IEEE Guide for Development of Specification for Turnkey Substation Projects

Sponsor

Substations Committee
of the
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Abstract: The technical requirements to engineer, design, specify, fabricate, manufacture, furnish, install, test, commission, and provide as-built documents for air-insulated substations are covered. This guide investigates the methods, practices, and requirements of both users and suppliers in order to promogate a systematic and coordinated approach for development of specifications for turnkey substation projects.
Keywords: substations, turnkey substations

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Introduction

(This introduction is not part of IEEE Std 1267-1999, IEEE Guide for Development of Specification for Turnkey Substation Projects.)

This guide is issued to aid users in developing and preparing specifications for air-insulated turnkey substation projects; its intent is advisory. The guide covers parameters to be supplied by the Purchaser or the Purchaser's engineer so that a substation project can be engineered, designed, specified, fabricated, manufactured, furnished, installed, tested, commissioned, and warranted by a turnkey Contractor. Permits and site preparation requirements shall be mutually agreed to by the Purchaser and the Contractor. Normally, services for initial development of the project and permitting shall be part of the turnkey services provided by the Contractor.

The significance of the word *turnkey* is to be understood to be inclusive of all initial development, engineering, procurement, construction, and commissioning. It also requires that the Contractor provides a single, integral system warranty and incorporates project and scope risk.

Nothing in this guide shall prevent the Purchaser from providing additional requirements and oversight for the Contractor or the Contractor's work. Such involvement and the degree should be spelled out in the specification.

Proposal data, noted in 3.4, which shall be completed by each bidding turnkey Contractor, are provided in order to elicit uniform responses and to facilitate technical proposal evaluation.

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Contents

1. Overview 1

1.1 Scope 1
1.2 Purpose 1
1.3 Contractor qualification/certification 1
1.4 Site data 1
1.5 Equipment and services furnished by the Purchaser 3
1.6 Special tools furnished by the turnkey Contractor 3
1.7 Purchaser terms and conditions 3

2. References 3

3. General requirements 4

3.1 General description 4
3.2 Optional additional equipment and services by the Contractor 4
3.3 Miscellaneous equipment and services by the Contractor 4
3.4 Proposal data by the Contractor 5
3.5 Other considerations 5

Annex A (informative) Design considerations 6

Annex B (informative) Bibliography 26

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IEEE Guide for Development of Specification for Turnkey Substation Projects

1. Overview

This guide covers the technical requirements to engineer, design, specify, fabricate, manufacture, furnish, install, test, commission, and provide as-built documents for air-insulated substations.

The Contractor should furnish all equipment, materials, and services as specified by the Purchaser and as indicated in the one-line diagram and the contract documents.

The Purchaser is responsible for the project data and information for use by the Contractor in the proposal. If either party supplies technical data, that party is responsible for the data accuracy.

1.1 Scope

The scope of this guide is to investigate the methods, practices, and requirements of both users and suppliers, and to promogate a systematic and coordinated approach for development of specifications for turnkey substation projects.

1.2 Purpose

The purpose of this guide is to develop, for producers and users, methods and procedures for formulating complete specifications for turnkey substations or projects.

1.3 Contractor qualification/certification

All designs, calculations, and drawings should conform to applicable, latest approved standards. If required, licensed professional engineers of the state or province where the site is located should certify calculations and drawings. Contractor experience, resources, financial capability, management, and any other qualifying criterion set by the Purchaser should be considered.

1.4 Site data

The Purchaser should provide the environmental site data shown in Table 1.

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Table 1—Site data

Type of data	Measurement
Installation	Outdoor or indoor
Elevation above sea level	m (ft)
Maximum ambient temperature	°C (°F)
Minimum ambient temperature	°C (°F)
Relative humidity	%
Maximum wind velocity	km/h (mph)
Maximum ice loading	mm (in)
Seismic condition	g/zone
Air quality	—
Special environmental considerations	—
Rainfall	mm (in) accumulated in 1 h and 24 h
Snowfall	mm (in) height of maximum drifts and cross depth
Frost depth	m (ft)
Keraunic level	Thunderstorm days per year
Soil resistivity (if known)	Ω-m
Grounding parameters	—
Fault current	kA (3 Ø and L-G)
Fault clearing time for primary and backup protection devices	s
Zoning restrictions	—
Setback required	m (ft)
Maximum permissible noise level	dB
Truck access required for mobile transformer	m (ft)
Oil spill containment required for transformer	—
Grading and landscaping required	—
Site security considerations	—
Zoning restrictions	—
Height restrictions	m (ft)
Wetlands	—

The Purchaser should provide wind and ice loading conditions. Special attention should be given to the simultaneous application of various loading criteria, which may include the seismic condition.

The Contractor should be able to rely on this information to prepare a bid without independent verification.

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1.5 Equipment and services furnished by the Purchaser

Where the Purchaser provides equipment and services, a clear understanding on division of responsibility should be reached between the Contractor and the Purchaser during the life of the project to avoid any conflict about the scope of the work. This may include the following:

a) List of engineering services provided by the Purchaser or the Purchaser's engineer;

b) List of any equipment supplied by the Purchaser;

c) All pertinent technical data on the equipment provided by the Purchaser, including drawings and data sheets;

d) Site development, including access roads and railroad crossings;

e) List of permits, licenses, and approvals from local, state or province, and federal agencies. The Purchaser may require permitting support;

f) List of the Purchaser's field supervision, inspection, and audit personnel;

g) Description of interface with existing facilities, including outage coordination on supervisory control and data acquisition (SCADA), ac/dc station service supplies, interconnecting cables, ground grid, telecommunication facilities, transmission line(s), and water and sewer supplies;

h) Potential staging areas, where applicable.

1.6 Special tools furnished by the turnkey Contractor

If specified, any special tools, lifting devices, or jigs required for the maintenance and operation of the facility should be provided by the Contractor and assigned to the Purchaser. If these special devices are needed during the installation stage, an agreement between the Purchaser and the Contractor should govern the use of these devices.

1.7 Purchaser terms and conditions

The Purchaser's commercial terms and conditions are beyond the scope of this guide. These are to be considered by the Purchaser and the Contractor on an individual basis.

2. References

This guide should be used in conjunction with the applicable standards, some of which are listed in Annex B. If the guides or standards are superseded by an approved revision, the latest revision shall apply.

In the event of conflict between the referenced standards, the drawings of the Purchaser and their specifications, or between standards issued by various authorities, such as local, state or provincial, federal, or other regulatory government agencies, the Contractor shall notify the Purchaser and secure written clarification as to what is acceptable before proceeding with the work.

The Contractor shall propose recommendations for materials or components when no standards are available.

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3. General requirements

3.1 General description

The substation electrical layout and equipment rating should be based on the one-line diagram furnished by the Purchaser. The Purchaser should also provide the electrical ratings and any special requirements, such as spatial limitations or protective measures, in particularly harsh operating environments.

The equipment should be capable of withstanding specified outdoor environmental conditions, as well as specified electrical, mechanical, and thermal ratings.

Optimized arrangements are required to provide easy access for operation, maintenance, and repair, and to facilitate future additions as described in the specifications.

3.2 Optional additional equipment and services by the Contractor

If required, the Contractor should include the following:

a) Insulation coordination study
b) Seismic study
c) Grounding study
d) Shielding and lightning protection
e) Spare parts and special tools
f) High-voltage test equipment, if required by the Purchaser
g) Electromagnetic field (EMF) study
h) Hazardous materials identification
i) Site contamination study
j) Hydrology study
k) Relay setting tables
l) Short circuit study
m) Protection relay coordination study
n) Load flow study
o) Overhead conductor sag chart
p) Geotechnical report including environmental considerations
q) Wind and/or ice load study
r) Noise level study

3.3 Miscellaneous equipment and services by the Contractor

The Contractor’s scope of work should include, but not be limited to, the following items required for a complete installation:

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a) All bus fittings, support insulators, and supporting structures necessary to operate and maintain all equipment.

b) All concrete foundations should include anchor bolts, steel reinforcing beams, and other associated parts. Foundation designs should take into account soil conditions, thermal expansion and contraction, equipment loads, and attachment points. Foundation layout should meet required electrical clearances.

c) Flexible connections for all equipment supplied should be provided as required, ensuring continuity of service during thermal expansion or contraction, vibration, and seismic activities.

d) Control, metering, monitoring, protection, indication systems, annunciators, cathode-ray tubes (CRTs), etc., including local control cabinets, should be provided as specified.

e) Ground grid and groundwire terminations for connection to the ground grid from structures and equipment.

f) Wiring and means for wiring between individual items of Contractor (or Purchaser) furnished equipment.

g) Nameplates for each piece of equipment, as specified by the Purchaser.

h) Sulfur hexafloride (SF_6) gas supply system, including density monitors and sufficient quantity of SF_6 gas for initial filling of circuit breakers, if applicable.

i) External surface preparation and coating, if specified.

j) If equipment is derated due to altitude and/or ambient temperature conditions, the Purchaser must be advised of the new rating in the proposal.

k) Sufficient quantity of transformer oil, if shipped separately. The Contractor should vacuum fill the transformer, if shipped without oil.

l) Fire protection equipment/structures.

3.4 Proposal data by the Contractor

If required, the Contractor shall include the following:

a) Preliminary project schedule with starting and completion dates for each required activity.

b) Contractor's previous experience, including specific experience on similar projects, shall be provided. Information shall include manpower, equipment, key personnel resumes, reference lists with contact person, and safety records of Contractor.

c) Complete data sheets for all major equipment shall be provided. Separate data sheets should be provided for each alternative.

d) Listing of exceptions to, and deviations from, the specifications shall be provided. All exceptions should be clearly and separately itemized.

e) If Contractor uses subcontractor(s), all relevant data requirements applicable to the Contractor will also apply to the subcontractor.

3.5 Other considerations

The Contractor should be responsible for inspecting and receiving equipment and materials delivered to the work site to ensure that the equipment and materials are undamaged and are in compliance with specifications. It should be the responsibility of the Contractor to protect the materials and equipment against damage and theft until the Purchaser accepts the project.

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Annex A

(informative)

Design considerations

A.1 Project scope

The Purchaser should provide the following information to the Contractor:

a) The scope of the project
   1) Substation one-line diagram—for the initial and ultimate stage, including metering, protection, telemetering requirements, and electrical parameters
   2) Number, location, and technical data of transmission/distribution lines (including underground)
   3) Phase rotation diagram
   4) Details of existing facilities, including underground utilities such as gas, water, and cables
   5) Geography of the site (e.g., boundary and topographical surveys, and soil borings)
   6) Soil resistivity measurements

b) Site constraints

c) A copy of the Purchaser's applicable standards, so that the Contractor can produce a design that will provide reliable integration into the Purchaser's system

d) Regulatory requirements

A.2 Land use and environmental considerations

The Purchaser may use the following list of biophysical and land-use study categories as a guide to determine the extent of the environmental effort required for the project. The extent of work required depends on the size and location of the project:

a) Terrain
   1) Surface and bedrock geology
   2) Soils
   3) Slope stability and erosion potential
   4) Permafrost

b) Vegetation
   1) Vegetation types
   2) Rare and endangered plants
   3) Revegetation potential

c) Agriculture
   1) Soils and drainage
   2) Forage and horticulture

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d) Forest resources

1) Stand type
2) Age class
3) Site class

e) Water resources

1) Drainage, including proposed dams, water diversion, and stream disturbance
2) Water quantity (surface and groundwater), including hydrologic regime data and water withdrawals
3) Water quality (surface and groundwater), including waste discharge and suspended sediments
4) Community watersheds and other water uses
5) Location of aquifers

f) Wildlife resources

1) Wildlife populations and capabilities
2) Sensitive species, periods, and habitat
3) Hunting, hiking, and trapping activities
4) Wildlife management activities

g) Heritage resources

1) Site and objects of historical, architectural, archaeological, paleontological, and scenic significance

h) Environmental hazards

1) Known and potential occurrence of hazards, such as snow avalanches, landslides, mudflows, windstorms, earthquakes, tidal waves, floods, and fire hazards
2) Existence of toxic or other hazardous materials on site

i) Land tenure

1) Private land
2) Government-owned land, ecological reserves, forest reserves, and other reserves and easements
3) Native American reservations and lease arrangements
4) Lands reserved for agriculture
5) Grazing leases and permits
6) Coal, mineral, petroleum, and aggregate reserves and leases
7) Status of plans and zoning (local government and agencies)
8) Land use and access

j) Fuels and hazardous materials

1) Storage, handling, and safety measures
2) Contingency plans for the containment and cleanup of fuel spills and toxic or other hazardous material

k) Waste management

1) Discharge of gaseous, aqueous, and solid wastes
2) Measurement to control and/or manage waste effects on the receiving environment

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A.3 Aesthetic and environmental impact considerations

The Purchaser may use the following list of possible aesthetic and environmental impact categories as a guide to determine the extent of the remedial action required for the site(s):

a) Noise
   1) Potential noise levels at various distances from sources on the site
   2) Existing noise levels from other sources external to the site
   3) Existing human residences and animal shelters in the vicinity of the site that may be affected

b) Visual
   1) Views of developed site(s) from various locations with proposed mitigation measures
   2) Other developments in the surrounding area and mitigation methods used by these developments
   3) Existing human residences in the vicinity of the site

c) Radio interference voltage (RIV)
   1) Interference levels at various distances from the site
   2) Existing interference from other sources in the vicinity not associated with the site
   3) Existing systems in the vicinity of the site that may be affected by any new interference

d) Electromagnetic field (EMF) levels
   1) Levels at various distances from the site
   2) Existing levels from other sources in the vicinity not associated with the site
   3) Existing human residences and/or animal shelters in the area of the site that might be affected by new EMF fields

A.4 Permits and ordinances

To ensure compliance with all relevant government requirements, the Purchaser should confirm areas where permits may be required or ordinances may be applicable. The Purchaser and the Contractor should define who will be responsible for the various permits and ordinances listed below.

a) Permits
   1) For governing the EMF strength at the boundary of the site
   2) For the installation and use of a new communications system, including the designation of the carrier frequency
   3) To use land in an agricultural land reserve for a purpose other than farming
   4) To remove soil from an agricultural land reserve
   5) For the use of state or provincial forest for other than enumerated purposes
   6) For the cutting of timber
   7) For the use of fire or explosives
   8) For the excavation or alteration of state/provincial heritage sites and to remove, move, or alter heritage objects from those sites
   9) To construct on government land, including access roads
   10) For location of project
   11) For occupation of the site
   12) For any buildings on the site

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13) For the storage, handling, and use of flammable and combustible liquids
14) For any railroad crossing
15) For wetland, flood plain areas, or within coastal management zones
16) For disposition of excavated soil
17) For water runoff, storm water management, and soil erosion

b) Ordinances (approval or inspection required) regarding

1) The disposition of government land, including sales, leases, right-of-ways, and easements
2) Plans affecting designated highways and access to highways, including setback and sight clearance restrictions
3) The construction, location, and operation of industrial roads, including the requirement to cross or join a public road or highway
4) Prevention and control of soil erosion
5) Plans affecting the passage of fish
6) The construction camp operations, including the sanitary control of industrial camps
7) The discharge or disposal of litter, sewage, or other waste material on land or into water
8) Fire protection for the site
9) Lighting of the site
10) Noise from the site
11) The type and height of fences or walls required around the site
12) The physical plant of any buildings on site, including electrical, plumbing, heating (other than electrical), and sanitary systems

A.5 Design criteria

A.5.1 Civil and structural design

A.5.1.1 Site preparation

The site development should include grading to provide suitable surface drainage and adequate storm water drainage. Specify if surface rock will be used. Site work must be coordinated with the equipment and bus layout. The degree and method of site compaction should meet the Purchaser's requirements.

A.5.1.2 Soil sterilization

Sterilization of soil within the substation should be considered by the Purchaser so as to prevent vegetation. A permit to use herbicides may be required.

A.5.1.3 Drainage

The design should provide for adequate drainage of precipitation from the site without impacting adjacent property owners.

A.5.1.4 Foundations and structures

When required, all foundation and structure designs, calculations, and drawings should be provided to the Purchaser with certification by a licensed professional engineer of the state or province where the site is located.

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A.5.1.5 Oil containment

The Contractor should provide a plan for oil containment systems to meet regulatory requirements for power transformers and other large oil-filled equipment in the substation. The oil containment system should be designed to provide for rain, ice, and snow accumulation. The Purchaser and the Contractor should agree initially on the allowable limit of oil and rain discharge while sizing the containment.

A.5.2 Mechanical design

The mechanical design of the substation should include the following:

a) Heating, ventilation, and air conditioning systems for buildings that require such systems. The space requirements for this equipment should be coordinated with the civil design group and the ac power requirements should be coordinated with the electrical design group.

b) Water and sewer connections required for the substation. This information should be included in the electrical design for the overall substation layout.

c) Noise abatement facilities required for equipment to be installed to meet any local ordinances. This information should be included in the appropriate design for the overall substation layout.

d) Level of fire protection for the substation as required by any local ordinances, national codes, or recognized standards. This information should be included in the appropriate design for the overall substation layout.

e) Levels of exhaust emissions of equipment to be installed and mitigation as required to comply with any local ordinances, national codes, or standards.

A.5.3 Electrical design

A.5.3.1 General

In general, the electrical design of the substation should include the following:

a) Coordination with other design groups

b) Preliminary and ultimate substation layout to establish station size requirements in consultation with the other design groups

c) Animal deterrent designs required for the substation

d) Ultimate low-voltage ac station service load requirements for the equipment at the substation, in consultation with the other design groups, so that this requirement can be incorporated in the overall system design

e) Sources of the preferred and alternate ac station power service

f) All control measurement, indication, and protection design, including wiring

A.5.3.2 Protection and control design

The protection and control (P&C) design should include the following:

a) P&C system required for the substation to meet the requirements of the Purchaser, including interfacing with communication equipment.

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b) Preliminary and ultimate number of cabinets and racks the substation will require. This information should be coordinated with the civil and electrical design groups for building layout designs and specifications.

c) Ultimate dc load profile the substation will have. This information should be coordinated with the electrical design group for sizing of the dc systems.

d) Settings for protective relays to be installed.

e) Control and instrumentation cable specifications.

A.5.3.3 Communication design

The communications design should include the following:

a) Communication system required for the substation to meet the requirements of the Purchaser, including the dc power supply system. The new system should be integrated with any system the Purchaser presently has or plans to have in the future. This information should be coordinated with other relevant design groups.

b) Visual impact of any towers that are required as part of the new communication system at the substation. Determine and specify mitigation required.

c) Mitigation required of any interference that a new communication system associated with the substation will have on any existing systems, such as nearby radio towers or airport communications, as required by national codes or standards.

d) Size of communication equipment the ultimate substation will require, including separate dc supply. This information should be coordinated with the civil design group so that the area required for this equipment can be taken into account in any buildings required.

e) Ultimate ac loads the communications equipment will require. This information should be passed on to the electrical design group to aid this group in the sizing of the ac station service required for the substation.

A.6 Substation layout/bus design

A.6.1 General

The substation should be designed in accordance with the Purchaser's specifications and criteria for expansion and operation of the power system. The following items should be considered for the design of a substation:

a) The need for fixed and switchable shunt compensation, if required

b) SCADA and communication requirements for normal, emergency, and restoration operation

c) Flexibility in energization sequences for lines, loads, and compensation

d) Coordinate equipment locations and adequacy, including monitorial and supervisory control for unmanned substations

e) Event recording, data logging, and displays for operator use in determining equipment status

f) Power circuit breaker out-of-phase, interrupting duty imposed by cascading or islanding events, shall be considered when a specific breaker subjected to this duty is identified

g) Uninterruptible power supply (UPS) for SCADA and programmable logic controller (PLC), if required

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A.6.2 Design

Arrangement of the substation should be the responsibility of the Contractor, subject to the Purchaser's review and acceptance.

a) Standard heights and phase spacing used by the Purchaser should be specified, if applicable.

b) Insulation coordination and electrical clearances should be in accordance with the Purchaser's standards, or as otherwise specified.

c) The Purchaser's working clearances in the substation should be specified. The substation arrangement must take this into account and allow for access to all equipment without the dismantling of any portion of the substation. The minimum distance from any structure to the substation fence shall be specified. The Purchaser should state qualification level of maintenance and operation personnel.

A.7 Bus work

A.7.1 General

It should be the responsibility of the Contractor to determine and specify all rigid bus, cable conductors, connectors, and supports. Connector selection should be coordinated with the design of the bus.

A.7.2 Design

a) The rigid bus shall be designed to applicable standards and the Purchaser's requirements.

b) The thermal ratings for the bus conductor should be industry standard unless otherwise specified by the Purchaser.

c) The bus design shall minimize the removal for maintenance of all adjacent components.

d) Bus design and bus design calculations should be subject to review and approval by the Purchaser.

e) Vibration damping system should be installed for all tubular bus, where needed, to mitigate aeolian vibrations.

f) Drainage holes should be drilled in the tubular bus at the lowest point of deflection to prevent accumulation of moisture.

g) All bus and connectors should be selected to minimize corona, and preferably be standard sizes.

h) Tubular bus should be line-marked near each end with the producer's name or trademark and the applicable alloy and temper designation. The Purchaser shall be furnished with a certificate stating that the material has been sampled, tested, and inspected in accordance with latest applicable standard.

A.7.3 Insulators

a) It shall be the responsibility of the Contractor to determine and specify all insulators.

b) Insulator selection should be coordinated with the design of the bus.

c) All insulators except strain bus insulators, if required, should be station post class, and made in accordance with all applicable standards.

d) Calculations shall be required to determine insulator strength and class requirements, and are subject to the Purchaser's review.

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A.8 Grounding and shielding

A.8.1 General

A complete grounding system is required. The Purchaser and the Contractor shall agree on who is responsible for making the following measurements:

a) Soil resistivity

b) Final ground grid resistance and continuity measurements

The ground grid should be designed using the applicable standards. The outdoor equipment, structures, and the control building, including all equipment within, should be grounded according to the Purchaser's requirements. The Purchaser and the Contractor should agree on the grounding methodology and the weight of person for grounding calculations.

A.8.2 Grounding design for control buildings

The grounding design for control buildings should conform to the Purchaser's requirements and should comply with the applicable standards.

A.8.3 Shielding

The substation design should provide for adequate shielding from direct lightning strokes within the substation area based upon local keraunic levels. References are included in Annex B to determine the required shield wires or static masts.

A.8.4 Grounding of fence and entrance gates

All fence posts and fabric shall be grounded according to the applicable standards, if required.

A.9 Lighting and power outlets

A.9.1 General

Yard lighting, power, convenience, and phone outlets in the substation may be specified by the Purchaser. Type, quantity, design, and procurement should be the responsibility of the Contractor subject to the Purchaser's review and acceptance. Compliance with applicable standards regarding lighting levels shall be maintained.

A.9.2 Design

Yard power outlets (e.g., 3 phase, 3 wire, 120 V, 240 V, or 480 V) may be specified by the Purchaser (e.g., for SF_6 gas cart, welding, and oil filtering equipment). Ground fault interrupter (GFI) outlets may be specified by the Purchaser for the convenience receptacle at each major piece of equipment, such as circuit breakers and motor-operated disconnect switches.

The convenience outlets may be accessible from the outside or inside of cabinets as agreed by the Contractor and the Purchaser. Externally mounted outlets should be provided with a weatherproof casing.

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A.10 Equipment

The Purchaser should provide a preferred supplier list to the Contractor. Equipment provided by the Purchaser shall withstand wind, ice, and seismic loads.

A.10.1 Circuit breakers

All circuit breakers should be furnished and installed by the Contractor in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations.

The Purchaser should provide, at a minimum, the following data to enable the Contractor to select equipment that is appropriate for the functional requirements:

a) Application (general purpose or capacitor switching)

b) System voltage rating

c) Basic impulse insulation level (BIL) rating

d) Continuous current rating

e) Interrupting current rating

f) Closing and latching capability

g) Maximum interrupting time

h) Live or dead tank

i) Number and accuracy class of bushing current transformers (if required) or free-standing current transformers

j) Control power supply requirements

k) Auxiliary power supply, and ac and dc requirements

l) Number of trip coils

m) Special requirements dictated by the Purchaser's standards or operating conditions, including spares, if any; or high-speed protection auxiliary contact

n) System parameters such as X/R ratio

o) Color

p) Number of auxiliary contacts

Normally, the Purchaser will have completed system power flow, fault, and stability studies, which may indicate the need for special requirements, such as

— Independent pole operation

— Transient recovery voltage (TRV) suppression requirements

— Capacitance current switching requirements

A.10.2 Interrupter switches (circuit switchers)

The Contractor should furnish and install all interrupter switches in accordance with the Purchaser's requirements and the Manufacturer's recommendations.

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The Purchaser should provide, at a minimum, the following data and requirements to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) System voltage rating
b) BIL rating
c) Continuous current rating
d) Switching duty
    1) Transformer
    2) Line
    3) Capacitor/reactor
    4) Load/fault
e) Integrally mounted isolating switch
f) Control power supply requirements
g) Auxiliary ac and dc power supply requirements
h) Options
    1) Ground blade requirements
        i) Mechanical interlock
        ii) Electrical interlock
        iii) Key interlock
    2) Arcing horn requirements
    3) Auxiliary switch requirements
    4) Testing requirements such as ice test requirements
    5) Operating requirements
        i) Manual
        ii) Motor

A.10.3 Disconnect switches

The Contractor should furnish and install all disconnect switches in accordance with the Purchaser's requirements and the Manufacturer's recommendations.

The Purchaser should provide, at a minimum, the following data and requirements to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) System voltage rating
b) BIL rating
c) Continuous current rating
d) Momentary current rating
e) Type designation
f) Live part material
g) Insulator electrical and mechanical characteristics and color

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h) Operating methods
   1) Manual
      i) Reciprocating spade handle
      ii) Torsion swing handle
      iii) Torsion gear box
   2) Motor
      i) Control voltage
      ii) Auxiliary contacts

i) Options
   1) Ground blades
      i) Mechanical interlock
      ii) Electrical interlock
      iii) Key interlock
   2) Arcing horns
   3) Load-break interrupter and attachments
   4) Auxiliary switches
   5) Testing requirements such as ice tests

A.10.4 Instrument transformers

The Contractor should furnish and install all current and voltage transformers in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations, as shown in one-line diagrams provided by the Purchaser to the Contractor.

The Purchaser should provide, at a minimum, the following data to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) System voltage rating
b) BIL rating

In addition, the data in A.10.4.1, A.10.4.2, and A.10.4.3 should also be provided by the Purchaser.

A.10.4.1 Current transformers

a) Ratio (single, dual, and multiratio)
b) Accuracy class
c) Burden
d) Thermal rating

A.10.4.2 Voltage transformers (inductive/resistive type)

a) Ratio
b) Accuracy class
c) Line-to-line or line-to-ground voltage
d) Burden

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A.10.4.3 Voltage transformers (capacitive type)

a) Ratio

b) Accuracy class

c) Capacitance

d) Carrier accessories

e) Line-to-line or line-to-ground voltage

A.10.5 Surge arresters

The Contractor should furnish and install all surge arresters in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations, including recommendations of an insulation coordination study.

The Purchaser should provide, at a minimum, the following data to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) Nominal system voltage

b) Maximum continuous operating voltage

c) Required protective characteristics

d) Line-to-ground short circuit

e) System $X0/X1$ and $R0/X1$

f) Any back-feed condition

g) Rated energy in kJ

A.10.6 Line traps/inductors

The Contractor shall furnish and install all line traps/inductors in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations.

The Purchaser should provide, at a minimum, the following data to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) System voltage

b) Continuous current

c) Type of tuning

d) Bandwidth and minimum impedance

e) Rated inductance

f) Mounting arrangement

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A.10.7 Voltage regulators

The Contractor should furnish and install voltage regulators in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations.

The Purchaser should provide, at a minimum, the following data to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) System voltage
b) BIL
c) Ampere rating
d) Line or station type
e) Tap range and percent of each step
f) Type of cooling
g) Loss evaluation amounts (optional)

A.10.8 Power transformers

The Contractor should furnish and install power transformers in accordance with the latest revision of applicable standards, the Purchaser's requirements, and the Manufacturer's recommendations.

The Purchaser should provide, at a minimum, the following data and requirements to enable the Contractor to select equipment that is appropriate for the functional requirements and that is in compliance with the Purchaser's standard practices:

a) Nominal system voltages
b) Megavolt-ampere (MVA) ratings, with or without fans
c) Cooling
d) Type
    1) Substation
    2) Generator step-up
    3) Station auxiliary
    4) Auto
    5) Special
e) Core or shell form, copper or aluminum windings
f) Single- or three-phase
g) Winding BIL, basic switching impulse insulation level (BSL), chopped wave withstand level (CWWL)
h) Bushing BIL, BSL, CWWL
i) Impedance
j) Temperature rise (above specified ambient)
    1) 55 °C
    2) 65 °C
    3) 55 °C or 65 °C

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k) Sound level

l) No-load taps if required, or if different from 2 × 2 steps 2.5% each in either direction of midposition (0).

m) Load tap changer

1) Location
   i) High-voltage
   ii) Low-voltage
2) Range and number of steps
3) Capacity
   i) Full
   ii) Reduced
4) Paralleling requirements
5) Control
   i) Automatic
   ii) Remote

n) Bushing current transformers

1) Location
2) Quantity
3) Ratio (single, dual, multiratio)
4) Accuracy class
5) Burden
6) Thermal rating
7) Special requirements (location, spacing)

o) Surge arresters

1) Mounting provisions only
2) Included (yes/no)
3) Maximum continuing operating voltage (MCOV)/class

p) Oil preservation system

q) Auxiliary power source

1) Voltage
2) Single- or three-phase

r) Special termination requirements

s) Special paint

t) Special tests

u) Any unique or unusual operating condition that could affect the design. In addition, the following data shall be provided for autotransformers:

1) Step-up or step-down operation
2) Tertiary
   i) Required or not required
   ii) Buried (yes/no)
   iii) Loaded voltage
   iv) Rating if greater than 35% of largest winding

v) Vector loading

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w) Accessories
   1) Winding temperature indicator
   2) Pressure relief device
   3) Sudden pressure and gas accumulation relay
   4) Dissolved gas monitoring device
   5) Special requirements

x) Loss evaluation
   1) MVA base
   2) Dollar amount on present worth or equivalent investment basis
      i) No-load
      ii) Load
      iii) Auxiliary

A.10.9 Protective relaying/metering and control design requirements

The Purchaser should adequately define the intended work scope and provide drawings as required based upon the following:

a) Standards to be followed

b) Relay functional one-line diagram

c) Switchboard arrangement

d) Component list

e) Schematic diagram requirements

f) Switchboard wiring diagram requirements

g) Equipment wiring diagram requirements

h) Cable schedule requirements

i) Any special requirements

A.10.9.1 Protective relaying

The Purchaser should provide guidance, work scope, and standards for application of the following protective relaying areas:

a) Line protection

b) Substation bus protection

c) Transformer protection

d) Breaker protection

e) Utility-consumer interconnections

f) Other substation protection

A.10.9.2 Instrumentation and metering

The Purchaser should define the work scope and requirements for instrumentation and metering, both local and remote, including the following:

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a) Functional requirements

b) Indicating and recording instruments

c) Transducers

d) Remote signaling requirements

The Purchaser should also consider putting test switches in current and potential circuits in front of the transducers for testing purposes.

A.10.9.3 Controls

The Purchaser should define the following local and remote control items:

a) Control and operation function

b) System phasing

c) Transformer control

d) Breaker control

e) Control for other substation devices

f) Supervisory control and data acquisition (SCADA)/energy management system (EMS)/remote terminal unit (RTU)

A.10.9.4 Alarm and fault monitoring

The Purchaser should define requirements for local and remote alarms and fault monitoring, including the following:

a) Annunciator

b) Sequence of events recording

c) Oscillograph/digital transient fault recorder

d) Fault locator

A.10.9.5 Communication

The Purchaser should define requirements for primary and backup (if applicable) communications systems, including the following:

a) General requirements

b) Power line carrier

c) Tone equipment

d) Microwave

e) Fiber optic

f) Radio

g) Communication processors for interfacing with microprocessor relays

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A.11 Construction

A.11.1 Construction work scope

The Purchaser's need to develop a detailed work summary (or schedule) is dependent upon the amount of involvement the Purchaser intends to have. The construction summary for a project, where the turnkey Contractor is providing the construction services, requires a minimum amount of detail.

The Purchaser should specify the general scope of construction work for the following:

a) Site work (grading, foundations, etc.)
b) Steel and bus work
c) Equipment setting
d) Fencing
e) Grounding
f) Transmission and distribution system interface
g) Control and protection system, both local and remote
h) Metering
i) Control and switchgear buildings
j) Safety requirements

A.11.2 Approved bidders list

The Purchaser shall have the option of developing an approved bidders list for construction subcontracts. The Purchaser may prefer to limit the turnkey Contractor's subcontractors to only those who previously have performed work for the Purchaser successfully. The Purchaser and the turnkey Contractor may negotiate the work to be performed by the turnkey Contractor or subcontracted by the turnkey Contractor to approved subcontractors.

A.11.3 Scheduling

In the request for proposal (RFP), the Purchaser should request inclusion of a schedule with the turnkey Contractor's submission. However, should the Purchaser elect to perform any of the engineering, procurement, or construction tasks, the schedule for the Purchaser's activities should also be furnished with the RFP in order to allow the Contractor to commit to a completion schedule. In any event, the Purchaser should specify the time required for the Purchaser's approval of any design and drawing submittals. The permitting bodies will be provided information for approval of certain segments of the engineering package. As the project proceeds, the Contractor should submit updates of the schedule on a regular basis in a format required by the Purchaser. The Contractor or the Purchaser should not modify or change the schedule without mutual consent.

A.12 Quality assurance/quality control

The Purchaser should prepare a quality assurance/quality control (QA/QC) program in the planning phase of the project. The Purchaser should acquire copies of all the specifications that are to be utilized by the Contractor prior to releasing the RFP. The specifications to be considered include the engineering preparation, drafting requirements, computer-aided drafting standards, equipment manufacturing requirements, construction techniques and preferences, and testing specifications, in addition to industry standards.

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The Purchaser should evaluate the need for involvement in implementing and enforcing a QA/QC program. The Contractor should allow any degree of involvement that the Purchaser desires.

The Purchaser should consider including the following activities:

a) Design review
b) Drawing review
c) Equipment and material procurement specifications review
d) Factory witness test
e) Construction representation
f) QA/QC of construction/installation activities
g) Testing and commissioning involvement (witness of duplicate testing)

The Purchaser should provide the Contractor with the RFP specifications of the Purchaser-furnished materials and the Purchaser's planned involvement in the project.

The Purchaser may elect to substitute the Purchaser's specifications for selected Contractor specifications.

A.13 Construction specifications

The Purchaser should provide requirements or specifications for the following:

a) Grading specifications
b) Foundation specifications
c) Structures
d) Fence specifications
e) Bus and equipment
f) Testing and monitoring
g) Compliance with applicable regulations
h) Purchaser-specific additional requirements

All construction work must be performed in accordance with applicable safety rules of the Purchaser or interconnecting utility. These rules should be provided to the Contractor with the RFP.

All applicable electrical codes and standards should be followed for the design and construction of the project. In addition, the interconnecting electrical utility should be consulted to determine if any of their design standards are applicable to the project.

A.14 Testing and commissioning

A.14.1 Testing standards

Substation tests can be divided into two categories:

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a) Component tests, and

b) System tests.

Applicable Manufacturer and utility or Purchaser requirements should be consulted to establish the specific test requirements. Test data from the Manufacturer or factory component should be provided during substation commissioning. Safety standards shall be followed in accordance with applicable codes.

A.14.2 Testing and records to provide positive assurance

The Purchaser should assure that the Contractor is responsible for the testing of the complete installation and for furnishing a record copy of all reports of the tests performed, the dates testing occurred, the person and company performing the tests, and the test results.

This information should be available for factory tests, field component tests, and field system tests.

A.15 Operation and maintenance training

The Purchaser should schedule time during the testing and commissioning phase of the project for the Purchaser's engineers to become familiar with the project and to witness the testing of the installation. The Purchaser may require the Contractor to provide training time for the eventual operators of the installation as noted in the RFP.

The Purchaser should consider the following topics for training:

a) Location and identification of major equipment components

b) Demonstration of equipment maintenance techniques

c) Demonstration of equipment operation, both locally and remote

d) Overview of the indicating instruments in the panels

e) Overview of the protective relay system, definition of zones covered by each relay, implication of trips, techniques for setting trip points, etc.

f) Review of equipment operation and maintenance manual

A.16 Documentation

As part of the Contractor's package, the Purchaser should require a final "as-built" drawing package. This package should include all drawings utilized in the design and construction of the substation, updated for any modifications made during the construction and testing phase of the project. The Purchaser must receive this package to ensure that maintenance can be done and that future modifications made can be implemented correctly.

The Purchaser should determine the number of "as-built" drawings and operation and maintenance manuals needed to properly operate and maintain the installation.

The Purchaser should require that all drawings provided by the equipment manufacturer be furnished on an "as-manufactured" basis, with any field modifications noted. In addition, the Contractor should furnish "as-built" bills of material with catalogue cuts for all components requested by the Purchaser.

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The Purchaser may also request that the Contractor provide a complete operation and maintenance manual with their substation “as-built” design package. The manual should include the following information:

a) Overview of the function of the installation

b) Outline of the manual

c) Detailed description of the relay and control system, including

   1) General description of each panel and its function
   2) Detailed description of each relay zone and its protection limits
   3) Detailed description of the annunciator panel, location of sensor points, definition of alarms, and recommended action
   4) Detailed description of sequence of events recorder, location of sensor points, and definition of events and causes
   5) Definition of normal operation of indicating instruments, e.g., ranges and accuracies for kilowatt-hours, ampere-meters, and voltmeters
   6) Description of backup remote protection systems

d) Complete set of all the equipment manuals

e) Complete list of recommended maintenance procedures for the substation components, including items scheduled for maintenance on a daily, weekly, monthly, and annual basis

f) Complete set of the Manufacturer’s operation and maintenance manuals for all equipment components

g) Safety issues regarding access to the substation and equipment, including clearance requirements, isolation procedures, and temporary grounding procedures

h) Set of test result records from the substation testing phase

i) Design calculations

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Annex B

(informative)

Bibliography

The following publications should be considered as typical when used in conjunction with this guide:

[B1] Accredited Standards Committee C2-1997, National Electrical Safety Code® (NESC®).

[B2] ACI 117-90, Standard Tolerances for Concrete Construction and Materials.

[B3] ACI 301-96, Specifications for Structural Concrete for Buildings.

[B4] ACI 304-89 (Reaff 1997), Guide for Measuring, Mixing, Transporting and Placing Concrete.

[B5] ACI 305-91, Hot Weather Concreting.

[B6] ACI 306-88, Cold Weather Concreting.

[B7] ACI 318-99, Building Code Requirements for Reinforced Concrete & Commentary.

[B8] ANSI B18.12-1962 (Reaff 1981), American National Standard Glossary of Terms for Mechanical Fasteners.

[B9] ANSI C29.9-1983 (Reaff 1996), American National Standard for Wet-Process Porcelain Insulators (Apparatus, Post Type).

[B10] ANSI C37.06-1997, American National Standard for Switchgear—AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities.

[B11] ANSI C37.12-1991, American National Standard Specification Guide for AC High-Voltage Circuit Breakers Based on a Symmetrical Current Basis.

[B12] ANSI C37.32-1996, American National Standard for Switchgear—High-Voltage Air Switches, Bus Supports, and Switch Accessories—Schedules of Preferred Ratings, Manufacturing Specifications, and Applications Guide.

[B13] ANSI C57.12.10-1988, American National Standard for Transformers 230 kV and below 833/958 through 8333/10 417 kVA, Single-Phase, and 750/862 through 60 000/80 000/100 000 kVA, Three-Phase without Load Tap Changing; and 3750/4687 through 60 000/80 000/100 000 kVA with Load Tap Changing—Safety Requirements.

[B14] ANSI C57.12.11-1980, American National Standard Guide for Installation of Oil-Immersed Transformers (10 MVA and Larger, 69–287 kV Rating).

[B15] ANSI C57.12.12-1980, American National Standard Guide for Installation of Oil-Immersed Transformers 345 kV and Above.

[B16] ANSI C63.2-1996, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 kHz to 40 GHz—Specifications.

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[B17] ANSI C93.2-1976, American National Standard Requirements for Power Line Coupling Capacitor Voltage Transformers.

[B18] ANSI C93.3-1981, American National Standard Requirements for Power Line Carrier Line Traps.

[B19] ANSI C93.4-1984, American National Standard Requirements for Power Line Carrier Line Tuning Equipment.

[B20] ANSI C298-1985, American National Standard for Wet Process Porcelain Insulators (Apparatus Cap and Pin Type).

[B21] ANSI Y14.15-1966 (Reaff 1988), American National Standard Electrical and Electronic Diagrams.

[B22] ANSI/NAAMM MBG 531-1993, Metal Bar Grating Manual.

[B23] ASTM A123/A123M-97ae1, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

[B24] ASTM A615/A615M-96ae1, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

[B25] ASTM A659/A659M-97, Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled.

[B26] ASTM C31/C31M-98, Standard Practice for Making and Curing Concrete Test Specimens in the Field.

[B27] ASTM C33-99a, Standard Specification for Concrete Aggregates.

[B28] ASTM C39/C39M-99, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

[B29] ASTM C94/C94M-99, Standard Specification for Ready-Mixed Concrete.

[B30] ASTM C143/C143M-98, Standard Test Method for Slump of Hydraulic Cement Concrete.

[B31] ASTM C150-99a, Standard Specification for Portland Cement.

[B32] ASTM C172-99, Standard Practice for Sampling Freshly Mixed Concrete.

[B33] ASTM C192/C192M-98, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

[B34] ASTM C260-98, Standard Specification for Air-Entraining Admixtures for Concrete.

[B35] ASTM C494-99, Standard Specification for Chemical Admixtures for Concrete.

[B36] ASTM D2472-92 (Reaff 1997), Standard Specification for Sulfur Hexafluoride.

[B37] IEEE Std 48-1996, IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV Through 765 kV.

[B38] IEEE Std 80-1986 (Reaff 1991), IEEE Guide for Safety in AC Substation Grounding.

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[B39] IEEE Std 314-1975 (Reaff 1989), IEEE Standard Graphic Symbols for Electrical and Electronic Diagrams.[1]

[B40] IEEE Std 484-1996, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.

[B41] IEEE Std 485-1997, IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.

[B42] IEEE Std 605-1998, IEEE Guide for the Design of Substation Rigid-Bus Structures.

[B43] IEEE Std 693-1997, IEEE Recommended Practice for Seismic Design of Substations.

[B44] IEEE Std 837-1989 (Reaff 1996), IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.

[B45] IEEE Std 980-1994, IEEE Guide for Containment and Control of Oil Spills in Substations.

[B46] IEEE Std 998-1996, IEEE Guide for Direct Lightning Stroke Shielding of Substations.

[B47] IEEE Std 1127-1998, IEEE Guide for the Design, Construction, and Operation of Electrical Power Substations for Community Acceptance and Environmental Compatability.

[B48] IEEE Std 1264-1993, IEEE Guide for Animal Deterrents for Electric Power Supply Substations.

[B49] IEEE Std C37.010-1979 (Reaff 1988), IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[B50] IEEE Std C37.011-1994, IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[B51] IEEE Std C37.012-1979 (Reaff 1988), IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[B52] IEEE Std C37.04-1979 (Reaff 1988), IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[B53] IEEE Std C37.082-1982 (Reaff 1988), IEEE Standard Methods for the Measurement of Sound Pressure Levels of AC Power Circuit Breakers.

[B54] IEEE Std C37.09-1979 (Reaff 1988), IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[B55] IEEE Std C37.1-1994, IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control.

[B56] IEEE Std C37.2-1996, IEEE Standard Electrical Power System Device Function Numbers and Contact Designations.

[B57] IEEE Std C37.11-1997, IEEE Standard Requirements for Electrical Control for High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

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[1]IEEE Std 314-1975 (Reaff 1989) has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181 (http://global.ihs.com/).

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[B58] IEEE Std C37.30-1997, IEEE Standard Requirements for High-Voltage Switches.

[B59] IEEE Std C37.35-1995, IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Interrupter Switches.

[B60] IEEE Std C57.12.00-1993, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

[B61] IEEE Std C57.13-1993, IEEE Standard Requirements for Instrument Transformers.

[B62] IEEE Std C57.13.3-1983, IEEE Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases.

[B63] IEEE Std C57.19.00-1991 (Reaff 1997), IEEE Standard General Requirements and Test Procedures for Outdoor Apparatus Bushings.

[B64] IEEE Std C57.19.01-1991 (Reaff 1997), IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.

[B65] IEEE Std C62.11-1999, IEEE Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV).

[B66] IEEE Std C62.22-1997, IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems.

[B67] NEMA 107-1987 (Reaff 1993), Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus.

[B68] NFPA 70-1999, National Electric Code® (NEC®).

Any other ANSI/IEEE standards, as far as applicable, shall be considered in performance of works. Equivalent IEC, Canadian, or other national standards apply for installations elsewhere.

In the event of conflict between the referenced standards, the drawings of the Purchaser and their specification, or between standards issued by various authorities, such as local, state or provincial, federal, or other regulatory government agencies, the Contractor shall notify the Purchaser and secure written clarification as to what is acceptable before proceeding with the work.

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