Building Code (UBC)
- Others in accordance with the equipment manufacturer's standards
- Others in accordance with applicable local, state, and federal codes
- Others in accordance with ITO safety and workplace policies

5. ENGINEERING AND DESIGN REQUIREMENTS

General – The IC shall perform all engineering functions to design the high voltage facilities as specified in the Contract. IC shall perform work with an engineering and drafting staff of either its own permanent employees or a contracted consultant. This staff shall have background in power engineering and shall have designed similar high voltage facilities and shall have extensive experience with the duties and responsibilities on similar substation projects. This staff shall have adequate CAD design hardware and software. The assigned engineers shall be approved by the ITO prior to release for design based on resumes and credentials submitted.

The ITO shall provide an engineer of each discipline required to design the facilities to act as a liaison to the IC's staff to address questions on technical matters.

5.1. Engineering Review Process - The ITO shall provide the substation drawings in both paper and CAD electronic file (on CD-ROM) format. To indicate areas of IC's work on the drawings: removed items are to be shown in red and added items in green. This shall be done for all stages of review and on the drawings issued for construction. Once design is initiated, two sets of paper copies of all Preliminary Engineering Review drawings and related documents shall be submitted for conceptual review by the ITO for authorization to proceed with engineering. Once authorized and design commences, two sets of paper copies of all Secondary Engineering Review drawings and documents shall be submitted for review by the ITO for authorization to procure material and finalize Detailed Engineering. Once authorized and design is completed, two sets of paper copies of all Detailed

Engineering Review drawings and related calculations and documents shall be submitted for review by the ITO for authorization to begin construction. To indicate areas of work on drawings: existing items are to be shown in black, removed items are to be shown in red, and added items in green.

All submissions are to be made to the ITO's project management representative as designated in the section on Project Management. The specific material to be submitted for each review phase is documented below in this section. This process must be incorporated within the IC's overall project schedule as to meet the project's in service date. Allow 5 (five) working days after receipt of submission for all reviews by the ITO, by which time, comments and corrections with authorization in writing must be rendered. Sufficient time must be allotted between the Detailed Engineering Review (third review) and the issuance of drawings for construction to allow for changes called for in this review to be made prior to releasing drawings for construction. Controls drawings shall not be issued for construction prior to being reviewed. The IC shall review and conform to all drawings returned from the ITO before construction.

If the ITO makes comments to any drawing during any review phase, the IC shall be responsible for carrying that change through to any other affected drawings. For example, if a CT ratio on a Single Line Diagram is changed during a review, the IC shall automatically make the related changes require on the Three Line Diagram, the Schematic, and any corresponding Wiring Drawings. The burden shall not fall upon the ITO to correct omissions and errors in the IC's work.

Engineering shall not change after final authorization without prior written ITO approval. Any work done by the IC, not in compliance with this specification and not authorized in writing by the ITO, shall be the responsibility of the IC for payment, correction, or liability.

This review and authorization process by the ITO does not release the IC from any requirements of the specifications, and is not to be taken as an engineering approval, thus releasing the IC from liability resulting from errors from faulty design or omissions.

5.2 Registered Professional Engineer and Sealing of Drawings – All detailed design engineering as required in the scope of work will be reviewed, approved, and stamped or sealed (to comply with state codes) by IC's registered professional engineers licensed to practice in the State where the project is located.

5.3 Conceptual Engineering - This shall include the proposed scope of work, single line diagram, control scheme, substation plan view, overall site plan, and assumptions. These shall be as defined in Contract Documents as developed and provided by the ITO in the study phases to enable IC to evaluate the project concept and viability to proceed. No deviations from the concept set forth in the studies and Contract Documents is permitted.

5.4 <u>Preliminary Engineering Review</u> – This shall include all Conceptual Engineering taken to the next step of development. The IC shall submit preliminary versions with sufficient detail and dimensioning of the: 1) Grading Plan with the newly graded area, proposed corner elevations, drainage courses, limits of cuts and fills, and oil containment concept; 2) Plan View with all proposed high voltage facilities, fence with gate(s), shield wires, buildings, cable troughs, and yard lights; 3) main Elevation View with proposed structures, buswork, and equipment; 4) Control Single Line Diagram and Three Line Diagram showing the interconnections of instrument transformers to metering, SCADA, and relaying devices indicating how the scheme will work for automatic protection/control and remote switching; 5) all Switchboard Front Views; 6) SCADA Points List; 7) Cable List (outdoor devices only); 8) Control Building Indoors Panel Layout; and 9) Station Service AC/DC Wiring Diagram. Where ITO drawings already exist, the IC shall revise them accordingly for the project as opposed to generating new ones.

5.5 <u>Secondary Engineering Review</u> - This shall include all Preliminary Engineering taken to further steps of development. The IC shall submit all items required in the Preliminary Engineering Review plus the following: 1) all Elevations Views, 2) Foundation and Fence Plan, 3) Cable and Grounding Plan, 4) Bill of Material, 5) all Schematic Diagrams, and 6) Oil Containment System. ITO's review must be completed before switchboard panel and equipment wiring is engineered, and before detailing final material requirements.

5.6 <u>Detailed Engineering Review</u> - This shall include final approval type drawings for all aspects of the project that are suitable to use for procuring material, securing permits, installing equipment, and performing start-up. Such deliverables shall include, but not be limited to, the following: electrical single line and three line diagrams, interconnecting diagrams, substation phase and ground fault calculations, equipment drawings, control/metering/SCADA/communication diagrams and schematics, SCADA point list, all schematic diagrams, all wiring diagrams, all switchboard front views, core boring and geotechnical plans, grading and erosion/sedimentation control plans, stormwater management plans, oil containment systems, site plans, screening/landscaping plans, foundation designs including loading information, structural design including calculations, bus deflection and thermal expansion designs including selection of insulators, phase spacing and bus length calculations, insulation coordination, all raceway, cable layouts and schedules, substation lightning shield wire and surge protection calculations, ground grid design including calculations, step and touch potentials, ground potential rise, bill of materials, detailed plan views, elevation, and sectional views for all applicable areas, AC/DC supply wiring, control building layout, panel layout, yard lighting, and all other design considerations.

5.7 Field Support and As-Built Engineering - The IC's registered professional engineers designing the project shall be responsible for providing field support during construction and approving all required field changes when required. They shall be responsible for maintaining a set of prints, communicating with the jobsite supervisor, and recording all field changes. All as-built revisions shall be drafted into the permanent CAD design drawing files by the IC and promptly provided to the ITO, no later than 2 (two) months after the project in service date, as part of fulfilling the Contract whereupon the ITO takes sole ownership of all engineering documents.

5.8 Land Surveying – On green-field projects, the IC shall perform all property and contour surveying necessary in order to create all site preparation engineering. Contour increments of 1'- 0" are required. On projects where the substation fence and graded area will be expanded, the IC shall be responsible for surveying to verify property line locations or existing or as-built site topographic conditions as shown on ITO's drawings, unless specific discussions and arrangements are made to indicate it is either not required or will be provided by the ITO.

5.9 Core Boring – If required, core boring to determine site geotechnical conditions or to verify or supplement ITO's core boring logs shall be the responsibility of the IC unless specific discussions and arrangements are made to indicate it is either not required or will be provided by the ITO.

5.10 Permits and Approvals - IC is fully and solely responsible for the design of the facilities including compliance with all applicable standards, codes, rules, regulations, and certifications of governing bodies having local, state, or federal jurisdictions. The IC shall determine all compliance requirements; perform any environmental, wetland, archeological, habitat, sound level, or EMF site studies needed; prepare the required documentation; submit the necessary applications and fees; conduct applicable public hearings; provide expert witness testimony; amend engineering (if needed); and follow through the entire process until all required permits and approvals are secured. Aesthetics shall always be considered as an integral part of the facility design.

Sufficient time to acquire all required permits must be built into the IC's overall project schedule.

5.11 Site Preparation - The IC shall use the ITO's standard specifications, unless otherwise stated in the Contract Documents. The ITO shall provide copies of these specifications. Generally, existing substation yards shall be assumed to be relatively flat with a 2% slope, unless otherwise indicated on the grading drawings. New facilities shall be designed with a 2% yard slope. Stormwater impoundments or drainage ditches shall not be located within the substation fenced area.

The IC's engineering shall thoroughly cover all areas concerning: erosion and sedimentation control, stormwater management, site clearing, excavation, oil containment, rock removal, rough and finish grading, access roads, yard stone cover, trenching, drainage ditching, reseeding, and all related tasks. Measures shall be taken to prevent stormwater from entering the control building through cable entrances. Herbicide treatment to control weed growth in the stoned area of the substation shall be provided by the ITO after final acceptance.

The IC shall use the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 2400-1 "Substation and Access Road Grading"
- AP MS 2400-5 "Erosion Control and Landscaping Application Table"
- AP MS 2400-6 "Erosion Control and Landscaping Crown Vetch Seeding"
- AP MS 2400-7 "Erosion Control and Landscaping Berm and Slope Type Seeding"
- AP MS 2500-1"Construction Roads, Water Bars, and Diversion Channels"

5.12 Oil Containment - The IC shall design an oil containment system for loss of oil in each power transformer specified as recommended by IEEE/ANSI standards. Other associated safeguards from fire and/or a ruptured tank, such as deluge systems and firewalls, shall not be included unless stated in the Contract Documents. Container volume to equal 110% of the transformer oil capacity plus 24-hour rainfall, 25-year storm capacity. An oil trap system or sump pump, with motor blocking in the event of oil loss, shall manage rain/drainage water over the permissible container level. IC shall use the ITO's standard specification provided, unless otherwise stated in the Contract Documents.

- AP MS 2500-10 "Oil Containment Liner Systems"

The IC shall coordinate with the ITO to determine if containment volumes for transformers ought to cover anticipated volumes for possible future transformer upgrades and/or possible future adjacent transformer installation.

5.13 Foundations - The IC shall be responsible for the detailed design and drawing of the steel reinforced concrete substation foundations as per the geotechnical conditions of the sites to meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 2600-1 "Foundation Material"
- AP MS 2600-2 "Placement of Concrete Foundations"
- AP MS 500-76 "Anchor Bolts"
- AP MS 2100-1 "Test for Compressive Strength of Molded Concrete Cylinders"

IC shall be responsible to obtain all equipment loading data, as well as physical characteristics of all equipment, for foundation design. ITO shall supply such data when the equipment is to be provided by the ITO. The IC shall coordinate with the ITO to determine if foundation loads for power transformers ought to cover anticipated loads for future transformer upgrades.

5.14 Structures – The IC shall design the structures required for the substation.

General Criteria: Limitation of deflections under normal and short circuit conditions shall be made to prevent damage of insulators, connections and equipment. Loads on dead end structures shall meet all utility mechanical design requirements, including maximum line tensions, line angle, NESC loading zone, wind loading, ice and snow conditions, and download and uplift factors. Structures shall be designed with a minimum of bolted joints. Steel structures shall be welded before galvanizing; field welding is not permissible. Lace or lattice structures shall not be used unless approved by ITO. All assembly hardware is to be included. Wood pole and cross-arm type construction are not permissible for stations with a primary voltage of 69kV and above. .

Typical structures types shall include, but not be limited to the following: transmission line termination dead-ends, shield wire poles, disconnect switch stands, bus supports, instrument transformer stands, surge arrester supports, and station service installations.

When IC design is specified over ITO standards, the design, detailing, drawing, and fabrication of all substation structures shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 100-5 "Design and Fabrication of Steel Poles"
- AP MS 2200-40 "Design of Substation Structures"
- AP MS 2200-50 "Substation Steel Structures"
- AP MS 2200-60 "Substation Aluminum Structures"
- AP MS 500-56 "Bus Support Height Adapters"
- AP MS 500-76 "Anchor Bolts"
- AP MS 500-77 "Substation Zinc-Coated Bolts"
- AP MS 500-78 "Substation High Strength Galvanized Bolts"
- AP MS 500-82 "Substation Aluminum Structural Tower Bolts"

5.15 Bus Conductor, Clamps, and Connectors – IC shall use the established ITO criteria for bus configuration regarding bus conductor sizes and phase spacing. For old ITO facilities designed before the current established standards were in effect, IC will be responsible for properly designing the substation bus system, choosing the proper conductor size, bus spacing, and open air bus lengths with regards to: continuous and fault current; thermal expansion; deflections due to dead load, wind, ice, and fault forces; Aeolian vibration damping in long tubular bus runs; and corona prevention (230kV and above). The ITO will provide fault levels and clearing times for system stations for study/design purposes.

General Bus/Connector Criteria: material to be aluminum (unless copper exists in the project area); main bus and cross bus runs and taps to be tubular; equipment risers/taps to be wire; connectors to be bolted not compression (welding is permitted only in EHV stations); dissimilar metal connections must utilize transition pads; hardware to be stainless steel; and quadrant-type strain clamps shall be used for line deadends.

When IC design is specified over ITO standards, the design of all substation bus work and connections shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 400-6 "Bare Solid and Stranded Cable"

- AP MS 400-15 “Primary & Secondary Underground Cable in Conduit”
- AP MS 400-20 “Aluminum Cable Steel Reinforced”
- AP MS 400-21 “Aluminum Clad Shield Wire and Guy Wire”
- AP MS 400-60 “Aluminum Bus Tubing”
- AP MS 400-65 “Universal Angle & Rectangular Bus Conductor”
- AP MS 400-84 “Conductor and Shield Wire Installation”
- AP MS 600-41 “Substation Bolted, Welded, and Compression Electric Power Connectors”
- AP MS 600-55 “Welding Aluminum Conductors”
- AP T&D Standard 28010 “Installation of Bolted Substation Connectors”

5.16 <u>High Voltage Cables and Terminations</u> - The IC shall design any high voltage underground cable, conduit duct bank, and manhole system required for this project. The IC shall ensure that all of the circuits are coordinated to their respective cables, conduits, and manholes. The design shall include cable and conduit schedules, outdoor cable and conduit duct bank routing layouts, installation details (such as depth, warning/protective measures, and concrete encasement), and indoor terminations in switchgear, if required.

Heat shrink, cold shrink, taped, or porcelain slip-on type stress cones will be used to terminate all power cables above 2.3kV. Stress cones shall be installed in accordance with the manufacturer's instructions. All cables shall be high-pot tested after terminations are completed.

The IC shall design underground distribution to all requirements of the latest revision to the following AP Material & Services Specifications and all associated ITO and industry specifications cross-referenced within:

- AP MS 400-22 “Jacketed Concentric Neutral Primary Cable”
- AP MS 2800-1 “Underground Distribution Cable Backfill Material”

5.17 <u>Insulators</u> – IC shall specify the proper insulators for bus supports, disconnect switches, and equipment support, and shall specify installation details on the electrical elevation drawings. High strength **porcelain**, station post insulators with hot dipped galvanized steel, mounting hardware will be used on all bus supports. Porcelain suspension insulators with hot dipped galvanized steel hardware shall be used on transmission line deadend assemblies.

The design of all substation insulation shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 300-20 "Suspension Type Wet-Process Porcelain Insulators"
- AP MS 300-25 "Suspension Deadend Synthetic Insulators 12KV and 34.5KV Distribution Lines"
- AP MS 300-26 "Suspension Deadend Synthetic Insulators 34.5, 46, and 69KV Subtransmission Lines"
- AP MS 300-40 "230kV & Below Apparatus and Bus Support Insulators"
- AP MS 300-45 "345kV & 500kV Apparatus and Bus Support Insulators"
- AP MS 300-50 "800kV & Below Outdoor Apparatus Bushings"
- AP MS 300-55 "500kV Substation Insulator and Hardware Assemblies"

5.18 Grounding System – The IC shall be responsible for properly designing the substation ground grid to insure that safe step and touch potentials and ground potential rise are present under phase-to-ground faults using back-up clearing times. The design and calculations shall conform to the latest revision of IEEE Standard 80 "Guide for Safety in AC Substation Grounding" and IEEE Standard 142 "Recommended Practice for Grounding of Industrial and Commercial Power Systems" and any other applicable standard. When connecting to an existing ground grid system designed prior to IEEE Standard 80, as indicated in the Contract Documents, the IC shall perform proper testing of the existing system, prior to designing ground grid additions. For new green-field sites, the IC shall perform all field tests, measuring the soil resistivity for a multi-level soil model in ohm-meters using the 4-electrode Wenner method, outlined in IEEE Standard 142. Several readings shall be obtained on the fence diagonals. If more data is needed due to wide test deviations, additional tests must be made throughout the substation area. The ITO will provide fault levels and clearing times for system stations.

The substation ground grid shall consist of:

- A perimeter ground loop, of the required size to prevent fusing of stranded soft drawn copper wire (minimum size to be 1/0), shall encircle the entire substation 3 feet beyond all fence lines and 3 feet beyond the swing line of all gates.

- An interior ground mesh, of the required size and spacing of stranded soft drawn copper wire (minimum size to be 1/0), shall be installed within the entire grid perimeter wire.

- Copperweld ground rods, 3/4" diameter x 8' long, suitable to be driven below grade, will be installed at all grid corners and at intervals of at least 100 feet on the perimeter grid wire. Deep ground rods will be specified if warranted for a safe grounding system design.

- Ground coils per T&D Standard 26090 “Ground Coil Installation” are to be installed under pier-type foundations to ensure the grid is in contact with deeper, moister soil in drought conditions and in contact with soil below the frost line in winter conditions.

- AASHTO #57 crushed stone will cover the entire substation area extending 5 feet outside substation fence. Depth will be 3 inches at 138kV, 4 inches at 230kV, and 6 inches at 345 and 500kV or at 63kA.

- All ground grid conductor will be buried at a minimum of eighteen inches (18”) below rough grade unless deeper burial is specified.

- Cadweld® or Thermoweld® exothermic welds, on clean grid wire, are required on all below grade connections.

- Connect all structures, equipment operating grounds, junction boxes, fence, and buildings to the grid. Ground tap leads will be stranded soft drawn copper wire of sufficient gauge to withstand fusing (minimum size to be 4/0). Each tap will be individually connected to the main ground network. Do not connect one tap to another tap. Safety grounds are to be separate from operating grounds.

- Typically, ground tap leads above ground will be supported by bolted type one-hole two-piece (clamshell) ground clamps at five (5) foot maximum intervals on structures. NEMA two-hole lug connectors will be used for ground connections to breakers, power and instrument transformers, in buildings, and all substation equipment. Where the item the IC provides has no ground connection point, extreme care shall be exercised in selecting a suitable location for drilling holes for the attachment of grounding conductor.

- Fence shall be grounded using a 1/0 minimum copper lead below grade and a #4 aluminum alloy 1435-0 tie wire above grade connected to the fabric at multiple points and to each strand of barb wire. Fence grounds shall be located on the inside of the fence so that no part of the fence will be over 60 (sixty) feet from a ground connection. Tie both gate panels and gateposts of all gates with a continuous copper wire of 4/0 minimum size.

If after installation of a designed grid, the final resistance indicates failure to achieve the designed value, the IC shall redesign to mitigate any shortcoming of the ground system, install the proper reinforcements to the grid, and retest for compliance, all at no extra cost to the ITO over the Contract amount.

5.19 Control Cable and Conduit – The IC shall design all control cable and conduit to interconnect all of the equipment required for this project. This shall also include any cable and conduit systems if required as part of this project by other utility companies. It shall be the responsibility of the IC to insure that all of the circuits are coordinated to their respective control cables and conduits. The design shall include cable and conduit schedules, interconnection wiring diagrams, outdoor cable and conduit layouts, and indoor panel layouts.

Cables shall be neatly routed from the indoor control or power panels to the control building cable entrance (cast in the building foundation) through an aluminum cable ladder system suspended from the control building ceiling. A 2” rigid woven wire Cablofil® cable tray shall be installed alongside and outside of the suspended aluminum cable ladder system for telephone circuitry, SCADA and other related circuits. From the building cable entrance, pre-cast concrete cable trenches with removable lids will be used as the main trunk and branches from the control building to the substation yard proper. Cables from the trench to the outdoor equipment shall follow the shortest route to their destination at a minimum depth of 24 (twenty-four) inches and either be: 1) direct buried in a layer of sand, covered with protective penta-treated boards 6 (six) inches over the cables, and followed with rock-free backfill, or 2) installed in a properly sized PVC conduit in rock-free backfill. All outdoor cables above grade shall be in properly sized rigid UV-resistant PVC conduits, or in liquid-tight flexible conduit only in areas where frost heaving can damage enclosure/cabinet bottoms. Conduits for circuits, which connect the substation to any external plant or utility, shall be stubbed and capped 5 (five) feet beyond the fence for connection by others. If necessary, outdoor UV-resistant PVC, painted galvanized steel, or aluminum junction boxes and pull boxes, shall be utilized.

Control cables shall be terminated with approved non-insulated shank, ring tongue crimped lugs using a ratchet-type crimping tool. All control wires shall be numbered at each end with heat shrink or other approved permanent markers. All cables shall be tagged at each end of the cable with tags as approved by the ITO’s representative permanently showing cable number.

Control and power wiring shall be distinguishable and separate per NEC. Low voltage analog and digital control circuits shall be properly shielded or routed separately from power circuits, so that power circuit does not induce error. AC and DC wiring shall be separated.

All indoor control, metering, communication, SCADA, and low voltage power wiring shall be multi-conductor cable. Control cable shall be multi-conductor, stranded copper, 600 volt (minimum), and color-coded to ITO standards, suitable for use indoor or outdoor, in cable tray and in conduit, above and below grade, in wet and in dry locations. In outdoor locations where voltages are 345kV and greater, 1000 volt insulation is required. Only stranded copper conductor control wiring shall be used outside of the control building. Aluminum wiring or aluminum lugs are not acceptable. Under no circumstances are cables to be spliced at any point. IC's design of all substation cables shall meet all requirements of the latest revision of the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 400-29 "600V Underground Cable"
- AP MS 400-70 "300V Telemetering, Communication & Supervisory Cable"
- AP MS 400-74 "1000V Control & Power Cable"
- AP MS 400-75 "600 Control, Power & Meter Cable"
- AP MS 400-76 "600V Type SIS Switchboard Cable"
- AP MS 600-39 "Crimp Terminal Connectors for Control and Meter Cable"
- AP MS 900-5 "Steel Conduit and Associated Fittings"
- AP MS 900-20 "Pre-Cast Concrete Cable Trench Components"
- AP MS 1500-40 "Underground Marking Tape"
- AP MS 2200-1 "Installation of Pre-Cast Cable Trench"

Current and potential circuits shall be 4/C #10 AWG copper minimum; however current cables in excess of 300 feet shall be 4/C #6 AWG copper minimum. Control circuits shall be 16/C #12 AWG copper minimum. Alarm circuits shall be 12/C #12 AWG copper minimum for transformers and 8/C #12 AWG copper minimum for breakers. Power circuits shall be 2/C #10 AWG copper minimum for mechanism heaters, and 2/C #10 with safety ground for building and yard lights and receptacles. Power circuits shall be 4/C #6 AWG copper minimum for transformer AC supply. DC Circuits shall be 2/C #10 AWG copper minimum. Shielded cable shall be used to all power transformers with a primary voltage of 138kV of greater and to all other 138kV and above transmission equipment.

For outdoor applications, Shielded Control Cables must be installed in the transmission portion of substation switchyards (Voltages 138kV and above). All cable shields and spare wires are to be grounded at both ends. Non-shielded outdoor Control Cables may be used for the distribution or sub-transmission portion of outdoor substation yards, unless the cables are routed through the Transmission portion of the station to reach the Control Building.

5.20 <u>Electrical Equipment</u> – Circuit breakers, circuit switchers, load break switches, disconnect switches, fuses, reclosers, switchgear, power transformers, and station service transformers (main and back-up) shall be designed for the line, capacitor, and/or transformer service as indicated on the Contract Documents. IC shall be responsible for properly sizing and selecting all interrupting and withstand ratings. IC shall be responsible for properly specifying all electrical equipment to conform with AP Engineering Manual Section 31, Subject Index 7.0 “High Voltage Operating Limits”. IC will propose any equipment size changes that may be advantageous to ITO.

For electrical equipment, the IC shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 700-1 “69kV and Below Three Phase Power Transformer”
- AP MS 700-2 “EHV Substation and GSU Power Transformer”
- AP MS 700-3 “69kV and Below Single Phase Power Transformer”
- AP MS 700-5 “Substation Station Service Transformers”
- AP MS 700-9 “23-69kV Single Bushing, Single Phase Voltage Transformers”
- AP MS 700-10 “23-69kV Two Bushing, Single Phase Voltage Transformers”
- AP MS 700-11 “138kV Single Phase Potential Transformers”
- AP MS 700-12 “230kV Single Phase Potential Transformers”
- AP MS 700-15 “23-34.5kV Single Phase Outdoor Current Transformers”
- AP MS 700-16 “46-69kV Single Phase Outdoor Current Transformers”

- AP MS 700-50 “115-230kV High Voltage Three Phase Power Transformer”
- AP MS 700-51 “115-230kV High Voltage Three Phase Power Transformer, Forced Air Cooling Equipment”
- AP MS 700-63 “Stack Rack Shunt Capacitor Banks Through 230kV”
- AP MS 700-64 “Single Bushing & Two Bushing Substation Capacitor Units”
- AP MS 700-81 “Outdoor, Single Phase Step-Voltage Regulators”
- AP MS 800-10 “Oil Recloser – Series Trip”
- AP MS 800-21 “Oil Recloser – Shunt Trip”
- AP MS 800-50 “EHV Power Circuit Breakers”
- AP MS 800-52 “15.5kV Vacuum Circuit Breakers”
- AP MS 800-55 “SF_6 Gas Insulated Circuit Breakers – 69kV and Below”
- AP MS 800-56 “SF_6 Gas Insulated Circuit Breakers – 121kV to 242kV”
- AP MS 800-65 “4.16kV Metal-Clad Switchgear”
- AP MS 800-70 “15kV Metal-Clad Switchgear”
- AP MS 800-72 “Rebuilding and Retrofitting Metal-Clad Switchgear”
- AP MS 1000-10 “15-69kV Vacuum Capacitor Switches”
- AP MS 1000-50 “Power Fuses”
- AP MS 1000-60 “Low Voltage Cartridge Fuses and Fuse Blocks”
- AP MS 1000-70 “23-34.5kV Metal-Enclosed Interrupter Switchgear”
- AP MS 1100-10 “230kV and Below Group Operated Air Switch”
- AP MS 1100-20 “15-69kV Hookstick Disconnects”
- AP MS 1100-25 “15kV Back Connected Switches”
- AP MS 1100-30 “Circuit Interrupting Switch”
- AP MS 1100-40 “345kV and 500kV Group Operated Air Switch”

- AP MS 1100-50 “Air Switch Outriggers”
- AP MS 1100-61 “Mechanism - Motor Operated, 180° Operator, 10,000 In-Lb”
- AP MS 1100-63 “Mechanism - Motor Operated, 180° Operator, 20,000 In-Lb”
- AP MS 1100-65 “Mechanism - Motor Operated, Reciprocating, 10,000 In-Lb”
- AP MS 1100-40 “Load Break & Non-Load Break Cutouts for 12kV and 34.5Kv Distribution”

Before procurement, the IC shall be responsible for bringing to the attention of the ITO any unusual, extraordinary, or unconventional features, requirements and/or operation of IC's equipment.

5.21 <u>Control Equipment and Panels</u> - The IC shall design the protection, control, metering, supervisory, and communication systems for the proper functioning of the interconnection substation. The IC shall utilize 3 (three) inch spacers between adjacent panels and racks for wiring.

The IC shall provide control, metering, and communication devices, instrument transformers, and panels meeting all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 1800-5 “High Voltage Metering Unit”
- AP MS 1800-6 “Meter Socket, 320A Single Position, Single Phase”
- AP MS 1900-1 “Substation Annunciator”
- AP MS 1900-2 “Current Transducers”
- AP MS 1900-3 “Voltage Transducers”
- AP MS 1900-8 “Three Phase - Three Wire Watt/Var Transducer”
- AP MS 1900-9 “Three Phase - Four Wire Watt/Var Transducer”
- AP MS 1900-10 “Coupling Capacitors”
- AP MS 1900-11 “Coupling Capacitor Voltage Transformers”
- AP MS 1900-12 “Line Traps”

- AP MS 1900-13 “Line Tuning Units”
- AP MS 1900-14 “Power Carrier Transmitter-Receiver”
- AP MS 1900-19 “Three Phase - Four Wire Watt/Var Transducer”
- AP MS 1900-20 “Three Phase - Three Wire Watt Transducer”
- AP MS 1900-21 “Three Phase - Four Wire Watt Transducer”
- AP MS 1900-22 “Three Phase - Four Wire Watt Transducer”
- AP MS 1900-23 “Vertical Steel and Rack Switchboard Panel - Fabrication and Wiring”
- AP MS 1900-25 “Three Phase Current Transducer”

5.22 Relay Coordination – The IC shall provide the protective relay design. The ITO shall provide the relay coordination studies for all equipment supplied within the substation, coordinate with local utility, with equipment supplied by others, and shall provide the Relay Setting Orders (RSO) for protection and control, unless specified otherwise. IC shall supply all related data required for equipment being supplied by others to the ITO in order to complete necessary relay coordination and settings in a timely manner.

5.23 Lightning and Surge Protection - IC shall provide and install a shield pole and wire system over the substation per NFPA 780 “Standard for the Installation of Lightning Protection Systems” and IEEE Standard 80 “Guide for Safety in AC Substation Grounding”. Shielding shall be provided for by the IC meeting all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 400-84 “Conductor and Shield Wire Installation”

The IC shall provide surge protection by using surge arresters that meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 1700-2 “Distribution Class Metal Oxide Arresters”
- AP MS 1700-10 “Intermediate Class Arresters”
- AP MS 1700-20 “Station Class Arresters, 115kV And Above”

For installations that include neutral grounding resistors, arresters must be sized appropriately to withstand phase-to-phase voltages.

5.24 Control Building and Station Service - The IC shall provide for a pre-engineered metal control building for non-EHV stations, as required for the project. The building shall utilize pre-fabricated wall and roof panels that act as the primary structural support. It shall be single story with a gable roof, and shall be 16'-0" wide by a minimum length of 24'-0" with increments of 4'-0" to the length required. The design shall allow for relocation of the rear wall and insertion of side wall and roof panels for future expansion of the building. The IC shall coordinate the size of the building to provide sufficient panel space for the ultimate future development of the substation. The interior color shall be white and the ITO will provide the color of the building exterior, unless otherwise dictated by local governing bodies. The IC will provide a lockset for the building door and the ITO shall furnish the core and keys.

The IC shall complete the interior of the building with ventilation louvers, cable ladder with support hangers, AC and DC power panels, control cable exit portals, conduit, lighting, heating, telephone service, and all associated wiring. Any outdoor AC/DC power supply and/or distribution shall be considered to be an extension and part of the overall building wiring design. For non-EHV stations, the station service shall be single phase 120/240V AC, unless other voltage levels are established at the facility. Station service, main and backup supplies if needed, are to be supplied from the secondary bus, power potential transformers, local subtransmission/distribution circuits, and/or generators, as specified in the Contract Documents.

If panel space is limited in an existing control building for the project, the building shall be expanded or a second building install by the IC, whichever is determined to be the most cost-effective alternate and approved by the ITO.

EHV station control buildings and station service shall conform to special requirements covered in the specification listed below.

The design of the substation control building and AC/DC supply panels shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 2300-10 "Metal Substation Control Building"
- AP MS 2300-11 "Specification for EHV Control Building"

- AP MS 1200-17 “Substation AC Lighting Panel Load Center”
- AP MS 1200-18 “Substation AC Power Panel Load Center”
- AP MS 1200-19 “Substation DC Breaker Type Panelboard”
- AP MS 1200-25 “Power Distribution Panel Outdoor Load Center”
- AP MS 1200-30 “Substation Safety Switch, Outdoor, Fusible”

5.25 Control Battery – The IC shall provide a control battery, rack, charger, eyewash station, and “Danger - No Smoking” sign, as required for this project. Control service shall be 125V DC, unless other voltage levels are established at the facility. The IC shall coordinate the voltage and ampere-hour ratings and rack length to provide sufficient capacity for the future development of the substation as foreseen by ITO planners. If a DC supply is already installed, the IC shall verify the battery’s capacity to adequately handle the project scope, and if necessary, replace it with a unit sufficient for future development.

The design of the substation control battery system shall meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 1300-10 “Substation Storage Batteries”
- AP MS 1300-51 “Battery Chargers”
- AP MS 1500-64 “17” X 10” Sign, Danger - No Smoking”

5.26 Yard Lighting – IC shall install yard lighting as required. Lighting will include general illumination for the movement of personnel and directed illumination for equipment inspection and for seeing high voltage bus and equipment live parts. Minimum illumination in the horizontal general area will be two (2) foot-candles, with maximum to minimum ratio of ten (10) in the yard. Minimum illumination for vertical tasks around high-voltage breaker, meter equipment, and transformer gauges will be five (5) foot-candles. Illumination levels shall be per the latest revision of NESC and Standard No. 6001 - "Engineering Guideline for Electrical Design". Lighting calculations will comply with lighting levels for switchyards, substations and transformer yards per the latest edition of the “Lighting Handbook” by the Illuminating Engineering Society of North America. Calculations with fixture layout and horizontal and vertical foot-candle printouts will be submitted for ITO review. IC shall use 125V, 150W outdoor incandescent medium screw base flood lamps to allow for use of ITO standard stock bulbs. Photoelectric control is not required and manual control is desired.

5.27 Fence and Gates - IC shall be responsible to design all fencing and gates enclosing the substation and, if required, storm water facilities. Fence to be aluminum-coated steel chain link fabric 7 feet high, including 1 foot of 3-strand barbed wire on top. A minimum of one 20 (twenty) foot wide double panel swing gate shall be located in the fence-line on the access road centerline. Pedestrian gates are not required unless stated in the Contract Documents. Equipment layout and accessibility, as coordinated between IC and ITO, shall determine the final quantities and sizes. Gates swing shall be to the outside of the fenced area. Fence shall be provided with 14” X 20” ‘Danger’ warning signs installed at intervals dictated by NESC. The ITO will provide a lock for the gate.

The IC shall provide fence by using materials that meet all requirements of the latest revision to the following AP Material & Services Specifications and all other associated ITO and industry specifications cross-referenced within:

- AP MS 2000-50 “Aluminum Coated Steel Chain Link Fence”
- AP MS 2000-55 “Aluminum Coated Steel Chain Link Fence Installed”
- AP MS 500-10 “Gate Latch for Double Swing Gate”
- AP MS 1500- 51 “14” X 20” Sign, Danger – High Voltage Inside – Keep Out”

6 MATERIAL AND EQUIPMENT PROCUREMENT

General - All items to be included in the project shall be as specified in the previous section on Engineering by the IC's engineering staff and shall be procured by the IC’s procurement staff. Any material ordered by the IC, that is not in compliance with this specification and not authorized in writing by the ITO, shall be the responsibility of the IC regarding any associated cost. It is IC's responsibility to insure that all equipment procured through Suppliers is delivered on schedule and complete as listed in the bill of materials and in compliance with the specifications.

6.1 Preparation – Flanged surfaces for radiators, bushings, and accessions, removed for shipment, shall be protected during shipment by bolted-on, matching steel covers. If weather conditions dictate, all space heaters shall be wired to accessible shipping terminal blocks for external power during shipment or storage.

6.2 Rail Shipment - In the event that a transformer, or other equipment, must be delivered by rail, there shall be impact recorders attached to the shipment, which shall record the horizontal, transverse, and vertical components of shock. Records obtained from these impact recorders shall be furnished to the ITO. The ITO must give prior approval for rail shipments.

6.3 Shipping Damage – All factory finishes damaged during shipment shall be immediately repaired, primed, and repainted by the IC per the Supplier's directions.

6.4 Material Surpluses – The IC will be responsible for the disposition of all unused or surplus material.

7 CONSTRUCTION AND INSTALLATION

General - All items to be installed for the project shall be as specified in the section on Engineering as designed by the IC's engineering staff, and per the section on Procurement as provided by IC's procurement staff, unless specified by ITO in the Contract Documents as performed by the ITO or others. The IC shall perform work with its own permanent construction crews and/or with approved contractors. The IC's construction workforce shall consist of construction personnel (labor, supervision, and administration), equipment, vehicles, tools, and personal protective equipment. The construction workforce shall have training in electrical power facilities and shall have extensive experience installing similar high voltage substation projects. All equipment, vehicles, and tools shall be of the proper capacity and horsepower to efficiently perform all work, and shall be maintained to function adequately. The assigned construction manager and field supervisor/superintendent shall be approved by the ITO prior to release for construction based on resumes and credentials submitted.

The IC shall be responsible for providing all labor and equipment for site preparation, foundations, structures, oil containment, ground grid, control cables, fence, insulators, bus work, electrical equipment, buildings, site rehabilitation and any other incidentals required for the project. For all equipment, regardless of source, the IC shall assemble all components and perform any gas and/or oil filling and processing required. Gas or oil samples shall be taken by the IC prior to filling equipment to test for moisture, contaminants, etc. per the ITO's test procedures. IC's work shall be in compliance with all building codes, governing regulations, right-of-way agreements, and stipulations set forth in the permits and approvals granted.

It is IC's responsibility to insure that the entire facility is constructed on schedule and complete as shown in the IC's engineering and in compliance with the standards, material, equipment, and construction methods specified therein. Any work done by the IC, not in compliance with this specification and not authorized in writing by the ITO, shall be the responsibility of the IC regarding corrective measures and cost.

The ITO shall provide a construction coordinator to act as a liaison to the IC's staff to address questions on construction matters.

7.1 ITO Oversight – As a basis for quality control, the ITO will have full-time, on-site inspection personnel during all construction and commissioning activities. The ITO's inspector will inspect the adequacy of such aspects of the project as: adherence to safety regulations; grading and compaction of the site; foundation excavation and rebar/anchor bolt placement before concrete is poured; concrete slump; cable routing before pulled cables are back-filled and terminated; ground grid runs and connections before back-filled; structure erection; material handling and storage; proper housekeeping; and work practices in general. The action or inaction of the ITO's inspector shall not relieve the IC of their responsibility and duty to fulfill their obligation under the Contract Documents.

7.2 IC Field Supervision – The IC shall provide a competent full-time, on-site field construction supervisor who has experience in the installation of high voltage substation facilities and the supervision of personnel on projects of similar size, scope, and duration. The supervisor shall be assigned for the full duration and extent of the project and shall be present continually during its progress. The supervisor will maintain an office on or adjacent to the jobsite, and will at all times keep in said office a complete copy of the drawings, specifications, and Contract Documents. IC will provide telephone and fax service in the field office. IC shall provide field office space and furniture for the ITO inspector during construction.

7.3 Construction Facilities - It is the IC's responsibility to arrange for temporary power and water onsite as part of the general construction. IC is responsible for office trailer, communications, storage trailers, and sanitary facilities. The IC is required to provide all facilities for startup as dictated by the project schedule.

7.4 Temporary Buildings – The IC may erect temporary buildings (storage sheds, shops, trailers, offices, etc.) and utilities at their own expense. IC will remove such temporary buildings and utilities upon completion of the work. At existing ITO facilities, ITO approval is required for these temporary installations.

7.5 Staking & Alignment – The IC shall layout the new substation facilities and shall be responsible for setting and maintaining necessary stakes, grade lines, and elevations for foundation installation. One benchmark shall be designated (by the IC for greenfield installations or by the ITO for existing installations) as the reference elevation for the project. The reference elevation shall be agreed upon by both the ITO and IC, prior to the start of construction for the project.

7.6 Protection of Material - IC is responsible for the protection and storage of all materials, supplies, and equipment for the project.

7.7 Structures/Equipment Touch-up – Warping may occur during the hot dip galvanizing process. Reaming holes may be required in some cases. Field drilling may also be required. All galvanized finishes damaged or reamed during installation shall be repaired, cleaned, primed, and repainted. No welding or flame cutting of galvanized steel shall be permitted without ITO permission. Minor damage to galvanized surfaces shall be touched up as follows:

- Paint Materials: One heavy coat of ZRC or Galvanox, Type I. Mineral spirits shall be used as a thinner for ZRC.

- Application: Remove all slag, weld spatter, burned zinc coating, and all other foreign matter by hand or power tools and apply one heavy brush coat of thoroughly mixed zinc coating the same day cuts and welds are made. The coating shall overlap the damaged galvanized areas a minimum of 1" with a 4 mils minimum rim thickness. Proper drying time must occur before structure assembly or equipment mounting proceeds.

All painted finishes damaged during shipment or installation shall be repaired, cleaned, primed, and repainted per the latest revision to the following AP Material & Services Specifications and all associated ITO and industry specifications cross-referenced within:

- AP MS 3800-5 “Electrical Equipment Paint for Air/Airless Spray, Flow Coating, and Brush Application”

7.8 Energized Equipment - The IC shall coordinate all work concerning energized equipment with the ITO’s representatives. ITO shall perform all required switching and lockout/tag out procedures.

To comply with the ITO’s grounding safety procedures, for all new power equipment installed (transformers, breakers, etc.), IC shall not connect the high voltage leads to the equipment until testing of the equipment is completed. Contact ITO in advance to coordinate completion of testing before final equipment primary connections are made.

All external cables entering the control building shall be landed and connected to new panels by the IC. At existing facilities, all external cables entering the building shall be landed and connected to all energized panels only by the ITO.

7.9 Collateral Work - ITO will be permitted to have 3rd party contractors, enter the property for the purpose of performing construction, maintenance, operation, testing, or auditing. IC shall cooperate with these entities.

7.10 Clean Up - As a part of the work included in the Contract Documents, the IC will complete the following:

- Completely remove and satisfactorily dispose of all temporary works and buildings unless directed otherwise by the ITO.
- Satisfactorily remove, fill, or grade all embankments, excavations, or cofferdams made for construction purposes unless directed otherwise by the ITO. This includes seeding and mulching of all disturbed areas.
- Remove all plant and equipment.
- Appropriately contain and dispose of all rubbish resulting from the operations under this Contract on a daily basis.
- Restore the site of the IC's operations to at least as good order and conditions as at the beginning of the work in the Contract Document.

7.11 Damage and Losses – Refer to the Operating Agreement of PJM Interconnection for the project.

7.12 Defective Work – Shall be in accordance with the Contract Document's General Terms and Conditions section on "Warranty".

8 TESTING AND COMMISSIONING

General – IC shall be responsible to ensure that equipment Suppliers satisfactorily perform all factory testing. IC shall notify ITO prior to the commencement of any factory or, in their area of responsibility, any field tests so that ITO's representative may witness these tests if required.

For testing to be done by the IC, The ITO shall be on site to witness all field inspection, commissioning, certification and testing, of all equipment and controls systems within the ITO switchyard. The IC must coordinate these activities with the appropriate ITO liaison giving sufficient advanced notice, so that the IC's schedule will be maintained. The ITO shall also be responsible for the start-up, energization, transfer of load, and commissioning functions required to place the ITO's interconnection facilities in service as specified in the Interconnection Service Agreement and Operating Agreement of PJM Interconnection. For testing to be done by the ITO, the IC shall provide appropriate on-site personnel required to act as a liaison to the ITO's field technicians to address questions on matters related to testing and commissioning that may be the result of the IC's related work under this Contract Documents.

8.1 <u>Factory Testing Requirements for IC Supplied Equipment</u> – The equipment Suppliers selected by the IC shall maintain a quality control and inspection program satisfactory to the ITO. Material supplied can be subject to shop inspection by the ITO or their duly authorized representative, both during manufacture and after completion.

In addition to IC's normal inspection procedures, the ITO reserves the right to:

- Inspect materials, documents, and manufacturing operations.
- Inspect the equipment during manufacture and testing.
- Witness the manufacturing, fabrication, and/or testing of any part of work, which concerns the subject equipment.
- Evaluate test results of non-destructive examinations.

IC shall afford ITO free plant access, suitable facilities, and ample notice of scheduled work on the project. IC shall give ITO written notice, a minimum of two (2) weeks prior to the test date, of the date and place at which any equipment will be ready for final shop inspection and to witness testing as specified for the individual equipment. ITO shall give IC five (5) business days prior notice of their intention to witness tests and/or inspect any equipment. Such inspection and/or witnessing shall not relieve IC of any obligations under these specifications.

The IC shall supply the ITO with 2 (two) complete sets of the detailed equipment outlines, nameplates, and operating drawings, and operating instructions, which shall be used by ITO to assist in the inspection during the manufacturing, fabrication, and testing of the equipment

The equipment shall be completely assembled, wired, adjusted, and tested at the factory in accordance with the most current standards specified in this document. After assembly, each item shall be tested for operation under simulated service conditions to assure accuracy of wiring, integrity of the control scheme, functionality, and satisfactory operation of the components to ensure an operational piece of equipment as part of the witness performance test. All external doors and hinged bolted panels providing access to high voltage areas shall be accessible.

IC shall obtain and furnish to ITO the standard factory test results for all equipment as well as other specified tests of similar units, and certified copies of test results, as specified in ANSI. For all instrument transformers and meters to be used for revenue, interstate, or interconnection metering, the documentation of the factory testing, calibration, and certification must be provided to the ITO.

The ITO shall be immediately notified of any unusual damage occurring during construction of the equipment and of all tests that do not meet specified or standard values. ITO shall be permitted, at their option, to personally inspect such damages and/or test failures.

8.2 Field Controls Testing – The ITO shall furnish qualified personnel to witness the field-testing of the equipment and electrical systems installed or constructed under the Contract Documents. The IC shall furnish all required tools and test instrumentation, including special equipment for bench testing of protective relays. It is the intent of this specification that field-testing be extensive and complete as specified to assure proper mounting, connection, adjustment, setting, and functioning according to the manufacturer's recommendations and detailed engineering in order to provide positive assurance of correct installation and operation of equipment.

8.2.1 Controls Installation – IC shall install new control and metering panels, SCADA RTU, annunciator, digital fault recorder, telephone protection panel, etc. IC shall be limited to working only on new or de-energized existing equipment. IC shall make minor repairs including, but not limited to, items such as loose hardware, broken wires, wiring errors, and inoperative targets. IC will label all new equipment and devices on new and/or modified control panels using a P-Touch type label maker. ITO will label panels with circuit names, position designations, etc. For stations with energized facilities ITO shall perform all the controls work on the energized panels.

8.2.2 Test Equipment Calibration - IC shall have a calibration program that assures that all test instruments used are calibrated in accordance with the International Electric Testing Association (NETA). Dated calibration labels should be visible on all test equipment.

8.2.3 Controls Wiring and Equipment Verification – IC shall visually inspect all arresters, switchgear, breakers, motor mechanisms, power and instrument transformers, line traps and tuners, relay and metering racks, SCADA RTU, communication and other station equipment to confirm that nameplates and equipment match the station drawings and manufacturer's specifications. IC will inspect all substation equipment for damage, loose hardware, missing parts, etc.

IC shall inspect all field wiring for loose terminations, missing or poor crimp connections, etc., and verify cable terminations, cable identification numbering, and other field wiring in both the control building and at all outdoor equipment. Cable ties cut to verify wiring are to be replaced in kind.

IC will verify ground connections to each control panel, rack, RTU, power panel, and any other device in the control building and also to every outdoor control-type cabinet (breakers, transformers, mechanisms, etc.).

8.2.4 Relay Testing – ITO Controls Technician will observe that the relay nameplate data matches information on the relay setting orders, station control drawings, etc. ITO will visually inspect all protective and auxiliary relays for any dirt, contaminants, moisture, broken leads, loose circuit boards, misadjusted contacts and/or any other types of physical or mechanical damage, both internal and external to the relay. If necessary, IC will clean any electromechanical contacts or other operating and/or mechanical relay components.

ITO Controls Technician will observe while the IC checks tight all internal and external screws, nuts, bolts, circuit board seating and other mechanical connections and/or hardware, and verify contact alignment and travel, disc rotation, freedom of movement of all moving parts, target operation, etc.

ITO Controls Technician will observe while the IC checks electrical and mechanical continuity of all taps, rheostats, pots, etc. IC will check impedance of each input and output circuit to the frame of the relay.

IC will perform standard manufacturer recommended acceptance tests on all auxiliary and protective relays. This will include verifying all input and output circuits on any electronic and/or microprocessor based relay. IC will then apply relay settings to all protective relays, timers, etc. as per ITO's Relay Setting Orders. IC shall perform final relay verification tests on all protective relays, timers, etc. (per ITO's requirements) to confirm that the relay is operating as per the applied relay settings, electrically operate and verify proper contact operation for all used and/or spare contacts on all auxiliary and lockout relays.

8.2.5 Automated Relay Testing – Automated relay testing is preferred but not required on protective relays. If automated testing is utilized and there is a choice of software, the ITO prefers RTS software, marketed by ENOSERV, LLC. in Tulsa, OK. This would enable electronic data files to be directly loaded into the ITO's Testing Database.

If RTS is utilized ITO may provide its own test routines for some relays. Regardless of the software used, both hard copies and electronic files of all relay test data are to be provided at the conclusion of the project.

8.2.6 Meter and Transducer Testing – IC shall be responsible for the programming, calibration, and adjusting, if necessary, all non-revenue meters whether on relay panels, SCADA racks, etc., in the control building. IC shall perform such functions for outdoor equipment, such as switchgear, breakers, transformers, reclosers, etc. IC shall be responsible for testing and verifying the calibration of all transducers in the control building. IC shall perform such functions for outdoor equipment.

ITO's metering technicians shall install, program, test, and place in service the ITO's power meters on any meter racks. ITO will be responsible for verifying all inputs/outputs, wiring, etc. to the meter racks.

8.2.7 Current Transformer Testing – ITO Controls Technician will observe while the IC checks polarity mark orientation on all CT's with respect to the three line diagrams and the manufacturer's drawings, and polarity test all CT's to verify accuracy with nameplate and manufacturer's drawings. IC will perform ratio and excitation tests on CT's on all combinations of taps. IC will perform insulation resistance tests from CT secondary to ground, and CT secondary to CT secondary.

ITO Controls Technician will observe while the IC verifies CT circuits from each CT through every relay, test switch, meter, etc. according to the AC schematic diagrams. This test may be performed either by injecting current at the CT secondary terminal block or by the DC pulse method. In either case, the current or DC pulse should be measured or verified at each test switch, relay, meter, etc.

If requested by the ITO, excitation tests shall be performed to compare data to manufacturer's published CT excitation curves

The IC shall use a yellow highlighter on a set of station drawings to document each circuit and device tested. The drawings shall be dated and signed by the person completing the tests.

8.2.8 Outdoor Power Equipment – IC shall adjust opening and closing limit switches, and any other in-service auxiliary (pallet) switches, on all air and/or vacuum switch motor mechanisms. IC shall verify correct operation of all auxiliary (pallet) switches, latch-check switches, pressure switches, low pressure cutouts, x-y relay scheme, tripping, closing, etc. on all power circuit breakers.

ITO Controls Technician will observe while the IC tests, verifies, and calibrates, as necessary, all sensor alarms and/or controls on transformers, breakers, switchgear, station battery, station service transfer schemes, and any other station equipment (temperature, pressure, vacuum, spring charge, current, voltage, etc). This will include the manufacturer's recommended tests on transformer LTC vacuum bottles, Qualitrol microprocessor based temperature monitors, etc.

ITO Controls Technician will observe while the IC tests and verifies correct operation of all transformer fan, pump, LTC, and other controls, such as raise/lower, auto/manual, VRBC (Voltage Reduction Bias Control), LTC travel limits and cutouts, braking timers, sump pump operation, etc.

ITO Controls Technician will observe while the IC verifies proper tuning of all line tuners and line traps, and check for presence of internal arrester in all line traps. ITO shall verify correct voltage and proper operation of all heaters in control cabinets of all outdoor equipment.

8.2.9 Function Testing Complete System - ITO Controls Technician will observe while the IC function tests every relay, trip, alarm, control handle, auto/manual switch, SCADA, Programmable Logic Controller (PLC) and any other control circuit to verify actual operation of each contact, test and/or isolation switch, interlock, etc. according to all station DC schematics. The IC shall conduct end-to-end function testing of relay systems that interconnect the station to the ITO's (or IC's) remote substation or generation facilities. This shall be performed as a final station check after all other work is completed.

IC shall pull fuses or open test switches in each CVT or PT junction box, apply appropriate voltages to load side and check for proper voltages at all relays, meters, test switches, etc.

IC shall setup, program, and single end tune all fiber optic or power line carrier communication systems used for relaying, transfer trip, metering, SCADA, communication, etc. IC shall conduct final end-to-end tuning and level checks with the remote locations.

IC shall be responsible for all external circuits to SCADA Remote Terminal Units (RTU), PLC (with or without station computer), and Digital Fault Recorders (DFR), including power supply, grounding, input and output circuits. ITO shall be responsible for the setup, programming, and internal verification of any SCADA RTU, PLC, and DFR. ITO shall perform final SCADA operational tests with ITO's System Operations.

The IC shall use a yellow highlighter on a set of station drawings to document each contact, circuit, device, or function tested in their area of responsibility. The drawings shall be dated and signed by the person completing the tests.

8.2.10 Test Reports – For the IC's area of responsibility regarding controls testing, written records of all tests performed (including relays, gauges, sensors, meters, transducers, etc.) showing date, personnel performing test, and results should be maintained. Copies of all test reports and data shall be submitted, both a hard copy and electronic file if available, to the ITO's control engineering liaison weekly.

8.2.11 Marked Drawings – For the IC's area of responsibility regarding controls testing, a complete set (copy or original) of ITO's drawings with highlighted AC and DC schematics (signed and dated) documenting any testing performed shall be submitted to ITO before energization of the facilities for reference. Include any approved field changes, corrections, notes, etc. These marked prints do not in any way relieve the IC of the responsibility of completing all final as-built drawing revisions specified in the section on Engineering and Design Requirements.

8.2.12 Equipment Damage - IC shall be fully responsible for all damage they may cause to material or equipment due to improper test procedures.

8.3 Field Equipment Electrical Testing – The ITO Personnel will observe while the IC performs all required electrical equipment tests on arresters, breakers, capacitors, bushings, CVT's, PT's, reclosers, regulators, switches, transformers, and any other power equipment. Tests shall include: Breaker Timing and Motion Analysis, Contact Resistance (Ductor), High Potential Leakage Current (Hi-Pot), Insulation Resistance (Megger), Oil Dielectric, Power Factor, SF_6 Moisture Analysis, Total Combustible Gas (TCG) and Oxygen, Transformer Turns Ratio (TTR), and Thermovision.

All tests shall follow procedures specified in the AP "Equipment Receiving and Inspection Guide" and the AP "Substation Notebook". Transformer oil testing shall be per AP MS 3900-70 "Oil Chemistry Analysis Testing".

8.4 Grounding System Test – The IC shall verify that all equipment is solidly bonded to the station ground grid. A Biddle Earth Resistance Tester, AEMC Earth Resistance Tester Model 4500, or equivalent shall be used for the test. Test results shall be provided to the ITO along with all other field test reports.

If ground grid design and installation was required, the IC shall determine the actual resistance of the installed ground grid by a Fall of Potential Test to verify compliance with the design. The test lead location, field measurements, test calculations, and results shall be provided to the ITO. Acceptable methods are:

- Three or four point methods, using an ammeter and voltmeter with AC or DC power supply.
- Commercial instrument method, using a "Megger" ground tester manufactured by James G. Biddle Co. of Philadelphia, PA or "Vibraground" tester from Associated Research, Inc. of Chicago, Il.

Ground Potential Rise (GPR) data shall be provided based on the final test.

8.5 Records – For all tests the IC is responsible for, IC shall maintain in a written record, all final factory tests, all controls and electrical tests, and all ground tests, showing dates, personnel making test, equipment or material tested, tests performed, and results. IC shall furnish copies of test records to ITO. If available, electronic records shall also be furnished on CD-ROM.

8.6 Defective Work - Shall be in accordance with the Contract Document's General Terms and Conditions section on "Warranty".

8.7 Commissioning and Field Acceptance – On-site commissioning encompasses complete review and verification of the equipment and installation process. The commissioning effort shall not be completed until all deficiencies noted by the ITO's commissioning personnel are resolved to the satisfaction of the ITO.

IC shall supply ITO with a tabulation of substation checkout procedures required for the initial starting and running of the equipment. ITO's control personnel will prepare any required energization procedures for new and/or revamped facilities. ITO's personnel shall be responsible for all switching, start-up, energization, load transfer, and commissioning activities.

The ITO shall conduct the Final Load Tests after all equipment is energized, in-service, and load current is flowing that includes:

- Read and record all relay currents and voltages both magnitude and angle
- Read and record all switchgear and panel meter readings
- Read and record all operation counter readings
- Read and record all transformer combustible gas test results

The IC shall have technical representatives present during the start-up, energization, load transfer, and in-service testing to assist the ITO, and to resolve any questions or problems that may occur related to IC's work.

9 PROJECT MANAGEMENT

General – The IC shall be responsible for performing all project management functions for the project. They shall have managed similar high voltage substation projects and shall have extensive experience with the duties and responsibilities required.

The ITO shall provide a project manager to act as a liaison with the IC's staff to address questions on business matters related to the project. The ITO's project manager shall serve also as the team leader for the ITO's personnel. Specific requirements to be provided by the IC are as follows:

9.1 Communication Management – Active communication shall be the basis for the successful completion of the project. The IC shall formulate a formal communication plan including a list of contacts, both IC and ITO, with their roles, e-mail addresses, and phone numbers at the project kick-off meeting. This plan will be adhered to until the project and all closeout reports and as-built revisions are completed. IC shall establish a single point of contact (project manager) for all communications between ITO and IC. A secondary point of contact shall be identified by the IC at the commencement of the project in the event the primary contact is not available. The ITO's project manager shall serve as the central clearing-house for all deliverables sent to the ITO and all responses returned to the IC. Technical matters that can be best resolved on a peer-to-peer level need not go through the project manager. However, the ITO's project manager shall be copied on all written correspondence (letters, memos, e-mail).

9.2 Meetings – Status update meetings shall be scheduled and held on a recurring basis, and shall be attended by the IC's project manager and appropriate staff to discuss and coordinate the progress of the overall project. Face-to-face meetings or teleconferences are acceptable. Type and frequency of meetings shall be determined by mutual agreement between ITO and IC. ITO prefers bi-weekly meetings as long as sufficient results are being accomplished as determined by the ITO. As circumstances warrant, either ITO or IC may request more or less frequent meetings. The IC shall provide minutes for the ITO's comment and approval within 5 (five) business days.

9.3 Progress Report - Shall be provided, at a minimum, monthly in the ITO provided format and will include: the original scope description and any scope changes; a current schedule along with a brief summary of major milestones showing scheduled and actual finish dates; a cost summary to date including the budgeted, actual, and remaining costs and the projected cost at completion; a brief description of the status in the last period; and a recovery plan if needed. If warranted and requested by the ITO, more frequent reporting shall be provided at no additional cost.

9.4 Outage Scheduling – Outages for existing facilities need to be scheduled By the ITO and through PJM well in advance of the actual outage date, as per PJM manual M03. Specifically, outages for the EHV System (500kV and 345kV) need to be scheduled approximately 1 year in advance of the outage. Outages to the transmission system (138kV & 230kV) need to be scheduled a minimum of 60 days in advance of the outage, however 6 month is the norm. Some facilities are season dependent with respect to loading and may not be able to be scheduled within these timeframes. Earlier is better.

10 DELIVERABLES

General – Deliverables shall be defined as all IC and Supplier correspondence, drawings, design data, permits, instruction books, software, programs, electronic files, test results, schedules, progress reports, and other documents required to be submitted both for review and for final ownership to fulfill the Contract Document. Media shall be electronic computer file on CD-ROM, vellums, and printed-paper copies, all distributed in required quantities at the proper times to ITO's personnel as defined in this section.

ITO's Company Name, Substation Name, Project Title, and Project Identification Number (PID) shall be shown on all deliverables and on the cover letter or packaging accompanying deliverables. For electronic media, a separate hardcopy listing of the CD-ROM (or disk) contents shall be provided to ITO.

Deliverables shall be sent at the various process check-points per the section on Engineering and Design Requirements, during the field tests per the section on

Testing and Commissioning, and in conjunction with the baseline schedule dates as set forth in the section on Project Management.

All deliverables shall be sent in the following quantities specified:

- Electronic Media — 1 copy — Final Transmittal Only
- Reproducible Vellum, full scale, rolled — 1 copy — Final Transmittal Only
- Paper Prints, 50% reduction*, folded — 2 copies — All Transmittals

  * (AP 400 and 500 Series drawing sizes only. All other prints: full scale)

Transmittal of As-Built Revisions (in the above formats and quantities) shall include only the deliverables affected.

All deliverables shall be sent to the attention of the ITO's project manager for distribution, unless alternate arrangements are agreed upon.

<u>Drafting Requirements</u> – Drafting shall be in CAD format conforming to ITO's standards. The IC shall comply with ITO's requirements regarding: system software, drawing numbers, CAD filenames, title blocks, drawing standards, size formats, file formats, ancillary files, file exchange options, general requirements, and specific design file requirements for each for engineering discipline. Drawing history (author, date, drafter, reviewer, approver, revision, etc.) in the ITO's document management system/database shall be the responsibility of the ITO.

For drafting services, the IC shall meet all requirements of the latest revision to the following AP Specification and all associated ITO and industry specifications cross-referenced within:

- AP Specification #DDR-03-12 "Specification for Outside Drafting Services".

Data for Detailed Connection (Wiring) and Interconnection Diagrams, Bills of Material, component, and material inventory shall be provided in electronic media in MS Word for Windows format.

Specific deliverables are as follows.

10.1 <u>Engineering Data Requirements</u> - All IC, Manufacturer, and/or Supplier engineering-related data, such as criteria, parameters, models, design, studies, etc. required for the project, equipment, or components, shall be provided per the requirements of this specification. Typical data is not acceptable.

10.2 Drawing Requirements – Other than in the conceptual engineering stage, **Typical Drawings are not acceptable!** The following drawings shall be supplied by the IC as applicable for the specific project:

- Project Single Line Diagram (conceptual version; 8½“ X 11” or 11” X 17”)
- Project Phasing Diagram (conceptual version; 8½ “ X 11” or 11” X 17”)
- Drawing Reference List – Substation Drawings
- Drawing Reference List – Controls Drawings
- Property Plan
- Grading and Erosion/Sedimentation Control Plan
- Oil Spill Response Site Drawing
- Oil Containment System
- Screening and Landscaping Plan
- Site Plan
- Foundation Details Drawings
- Structure Fabrication and Erection Drawings
- Foundation and Fence Layout
- Cable and Grounding Layout
- General Arrangement
- Plan View
- Elevation/Section Views with Details
- Control Building Indoor Layout
- Control Building Cable Tray Layout
- Bill of Material - Substation
- Bill of Material – Control Building
- Manufacturers’ Equipment Drawings (outline, nameplate, instructions, etc.)
- Controls One Line Diagram
- Block Tripping Diagram
- Controls Three Line Diagram
- Bill of Material – Switchboards
- Switchboard Front Views
- Panel Wiring Diagrams
- Swing Panel Wiring and Equipment Placement Diagrams

- Breaker Schematic Diagrams
- Breaker Wiring Diagrams
- Circuit Switcher Schematic Diagrams
- Circuit Switcher Wiring Diagrams
- Motor Mechanism Schematic Diagrams
- Motor Mechanism Wiring Diagrams
- AC Schematic Diagrams
- DC Schematic Diagrams
- Bus Differential AC Schematic Diagrams
- Bus Differential DC Schematic Diagrams overload
- Transformer Differential and Overload AC Schematic Diagrams
- Transformer Differential and Overload DC Schematic Diagrams
- Transformer Schematics
- Transformer LTC Schematics
- Transformer Wiring and Control
- Potential Transformer Wiring Diagrams
- CVT Schematic Diagrams
- Recloser Wiring Diagrams
- VRBC Schematic Diagram
- Annunciator Alarm Schematics
- SCADA Point List
- SCADA Schematic Diagram
- SCADA Connection Diagram
- Substation Integration and Local Area Network Schematic
- Metering Diagram
- Meter and SCADA Rack - Front and Rear View Layout and Bill of Material
- Meter Connection Diagram
- Metering AC and Data Schematic
- Panel Construction Details
- Cable List
- Control Building AC and DC Wiring Diagram and Control Panel Layout

For a new substation, the ITO shall provide blank Drawing Reference List templates and typical drawings in paper and electronic media as examples and guides to conform to ITO’s drawing nomenclature and numbering standards. For existing substations, the ITO’s shall supply its CAD drawings on CD-ROM.

Specific requirements for certain types of drawings are as follows:

10.2.1 <u>Electrical Equipment Elementary Diagrams</u> – Elementary (schematic) wiring diagrams shall be furnished for each breaker at 4kV or above and for each different control scheme. Drawings shall be developed one per breaker. Each elementary diagram shall show all control devices and device contacts, each of which shall be labeled with its proper ANSI device function number. Each elementary diagram shall show devices with all spare contacts tagged. Terminal block terminal numbers shall not be shown with the exception of slide link blocks and on potential schematics. Schematics for remote annunciation, trip, close, lockout and ITO interface shall be supplied at drawing review and shall be included in IC's drawing package. Both Detailed and As-Built (installed) drawings shall incorporate ITO terminal board points.

10.2.2 <u>Detailed Connection (Wiring) Diagrams</u> – Detailed Connection (wiring) diagrams shall be furnished showing the approximate physical location of all items in each unit, all wiring within each unit, all interconnecting wiring between units, and identification of all terminals, terminal blocks, and wires. A Cable list drawing must be provided that documents the destination, function, and cable specifics, for all indoor and outdoor cables. .

Clear identification, by some distinguishing method, of all wiring that is to be installed shall include, but not be limited to, leads from external current transformers, trip circuits from remote devices, auxiliary contacts to remote devices, incoming DC control power, and separate incoming AC power. This shall also include spare auxiliary contacts and relay contacts, which shall be wired to terminal blocks for future use.

10.2.3 <u>Bills of Material</u> – All material lists shall be furnished indicating: 1) the item number; 2) the required quantity and its corresponding unit of measure; 3) source of the item (manufacturer, catalog number, or former substation if relocated); and 4) item description (including type of device, voltage and current ratings, interrupting rating, insulation rating, phase spacing, conductor size, material, surface finish, descriptive dimensions, catalog number, and other pertinent information). Each item description must have sufficient detail per the following examples:

- *Connector, terminal, bolted, aluminum, 3” SPS tubing to 3” 4 hole NEMA pad, with mounting hardware*

- *Switch, air, vertical break, 138KV, 2000A continuous, 100KA momentary, 650KV BIL, 3 phase, group operated, upright mounted, with arcing horns*

10.3 Spare Parts, Lubricants, and Chemicals – IC shall provide information on the following items:

- Spare parts, lubricants, and chemicals for startup and commissioning
- Spare parts, lubricants, and chemicals required for 2-year operation
- Special tools, such as breaker timing equipment, fittings, and unique maintenance tools
- If switchgear is included with the project, a rack in grounding device is required, along with a breaker dolly for removing breakers from the cubicle

This information and lists are to be enclosed in an 8½" X 11" binder. These lists shall contain:

- Quantity of each (or assembly)
- Recommended purchase price
- Weight (net and shipping)
- Delivery time
- Parts drawings, showing parts numbers and location of parts, shall bear the following information:
  - Equipment identification (for which the part is intended)
  - Part number (if any)
  - Part description including material

These lists may identify subassemblies rather than individual parts to the extent considered practical and economical.

10.4 Component Test Sheets – IC shall provide manufacturers test records for all CT's, VT's, relays, meters, devices, and calibrated components with the final drawings or at factory testing.

10.5 Installation, Operating, and Maintenance Instructions – IC must furnish installation, operating, and maintenance instructions that cover all the equipment furnished including all protective relays, power fuses, auxiliary relays, etc., and will include characteristic curves of each different protective relay and power fuse. All certified equipment data sheets and mechanical and thermal damage characteristics of all transformers must be included.

10.6 Specification Conflicts - In the event the IC believes that a conflict exists between this general specification and any other specification or documents supporting this specification, not covered as an exception by the Contract Documents, the IC shall promptly bring such conflicts to the attention of the ITO. The ITO shall rule on these conflicts before work affected by the conflict is started or continued. So that work shall not be delayed, these rulings may be verbal, with written confirmation following.

Originated By: R. J. Slebodnik

Approved: James H. Myers III 4/28/06
James H Myers, III
General Manager, Projects

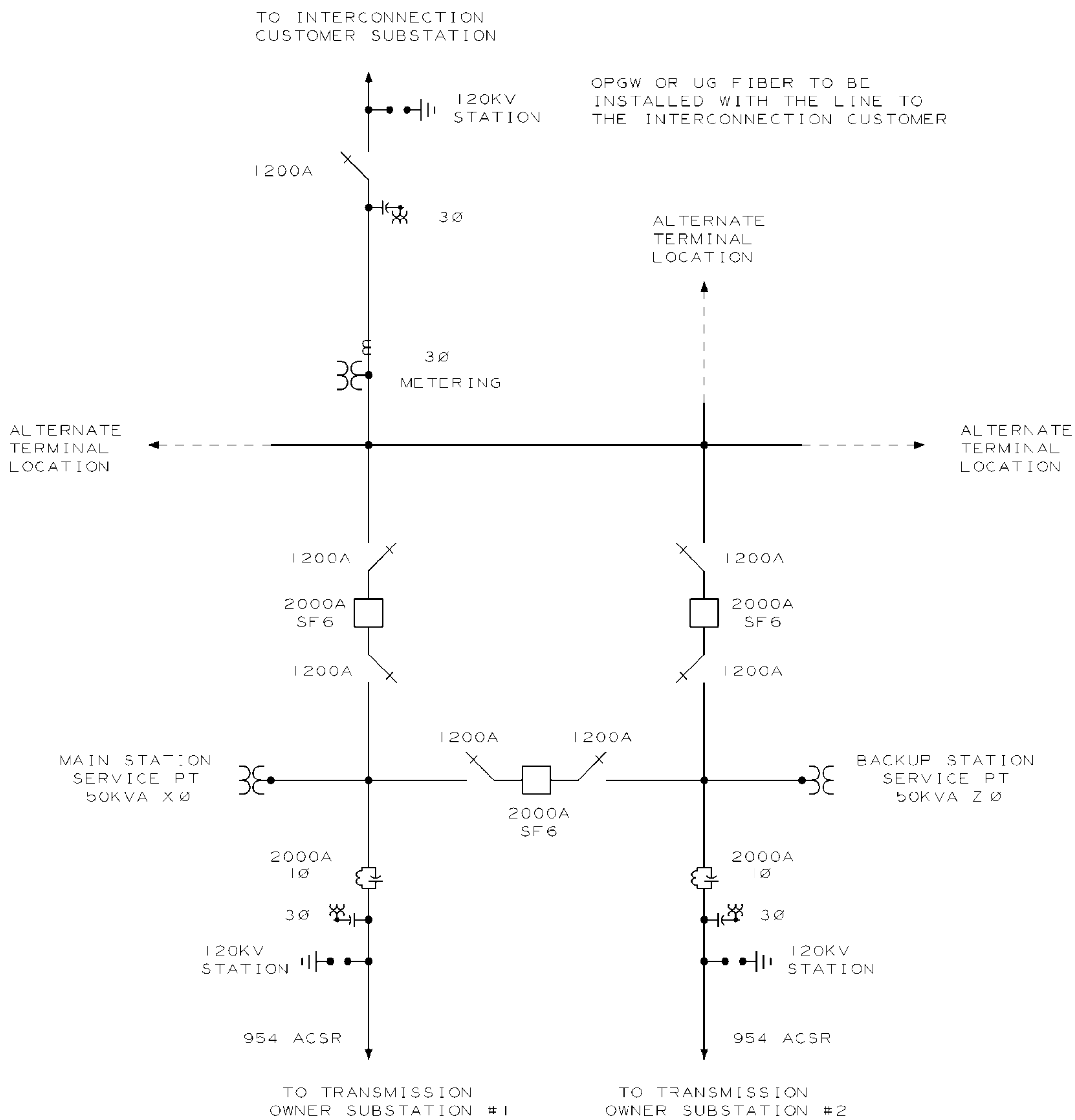
Date: 28-Dec-05

Approved: Robert L Henry 5/2/06
Robert L. Henry
Director, Transmission Projects

Revision Code Legend
(A) to denote a new paragraph
(R) for a revised paragraph
(E) between remaining paragraphs shows paragraph has been deleted

<u>138KV INTERCONNECTION STATION DATA</u>

Single Line Diagram representing a typical 138kV AP interconnection switching station.



Allegheny Power System

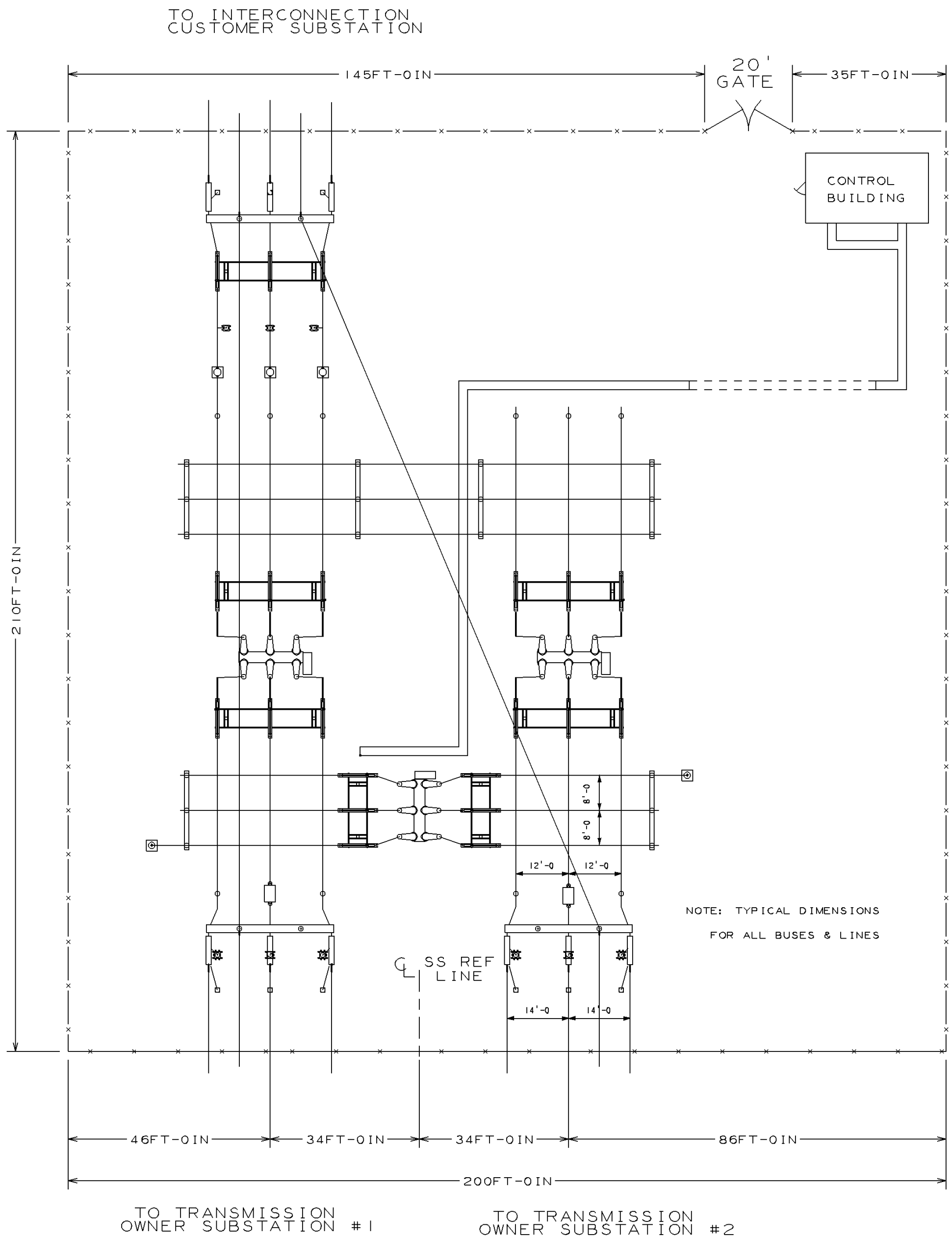
SINGLE LINE DIAGRAM

TYPICAL 138KV INTERCONNECTION
TRANSMISSION OWNER SUBSTATION

SOURCE: TRANSMISSION PROJECTS
DATE: 20-OCT-05

TYPICAL THREE TERMINAL 138KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

An Electrical Layout representing a typical 138kV AP interconnection switching station.



Allegheny Power
PRELIMINARY LAYOUT
TYPICAL 138KV INTERCONNECTION STATION
SCALE: N. T. S.
SOURCE: TRANSMISSION PROJECTS DATE: 20-OCT-05

TYPICAL THREE TERMINAL 138KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

SPECIFIC AP 138kV DESIGN CRITERIA REQUIREMENTS

Electrical Design Criteria:

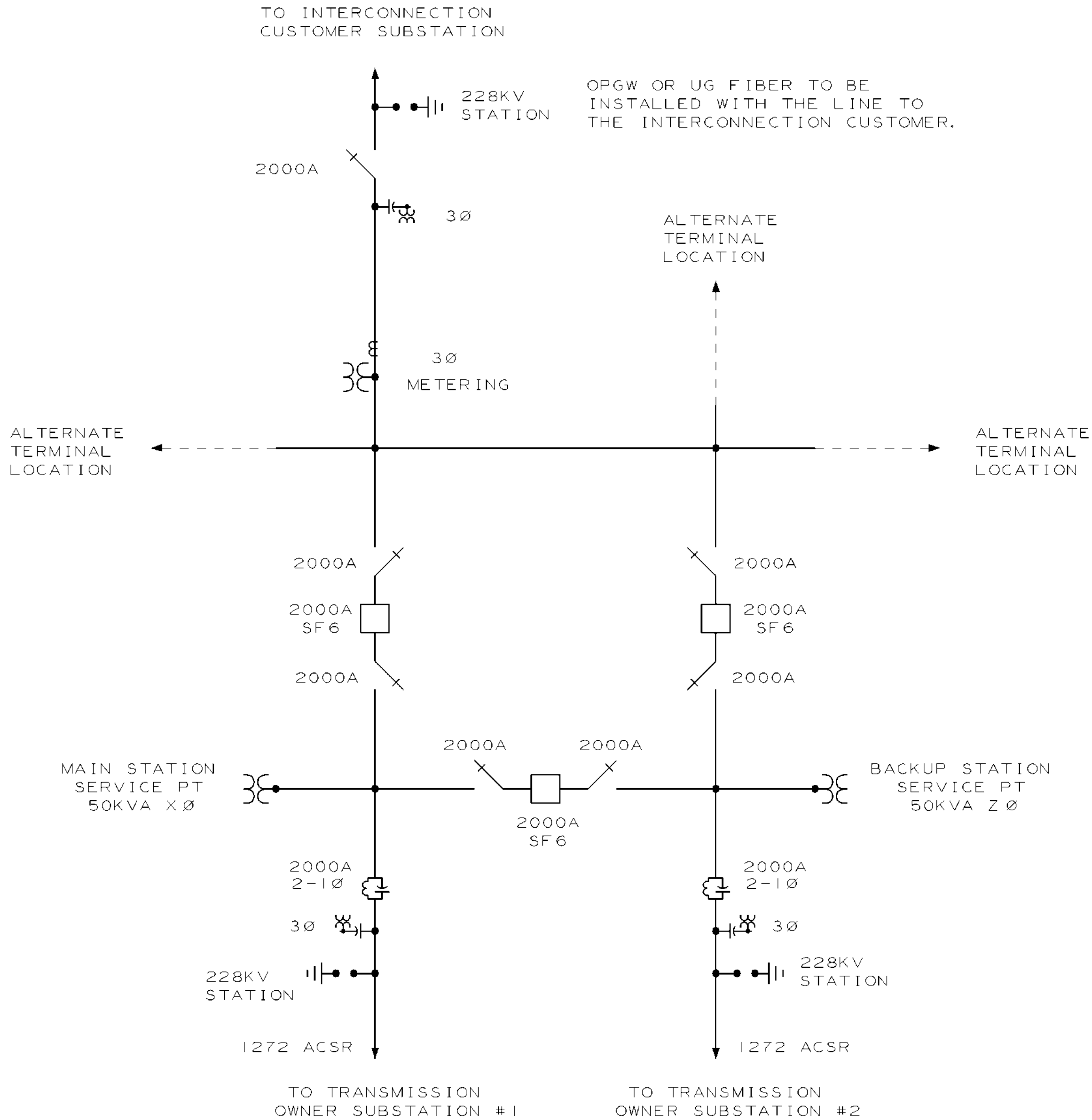
A.	Nominal Voltage Rating	138 kV
B.	Maximum Voltage Rating	145 kV
C.	BIL Rating	650 kV BIL
D.	Surge Arrester Duty Cycle	120 kV
E.	Continuous Current Rating	1200 or 2000 A
F.	Fault Current Rating	40 or 63 kA
G.	Ambient Temperature	- 35˚ C to + 40˚ C
H.	Maximum Temperature Rise	100˚ C
I.	Bus Conductor	Tubing, Aluminum, 3" SPS, Schedule 40
J.	Maximum Tubing Deflection	One tube diameter
K.	Aeolian Vibration Control	336.4 kcmil 18/1 ACSR span exceeding 20'
L.	Bus Heights	16'-0" & 24'-0"
M.	Phase Spacing, for Bus & Switch	8'-0" & 12'-0"
N.	Phase-to-Ground Clearance	52"
O.	Yard Stone Cover	3" ASTM #57 or Equivalent

Civil Design Criteria:

1. In addition to equipment, a 250 pound man on the structure or on a ladder against the structure.
2. Deflection of structures due to loading will be limited to 1/300 of the span in the vertical direction and 1/200 of the span in the horizontal direction.
3. Substation graded yard slope to be approximately 2%.
4. The design criteria is based on the worst case of the following conditions:
   a. An 80 mph wind load and a fault current of 40 kA
   b. ½" radial ice load with a 40 mph wind and a fault current of 40 kA
5. Line Deadend: Tension of 2000, 5,000 or 12,000 lbs/ wire with a Maximum Allowable Angle of 15 º off the deadend with a total of 30 º if the deadend is rotated 15 º

230KV INTERCONNECTION STATION DATA

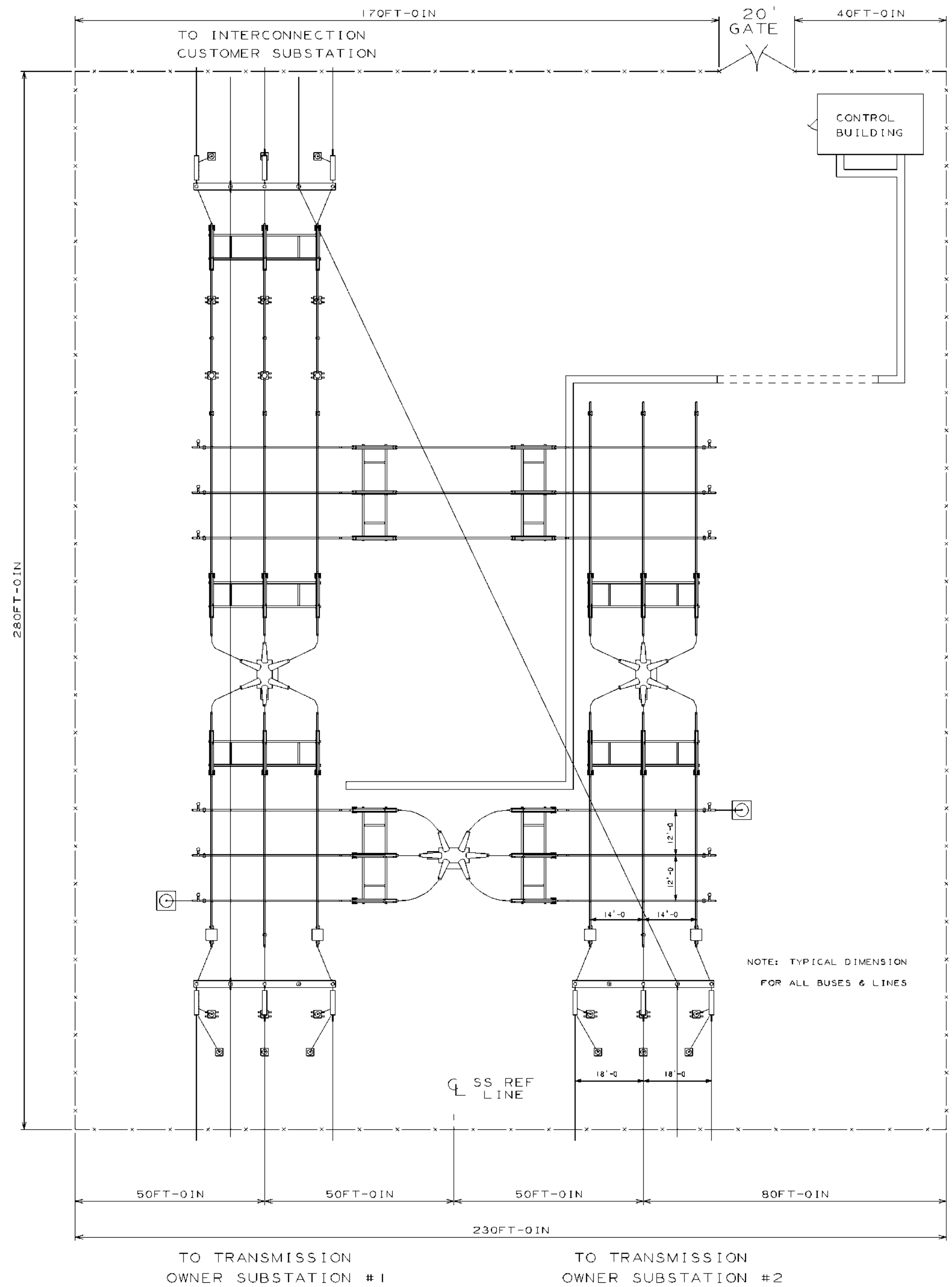
Single Line Diagram representing a typical 230kV AP interconnection switching station.



Allegheny Power System
SINGLE LINE DIAGRAM
TYPICAL 230KV INTERCONNECTION TRANSMISSION OWNER SUBSTATION
SOURCE: TRANSMISSION PROJECTS DATE: 20-OCT-05

TYPICAL THREE TERMINAL 230KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

An Electrical Layout representing a typical 230kV AP interconnection switching station.



Allegheny Power

PRELIMINARY LAYOUT

TYPICAL 230KV
INTERCONNECTION STATION

SCALE: N. T. S.

SOURCE: TRANSMISSION PROJECTS
DATE: 20-OCT-05

TYPICAL THREE TERMINAL 230KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

SPECIFIC AP 230kV DESIGN CRITERIA REQUIREMENTS

Electrical Design Criteria:

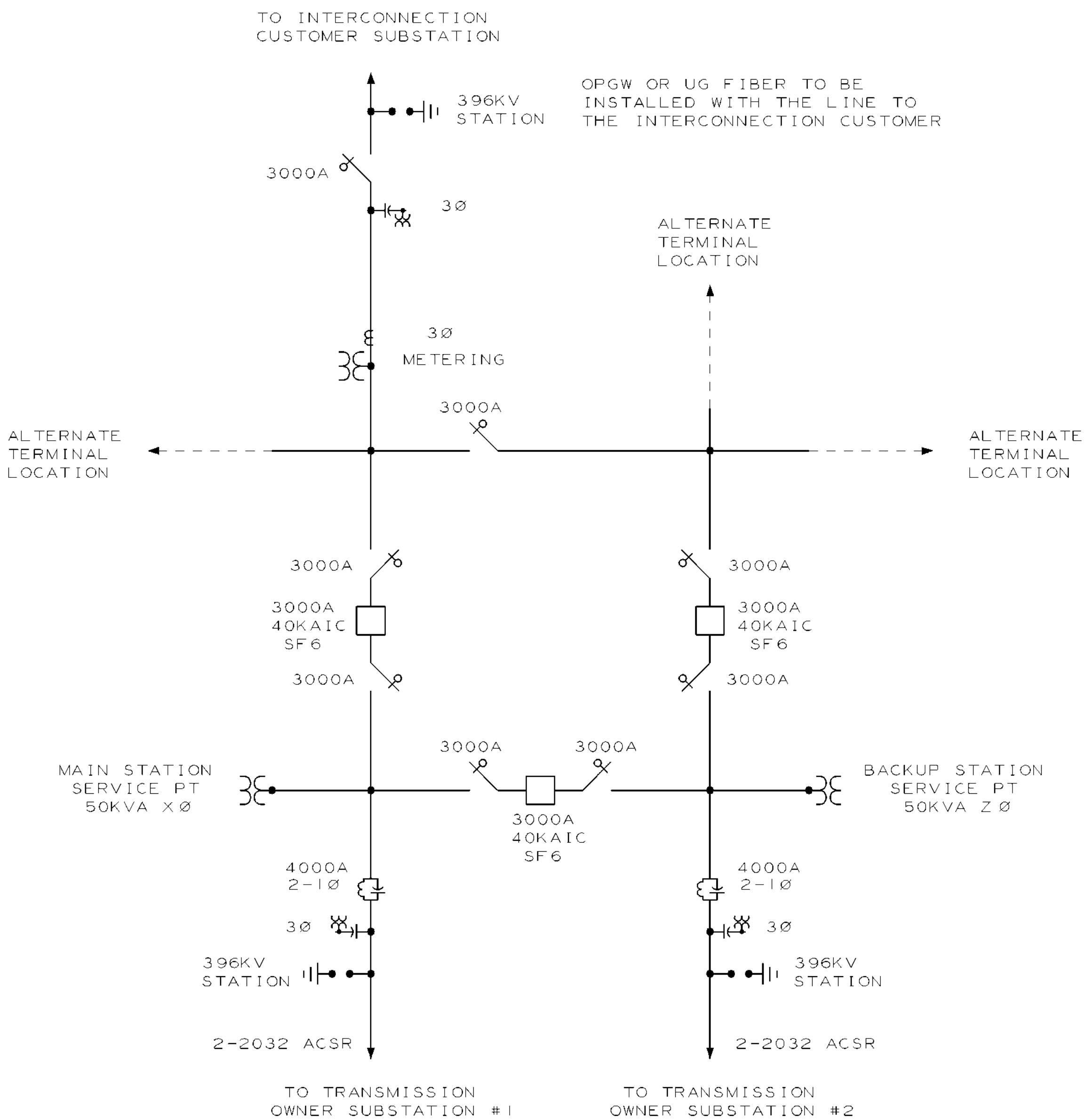
A.	Nominal Voltage Rating	230 kV
B.	Maximum Voltage Rating	242 kV
C.	BIL Rating	900 kV BIL
D.	Surge Arrester Duty Cycle	228 kV
E.	Continuous Current Rating	1200 A
F.	Fault Current Design Rating	40 kA
G.	Ambient Temperature	- 35˚ C to + 40˚ C
H.	Maximum Temperature Rise	100˚ C
I.	Bus Conductor	Tubing, Aluminum, 4” SPS, Schedule 40
J.	Maximum Tubing Deflection	One tube diameter
K.	Aeolian Vibration Control	954 kcmil ACSR in span exceeding 20’
L.	Bus Heights	20’-0” & 30’-0”
M.	Phase Spacing, for Bus & Switch	12’-0” & 14’-0”
N.	Phase-to-Ground Clearance	76”
O.	Yard Stone Cover	4” ASTM #57 or Equivalent

Civil Design Criteria:

1. In addition to equipment, a 250 pound man on the structure or on a ladder against the structure.
2. Deflection of structures due to loading will be limited to 1/300 of the span in the vertical direction and 1/200 of the span in the horizontal direction.
3. Substation graded yard slope to be approximately 2% or less.
4. The design criteria is based on the worst case of the following conditions:
   a. An 80 mph wind load and a fault current of 40 kA
   b. ½” radial ice load with a 40 mph wind and a fault current of 40 kA
5. Line Deadend: Tension of 2000, 5,000 or 15,570 lbs/ wire with a Maximum Allowable Angle of 15 º off the deadend with a total of 30 º if the deadend is rotated 15 º

500KV INTERCONNECTION STATION DATA

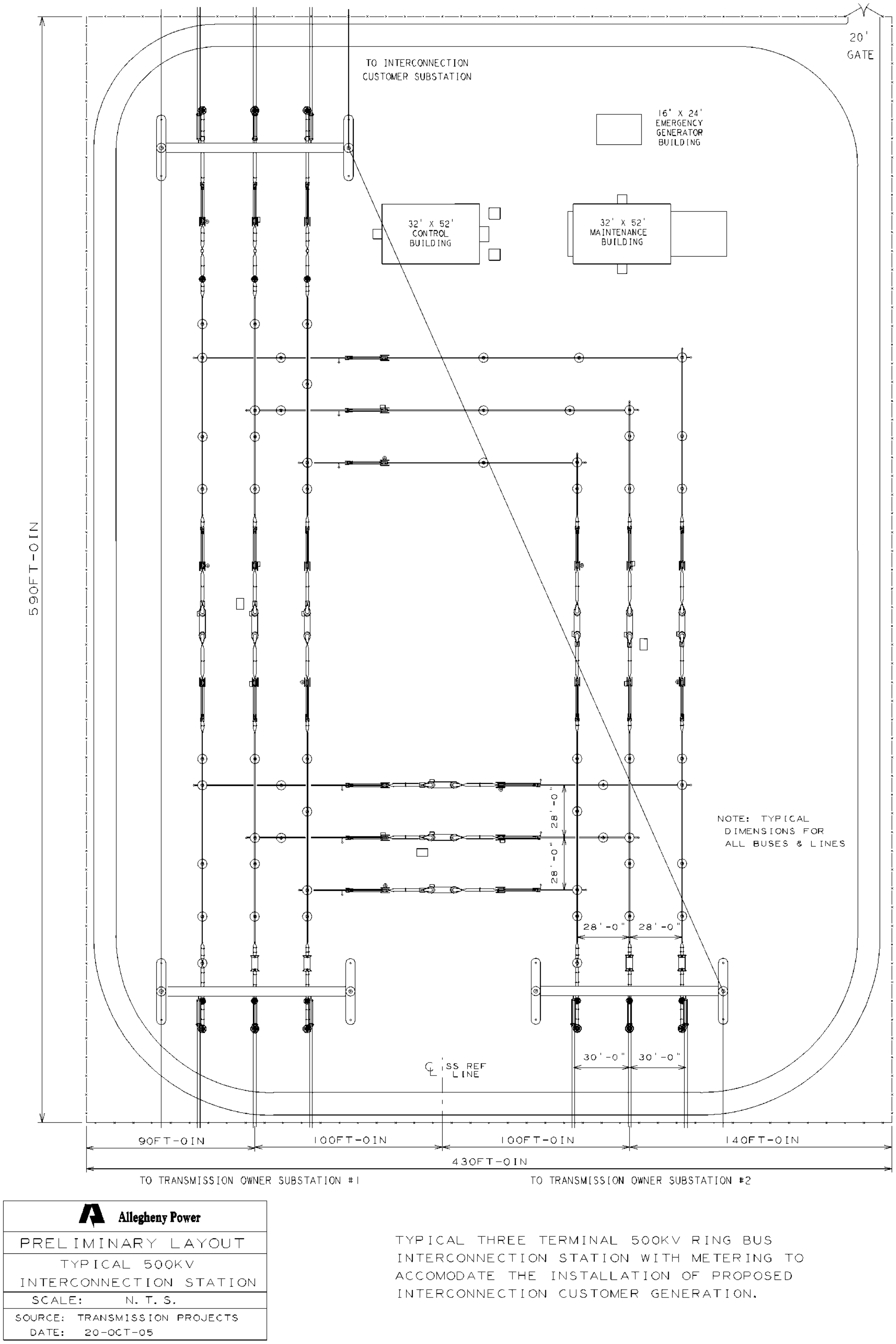
Single Line Diagram representing a typical 500kV AP interconnection switching station.



Allegheny Power System
SINGLE LINE DIAGRAM
TYPICAL 500KV INTERCONNECTION TRANSMISSION OWNER SUBSTATION
SOURCE: TRANSMISSION PROJECTS DATE: 20-OCT-05

TYPICAL THREE TERMINAL 500KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

An Electrical Layout representing a typical 500kV AP interconnection switching station.



TYPICAL THREE TERMINAL 500KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

SPECIFIC AP 500kV DESIGN CRITERIA REQUIREMENTS

Electrical Design Criteria:

A.	Nominal Voltage Rating	500 kV
B.	Maximum Voltage Rating	550 kV
C.	BIL Rating	1800 kV BIL
D.	Surge Arrester Duty Cycle	396 kV
E.	Continuous Current Rating	3000 A
F.	Fault Current Design Rating	40 kA
G.	Ambient Temperature	- 35˚ C to + 40˚ C
H.	Maximum Temperature Rise	100˚ C
I.	Bus Conductor	Tubing, Aluminum, 5” SPS, Schedule 80
J.	Maximum Tubing Deflection	One tube diameter
K.	Aeolian Vibration Control	954 kcmil ACSR in span exceeding 20’
L.	Bus Heights	30’-0” & 56’-0”
M.	Phase Spacing, for Bus & Switch	28’-0”
N.	Phase-to-Ground Clearance	156”
O.	Yard Stone Cover	6” ASTM #57 or Equivalent

Civil Design Criteria:

1. In addition to equipment, a 250 pound man on the structure or on a ladder against the structure.

2. Deflection of structures due to loading will be limited to 1/300 of the span in the vertical direction and 1/200 of the span in the horizontal direction.

3. Substation graded yard slope to be approximately 2% or less.

4. The design criteria is based on the worst case of the following conditions:

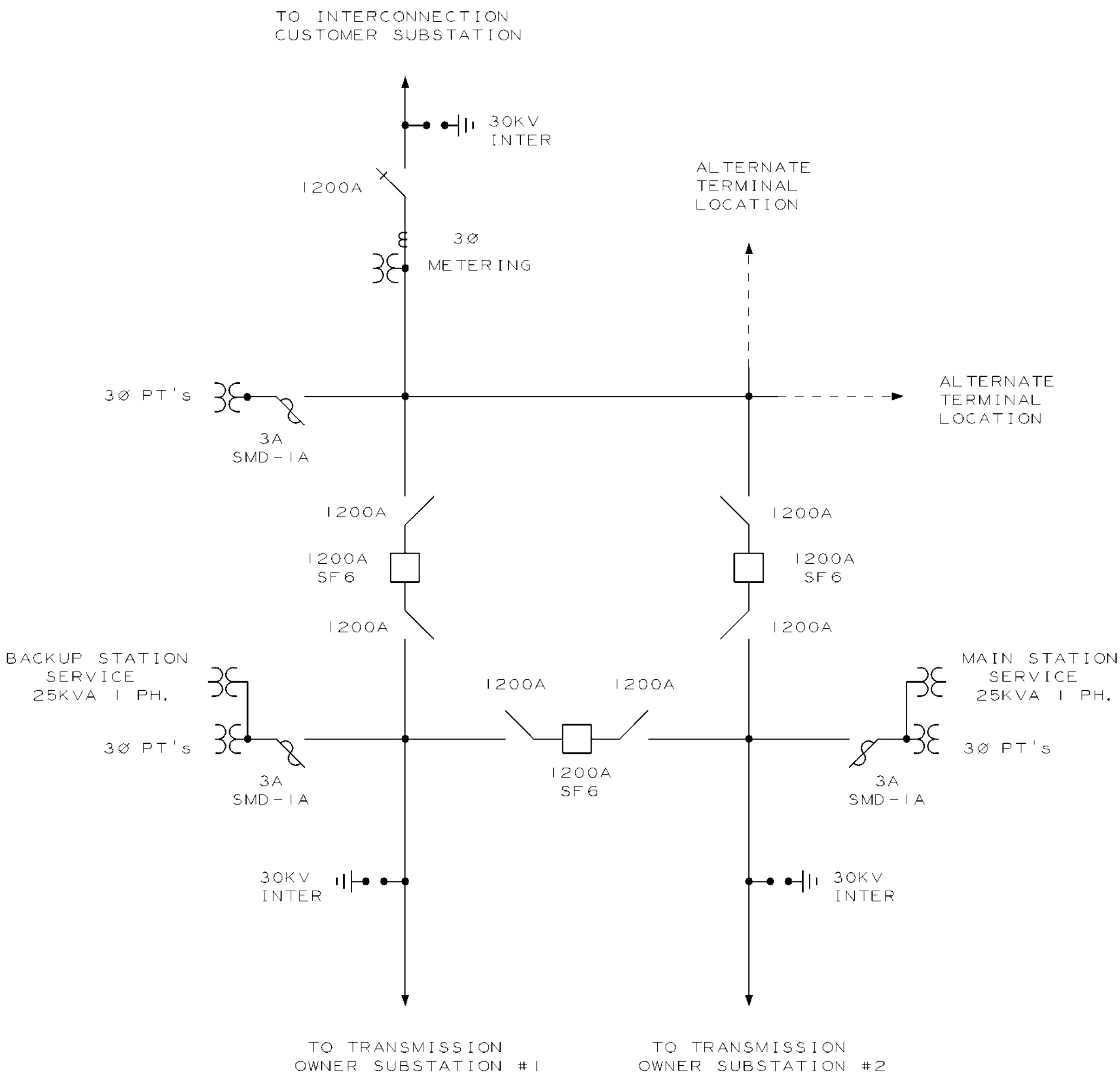
   a. An 80 mph wind load and a fault current of 40 kA

   b. ½” radial ice load with a 40 mph wind and a fault current of 40 kA

5. Line Deadend: Tension of 12,000 lbs/ phase, 4, 000 lbs per shield wire, with a Maximum Allowable Angle of 30 º

<u>23 TO 34.5KV SUBTRANSMISSION INTERCONNECTION STATION DATA</u>

Single Line Diagram representing a typical 23 to 34.5kV AP interconnection switching station.



Allegheny Power System

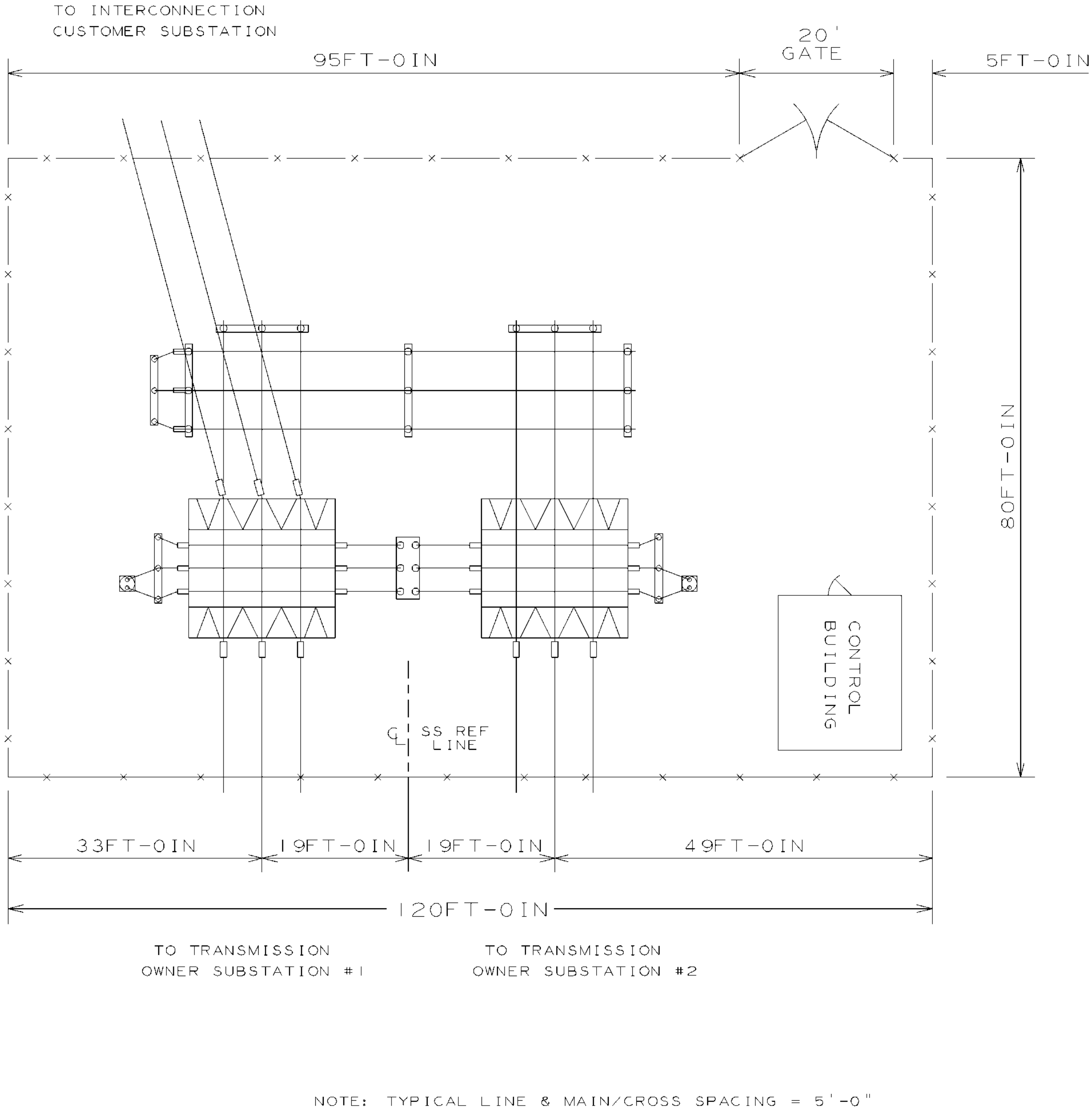
SINGLE LINE DIAGRAM

TYPICAL 34.5KV INTERCONNECTION
TRANSMISSION OWNER SUBSTATION

SOURCE: TRANSMISSION PROJECTS
DATE: 20-OCT-05

TYPICAL THREE TERMINAL 34.5KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

An Electrical Layout representing a typical 23 to 34.5kV AP interconnection switching station.



Allegheny Power
PRELIMINARY LAYOUT
TYPICAL 34.5KV INTERCONNECTION STATION
SCALE: N. T. S.
SOURCE: TRANSMISSION PROJECTS DATE: 20-OCT-05

TYPICAL THREE TERMINAL 34.5KV RING BUS INTERCONNECTION STATION WITH METERING TO ACCOMODATE THE INSTALLATION OF PROPOSED INTERCONNECTION CUSTOMER GENERATION.

SPECIFIC AP 23 TO 34.5 kV DESIGN CRITERIA REQUIREMENTS

Electrical Design Criteria:

A. Nominal Voltage Rating	23, 25 & 34.5 kV
B. Maximum Voltage Rating	25 kV & 38 kV
C. BIL Rating	200 kV BIL
D. Surge Arrester Duty Cycle	24 kV & 30 kV
E. Continuous Current Rating	2000 A
F. Fault Current Rating	30 kA
G. Ambient Temperature	- 35˚ C to + 40˚ C
H. Maximum Temperature Rise	100˚ C
I. Bus Conductor	Tubing, Aluminum, 3” SPS, Schedule 40
J. Maximum Tubing Deflection	One tube diameter
K. Aeolian Vibration Control	Not Required
L. Bus Heights	22’-0”
M. Phase Spacing, for Switch & Fuse	5’-0”
N. Phase-to-Ground Clearance	15”
O. Yard Stone Cover	3” ASTM #57 or Equivalent

Civil Design Criteria:

1. In addition to equipment, a 250 pound man on the structure or on a ladder against the structure.
2. Deflection of structures due to loading will be limited to 1/300 of the span in the vertical direction and 1/200 of the span in the horizontal direction.
3. Substation graded yard slope to be approximately 2% or less.
4. The design criteria is based on the worst case of the following conditions:
    a. An 80 mph wind load and a fault current of 40 kA
    b. ½” radial ice load with a 40 mph wind and a fault current of 40 kA
    c. Line Deadend: Tension of 2000 lbs/ wire with a Maximum Allowable Angle of 30