



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 2.1
DISTRIBUTION TRANSFORMERS



2017



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 2.1 STANDARD SPECIFICATIONS
DISTRIBUTION TRANSFORMERS**

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**WAPA ES 2.1 STANDARD SPECIFICATIONS
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2.1.1 GENERAL: Distribution transformers shall be in accordance with applicable parts of IEEE C57 and Western's requirements which include limits on percent impedance voltage ratings. Only equipment of current manufacture shall be furnished.

2.1.2 PERCENT IMPEDANCE VOLTAGE LIMITS: Transformer percent impedance voltage ratings shall fall within the following limits:

Percent Impedance Voltage Rating Limits

<u>Single-Phase Transformers</u>		<u>Three-Phase Transformers</u>	
<u>Rating (kVA)</u>	<u>Limits (% IZ)</u>	<u>Rating (kVA)</u>	<u>Limits (% IZ)</u>
25	1.0 – 5.0	75	1.0 – 5.0
37.5	1.2 – 5.0	112.5	1.5 – 6.0
50	1.6 – 5.0	150	1.9 – 6.0
75	2.4 – 5.0	225	2.9 – 6.0
100	3.2 – 5.0	300	3.8 – 6.0
167	3.2 – 5.0	500	5.75 – 6.3
250	4.7 min	750	5.75 min

The lower percent IZ limits furnished shall prevent transformer secondary faults from exceeding 22,000 amps.

2.1.3 AVERAGE WINDING TEMPERATURE: The design of the transformer shall be such as the average winding temperature does not exceed 55°C at base rating, and when tested at 112% of base rating, shall not exceed 65°C.

2.1.4 DIELECTRIC COOLANT: The design of the transformer shall be such as the dielectric coolant shall be Envirotemp FR3 fluid or equal. The dielectric coolant shall be listed less-flammable fluid meeting the requirements of National Electrical Code Section 450-23 and the requirements of the National Electrical Safety Code (IEEE Std C2™-2002 standard), Section 15. The dielectric coolant shall be non-toxic, non-bioaccumulating and be readily and completely biodegradable per EPA OPPTS 835.3100. The base fluid shall be 100% derived from edible seed oils and food grade performance enhancing additives. The fluid shall not require genetically altered seeds for its base oil. The fluid shall result in zero mortality when tested on trout fry (per OECD G.L. 203). The fluid shall be certified to comply with the US EPA Environmental Technology Verification (ETV) requirements, and tested for compatibility with transformer components. The fluid shall be Factory Mutual Approved®, UL® Classified Dielectric Medium (UL-EOUV) and UL® Classified Transformer Fluid (UL-EOVK), Envirotemp™ FR3™ fluid or equal.

2.1.5 MATERIAL:

1. BUSHINGS: Bushings shall be gray in color.
2. PRESSURE RELIEF: A pressure relief method shall be provided to automatically relieve internal gas pressure.
3. PAD MOUNTED TRANSFORMERS: Pad mounted transformers shall have the following features:
 - a. Oil level gage.
 - b. Oil sampling device.

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- c. Dead front high-voltage terminations and equipment conforming to IEEE C57.26 requirements. Bushing wells and parking stands for mounting accessory equipment shall be universal type. Bushing wells shall be externally clamped and in accordance with IEEE 386.
- d. Low-voltage bushings shall be molded epoxy type and provided with blade-type spade terminal with NEMA CCI standard hole spacing. The low-voltage neutral shall be an insulated bushing grounded to the transformer tank by a removable grounding strap.
- e. The high-voltage and low-voltage compartments shall be separated by a metal barrier, shall be located side-by-side on one side of the transformer. When viewed from the front, the low-voltage side shall be on the right. Each compartment shall have a door. There shall be a locking mechanism and pad lock provisions to prevent opening the doors. There shall be a metal Data Pocket attached on the inside of one of the doors which will hold a copy of the instruction manual and final drawings.
- f. The tank shall be complete with an anodized aluminum laser engraved nameplate. This nameplate shall meet Nameplate B per IEEE C57.12.00-2010 standard.

2.1.6 TESTS: Transformers shall receive routine tests required by paragraph 8.1.1 of IEEE C57.12.00 and paragraph 4.1 of IEEE C57.12.20 except that load loss and exciting current tests are not required.

2.1.7 PAINTING: The distribution transformers shall be painted ANSI 70 gray in accordance with the manufacturer's standard painting system.

2.1.8 SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required for metal tag to be attached to equipment may be provided on the nameplate. A seismic report is not required for the low seismic performance level.

2.1.9 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete, accurate in their content, and legible. Drawings shall be prepared using CAD or drafting equipment, shall be drawn to scale, and shall have neat lettering. Drawings or informational data shall be provided as a standard PDF file, Electronic CAD (*.dwg) (AutoCAD 2010 or 2014 formats), Microsoft Word (.doc/.docx) or Microsoft Excel .xls/.xlsx formats. Freehand sketches or skewed scans will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming to the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and IEEE C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

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Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

TYPE OF DRAWINGS AND DATA	SECTION 2.1.7 PARAGRAPH	DELIVERY TIME (CALENDAR DAYS)	TYPE OF MATERIAL
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints in PDF or CAD Drawings
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline PDF or CAD Drawings
Final drawings	4.a.	21 days prior to shipment	CAD Drawings and PDF
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists in Excel, Word or PDF
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books, Word or PDF
Equipment insulating liquid PCB certification	4.d.	Prior to shipment of equipment	Certified Data in PDF
Equipment and oil test reports	4.e.	7 days prior to shipment of equipment	Certified Data in PDF

* Furnish one print of each final drawing and a copy of instruction manual with equipment.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. **INSTALLATION DRAWINGS AND DATA:** The required delivery time and type of material for installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:

- a. Transformer outlines, dimensions, and weights
- b. Base type, dimensions, and mounting details.
- c. Location, types, sizes, and projections of required embedded anchor bolts.
- d. Location and size of required openings in the foundation for conduits.
- e. Orientation of equipment and a complete anchor bolt setting plan.
- f. Size and location of jacking pads for transformer.
- g. Overall equipment cabinet dimensions, including height above equipment base.
- h. Seismic qualification report. Data and requirements shall be provided in accordance with ANSI 693. A seismic report is not required for the low seismic performance level.

3. **INFORMATIONAL DRAWINGS AND DATA:** The required delivery time and type of material for informational drawings and data are listed in Table-A. The drawings and data shall:

- a. Include outlines, details, schematic diagrams, wiring diagrams and instructions.
- b. Specifically verify conformance with equipment requirements.

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- c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.
4. FINAL DRAWINGS AND DATA: The minimum delivery time and type of material for final drawings and data are listed in Table-A. The drawings and data shall include the following:
- a. Final Drawings: Final drawings shall be furnished and shall show changes, and revision dates therefor, made up to the time the drawings are furnished.

Final Drawings shall include the following:
 - (2) Outlines of equipment.
 - (3) Wiring and schematic diagrams.
 - (4) Nameplate drawing.
 - b. Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing. Separate lists are not required if data is shown on outline drawings.
 - c. Manufacturer's instructions covering installation, operation, and maintenance repair for the equipment. Equipment shipped shall include a print of each final drawing, as required above, and a printed copy of the instructions.
 - d. Insulating Liquid Certification: Certification shall be furnished showing that insulating liquids used in equipment do not contain polychlorinated biphenyls.
 - e. Test Reports: Prior to shipment, the Contractor shall furnish certified copies of required test reports, performance curves, and data. Any equipment that does not successfully pass the testing requirements will be rejected.
5. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

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WAPA ES 2.3
OUTDOOR SWITCHGEAR ASSEMBLIES



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 2.3 STANDARD SPECIFICATIONS
OUTDOOR SWITCHGEAR ASSEMBLIES**

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WAPA ES 2.3 STANDARD SPECIFICATIONS OUTDOOR SWITCHGEAR ASSEMBLIES

2.3.1 GENERAL: Outdoor switchgear assemblies shall be designed, manufactured, and tested in accordance with applicable parts of these specifications, and applicable ANSI, NEMA, and NEC standards. Only new equipment of current manufacture shall be furnished. In the event of contradictory requirements, the requirements of these specifications shall apply. Ferrous equipment surfaces which are not galvanized shall be painted gray. The paint shall be qualified in accordance with ANSI C37.20.1, paragraph 5.2.8.

1. Project Specifications will indicate the major components required which normally include a transfer switch (manual or automatic) with load-side circuit breaker, panelboard(s), and lighting contactor. A ground sensor system is required only when the load side breaker is rated 1,000 amps or more. Metering current transformers are required only when specified. Major equipment includes associated relays.

2.3.2 EQUIPMENT QUALIFICATION: Before furnishing automatic transfer switches under these specifications, they must be qualified by furnishing the following:

1. Catalog data indicating that the transfer switches are a commercially manufactured product and that they can perform all the functions required by these specifications.

Any list of installations in which the cataloged automatic transfer switches have satisfactorily performed all the required functions would also be appreciated.

2.3.3 SWITCHGEAR ASSEMBLY FEATURES: A station service switchgear assembly shall meet the requirements of ANSI C37.20.1 and have the following features:

1. GENERAL:

- a. Be completely assembled, wired, adjusted, and tested at the factory before shipment. Be shipped assembled as complete as practicable, and be packaged and braced to prevent damage in shipment and to facilitate easy handling when unloading and during installation.
- b. Be self-supporting, deadfront and freestanding for pad mounting outdoors and be compatible with the associated equipment.
- c. All components shall be inside the enclosure.
- d. Bottom of assembly shall be provided with blank, removable, accessible steel plates, with gaskets, through which external cables can enter.
- e. Provisions shall be made to ground the switchboard assembly. Ground connections shall be suitable for up to No. 4/0 AWG copper cables.

2. ENCLOSURE: The station service switchgear assembly enclosure shall be NEMA type 4 watertight and shall have the following features:

- a. Be constructed to pass tests in accordance with ANSI C37.20.1, Section 5.2.9. The enclosure shall be a maximum of 9 feet high, excluding bases; however, in no event shall the centerline of the top circuit breaker handle be more than 6 feet 6 inches high.
- b. Wire bending space shall meet requirements of NEC 384-35.
- c. Caulking of joints as a method to waterproof the enclosure is unacceptable. Use of gaskets meeting the requirements of ANSI 37.20.2, paragraph A3.13.3. is an acceptable method to waterproof the enclosure.
- d. Mounting bolts, nuts, and washers for electrical equipment and material used outdoors and unprotected from the weather shall be of noncorrosive metal. Cadmium-plated mounting hardware will be permitted only where protected in weatherproof enclosures.

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- e. The steel construction of the base-mounted enclosures shall be free standing and totally enclosed with sheet steel of at least 12 gauge. The enclosure can have either channel bases approximately 1 5/8 inches high, or rectangular steel tubing bases approximately 2 inches high and 4 inches wide which do not obstruct cable raceway. The enclosures can have manufacturer's standard bases, provided that all other requirements are fulfilled.
 - f. Exterior weatherproof and watertight access doors shall have top and bottom strikes, center latch, and door handle. The strikes and latch engaged by the door handle shall pull the door securely against the gasket and enclosure and shall be adjustable. Doors shall be elevated 3 inches from the concrete foundation.
 - g. The access doors shall be complete with latches and continuous hinges that will allow the doors to open not less than 105° from the fully closed position. The doors shall have provisions for padlocks.
 - h. A light equipped with a clear glass safety globe shall be provided to adequately illuminate the interior of each compartment. The light shall be suitable for connection to a 120 V ac supply. Shockproof mounting of the light to protect the light from filament breakage shall be provided. An automatic pushbutton light switch actuated by opening a compartment door shall be provided to control the light to that compartment.
 - i. Two 250-W strip heaters shall be installed in each compartment of the station service switchboard. Wire mesh shall be installed over the heaters to protect cable and personnel from contact with the heaters. A disc thermostat shall regulate the heaters so that the temperature inside the cabinet is above 60°F, and the heaters are turned off above 70°F.
 - j. One weatherproof, separately fused, 15-amp, 125-V, 2-pole, 3-wire, polarized, duplex, grounded receptacle outlet with a built-in ground fault circuit interrupter shall be furnished and mounted on the exterior of the enclosure. The interrupter shall automatically interrupt the circuit for ground-fault currents of 5 milliamperes or greater and shall interrupt dangerous ground-fault current within 1/30 of a second. The receptacle shall be connected to a dedicated 20-amp breaker located at the ac distribution panel within the switchboard assembly. The receptacle shall have a test button to check the operation of the interrupter and a reset button that moves to a trip-indicating position upon operation of the interrupter. The receptacle shall have a NEMA standard configuration 5-15R, shall fit in a standard single-gang box, and shall be furnished with a cast-metal weatherproof cover plate having a spring-loaded, gasketed lift cover. The receptacle shall be Pass and Seymour Catalog No. 1591, or equal.
 - k. AC power for lighting, heaters and receptacles within the switchgear assembly shall be obtained from the ac panelboard[s] within the switchgear assembly.
 - l. Grounding shall be in accordance with ANSI C37.20.1, paragraph 6.1.2. A ground bus shall be provided at the bottom and rear of the switchgear assembly enclosure and solderless, clamp-type copper lugs or terminals shall be provided for connecting up to 4/0 AWG copper ground cable. The ground bus shall electrically connect together the primary equipment and device structures in the switchgear assembly.
3. TERMINAL BLOCKS: Terminal blocks for control wiring shall:
- a. Be rated at least 600 V and 25 amps and be suitable for use with No. 8 AWG wire.
 - b. Be molded-block type to accommodate ring connectors 1/2 inch wide (outer diameter) at the terminal screws, with binding-head or washer-head screws having serrated or grooved contact surfaces or having lockwashers, and have molded insulating barriers between terminals.
 - c. Have a removable marking strip and cover. The Contractor shall show circuit designations on the elementary schematic and wiring diagrams. These designations shall be machined

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lettered, stamped, engraved, or neatly marked with permanent ink on one side of the terminal block marking strips. The terminal arrangement shall group the conductors in each cable.

- d. Examples of terminal blocks meeting the above requirements are:
 - (1) Buchanan Catalog No. B112.
 - (2) General Electric Company, Type EB-25A12W.
 - (3) Connection, Inc., Type KU12.
 - e. Two spare terminal blocks shall be provided.
4. LIGHTING CONTACTOR: The lighting contactor shall have the following features:
- a. Be of the latching type with a minimum of six normally open poles and a minimum of 20 amps per pole.
 - b. Be rated for 240 V ac continuous operation.
 - c. The operating coil of the contactor shall be 120 V ac, suitable for continuous operation and shall be wired to a terminal block.
 - d. Be remotely controlled by a momentary switch located in the control building and by Supervisory Control and Data Acquisition (SCADA).
5. NAMEPLATES: Engraved nameplates shall be furnished and mounted for each terminal block, panelboard, breaker, relay, or other devices. These shall be shown on the Contractor-provided arrangement drawing and nameplate list.
- a. Nameplate material shall be laminated phenol resin sheet, 1/16-inch-thick that is cut to size. Edges are to be beveled. The nameplate material shall have semi-matte black surfaces and white center equal to Lamicoid No. 7025 satin finish.
 - b. Each device within an enclosure shall be identified with permanent markings on or adjacent to it. The markings shall show the device name or standard NEMA device function number.

2.3.4 AC DISTRIBUTION PANELBOARDS:

Ac distribution panelboards shall have the following features:

- 1. Be manufactured and furnished in accordance with the drawings, NEMA, and UL standards.
- 2. Be for use on a 3-phase system as shown on the Government-furnished drawings.
- 3. Be furnished with all auxiliaries, buses, and wiring ready for operation when connected to external cables.
- 4. Be made up of molded-case air circuit breakers individually mounted on a fixed framework behind an easily removable trim.
- 5. Bus bars shall be securely supported by the structural frames but shall not depend upon breakers for support. A back pan shall be provided as a foundation for mounting the bus and breakers. The mounting pan shall be of rigid construction to insure against damage during shipment and installation. The reinforcing may be in the form of flanging of the back pan for the entire length of the pan, or a flat back with angle iron securely fastened to both sides. Non-reinforced back pans of ordinary flat sheet steel will not be acceptable.
- 6. Board frames and enclosure shall be constructed so that adequate clearance is provided for an incoming cable raceway.

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7. All wiring shall be completely accessible for operation and maintenance and removal and replacement. Side wiring ducts with hinged panels shall be provided to allow wiring changes without exposure to live bus. The board shall have openings in the bottom plates for routing all incoming and outgoing cables. Provisions shall be made near the bottom of the board for supporting all incoming and outgoing cables.
8. The neutral bus of each ac board shall be provided with a sufficient number of terminals to accommodate a neutral lead in each circuit from each breaker. The neutral bus shall be insulated from the panel enclosure.
9. Terminal block arrangement and location shall be such that incoming and outgoing cables can be supported. Adjacent rows of terminal blocks shall be separated at least 6 inches edge to edge. Terminal blocks used for cross-panel or inter-panel wiring shall be readily accessible without having to remove wiring gutter covers.
10. To facilitate interconnection of wiring between panels at shipping splits, terminal blocks shall be provided on each panel adjacent to the split. All interconnections shall be terminated on these blocks, and all interconnections between these blocks shall be completed by the Contractor using jumpers cut to proper length and provided with lug connectors at each end of the jumper.
11. Panelboard buses shall be rated 600 V and have a minimum interrupting rating of 22,000 amps rms momentary.
12. Bus bars shall be copper and be insulated to 600 V. Unless silver-plated, main- and branch-circuit connectors shall use copper based on 1,000-amp-per-square-inch current density with contact surfaces not more than 200 amps per square inch. Main buses and back pans shall be so designed that branch circuits may be changed without additional machining, drilling, or tapping. Screws and bolts used for making copper connections shall be equipped with approved lock-washers to prevent loosening. Riveted bus connections will not be acceptable.
13. The board assemblies shall be designed so that any individual circuit breaker can be removed and changed without disturbing adjacent units, without loosening or removing supplemental insulation supplied to meet the requirements of the Underwriters' Laboratories, Inc., and without additional machining, drilling, or tapping.
14. Connections between circuit breaker terminals and buses shall be copper bars designed to prevent excessive stress on the bus or the circuit breaker during expansion due to temperature changes.
15. Circuit breakers shall be in accordance with NEMA Publication No. AB1 and the following:

Circuit breakers shall be of the manually-operated, molded-case, bolt-on type with either a thermal magnetic trip unit or a thermal and independent magnetic trip unit. Each circuit breaker shall have a voltage rating of 240 V and an interrupting rating of 22,000 amps symmetrical at 240 V. Current limiting molded case breakers, which do not use fuses, or parts that require replacement after each operation will be acceptable. Cascade application of the circuit breakers is not acceptable. Continuous current rating and minimum number of poles is shown on the drawings.

Multiple-pole circuit breakers shall have a common trip. Tandem or handle-tie breakers are not acceptable.

Each circuit breaker shall be provided with an operating handle on the front panel for opening and closing the breaker manually. Each operating handle shall protrude through the removable panel and shall have lockout/tagout capability.

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Visual indication of circuit breaker position shall be provided on the front panel for each circuit breaker and shall be visible from the operating position. The position indicator shall indicate whether the circuit breaker is open, closed, or has been automatically tripped by an overload.

The circuit breakers shall be trip free so that the contacts cannot be held closed against an abnormal overcurrent or short-circuit condition.

Copper clamp-type lugs or terminals suitable for copper conductors shall be provided on each breaker for the copper conductor sizes as shown on the drawings.

The Contractor shall provide and install all spare breakers, and provide all mounting material for future breakers.

16. Each distribution board branch circuit shall be provided with a nameplate for each circuit breaker.

2.3.5 MANUAL TRANSFER SWITCH:

1. The manual transfer switch shall be manufactured and furnished in accordance with the drawings, NEMA and UL standards
2. The manual transfer switch shall be dead front, and enclosed in the free standing, NEMA 4 enclosure. The manual transfer switch shall be for use on the specified 3-phase, system, be suitable for motor loads as well as lighting loads, and be rated for continuous loads as indicated on the drawings. The manual transfer switch shall be capable of making or breaking any load within the rating of the switch.

2.3.6 AUTOMATIC TRANSFER SWITCH, CONTROLS, AND RELAYING:

1. GENERAL: The automatic transfer switch shall be manufactured and furnished in accordance with the drawings, NEMA and UL standards.

The automatic transfer switch shall be dead front, and enclosed in a free-standing, NEMA 4 enclosure. The automatic transfer switch shall have a hinged and lockable door with two keys provided, be suitable for motor loads as well as lighting loads, and be rated for continuous loads on a 3-phase ac system as indicated on the drawings. The automatic transfer switch shall be capable of making or breaking any load within the rating of the switch.

The automatic transfer switch shall be provided with a main molded case circuit breaker on the load side of the switch. The breaker shall meet section 2.3.8 requirements.

2. CONTROLS: The automatic transfer switch shall be designed for either manual or automatic operation as determined by the setting of the mode selection control switch. This switch shall have positions labeled for "Independent Manual" and "Automatic" modes only. A second selector switch shall be provided to select either Source A or Source B as the primary station service source. Source A and Source B shall be labeled for the transformer or engine/generator that is feeding it.

Under normal operating conditions, both sources will be energized, the control selector switch will be set on "Automatic", the primary source breaker will be selected.

3. "INDEPENDENT MANUAL" MODE OPERATION: With the selector switch set on "Independent Manual", the transfer may be operated manually at the transfer switch (alarming, status, and protective relaying shall not be affected).

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4. "AUTOMATIC" MODE OPERATION: Automatic control logic shall be performed in accordance with the following:
- a. "Independent Manual" to "Automatic" Mode Change: Upon placing the changeover switch in "Automatic" mode, the primary source shall be selected providing the primary power supply is energized and in a normal condition.
 - b. Primary Source Failure: A transfer operation shall occur upon operation of the source undervoltage relay or the station service transformer protection relays (if applicable). If the secondary source is an engine/generator, a timing circuit of time from 1 to 30 seconds, adjustable, shall be provided for power transfer from the primary source to the engine/generator source upon loss of voltage of the primary supply. This timing circuit shall allow the engine/generator to reach operating speed prior to the "Automatic" transfer occurring. Contacts shall be wired to an easily accessible terminal block location for use with the engine/generator as indication that the primary source has failed. These contacts will be used by the engine/generator controls to initiate the start sequence for the engine/generator.
 - c. Secondary Source Failure: Failure of the secondary source (operation of the undervoltage relay or transformer relays) shall initiate a transfer operation to return to the deenergized primary source.
 - d. Restoration of the Primary Source: The changeover switch shall automatically return upon restoration of voltage to the primary source or after the set time delay if an engine/generator is Source B.
 - e. Blocked Automatic Transfer: Automatic transfer shall not occur:
 - if the changeover switch is in "Independent Manual" mode.
 - in the case of simultaneous loss of voltage on both sources.
5. RELAYING: All sensing and protection relays shall be electronic, solid state, with dry contact outputs (solid state outputs are not acceptable). One set of "Form C" contacts for each relay shall be wired out to terminal blocks for status indication.
- A dc breaker shall be provided for each source's relaying power supplies. All inputs, outputs, and dc supply for each relay shall be connected through an FT-1 test switch to facilitate testing.
- a. Undervoltage and Voltage-Unbalance/Phase Sequence Relays: Each source shall have a solid state undervoltage and voltage-unbalance/phase sequence relay of the Basler Type BE4-47N/27 or equal.
 - b. Timing Relays: Time delay on return to normal, 1 second to 30 minutes adjustable.
6. REMOTE SUPERVISORY CONTROL MONITORING: Provisions shall be made for the monitoring of the following equipment.
- a. Voltage level of all three phases on the primary and secondary sides of the automatic transfer switch.
 - b. Automatic transfer switch position indication.
 - c. Independent Manual/Automatic mode selector and Source selection control switch positions.
 - d. Breaker alarms.
 - e. Individual relay alarms.
 - f. Station service transformer sudden pressure and pressure relief relay alarms.

**WAPA ES 2.3 STANDARD SPECIFICATIONS
OUTDOOR SWITCHGEAR ASSEMBLIES**

- g. Provisions shall be made for remote supervisory control of the automatic transfer switch.
- h. Pilot lights shall be provided for primary and secondary supplies.

2.3.7 LOAD SIDE MAIN BREAKER:

1. GENERAL: When a main breaker is required for the load side of a transfer switch, it shall be 3-pole molded-case type in accordance with Federal Specification W-C-375a and NEMA Publication No. AB1 and rated as shown on the drawings.

The circuit breaker shall be of the manually-operated, molded-case, bolt-on type with either a thermal magnetic trip unit or a thermal and independent magnetic trip unit.

The breaker shall be single throw, trip free in any position, 60 Hz, interchangeable trip type. Circuit breaker shall have ratings as shown on the drawings and features as follows:

- a. Operation: Circuit breaker shall have thermal, time, and instantaneous over-current tripping devices of the magnetic direct-acting type or of the static type on each pole to provide instantaneous and time-delay tripping functions in accordance with the NEMA standard.

Current-limiting molded case breakers which do not use fuses or parts that require replacement after each operation will be acceptable.

The three-pole circuit breaker shall have a common trip. A tandem or handle-tie breaker is not acceptable.

- b. Operating Handle: Circuit breaker shall be provided with an operating handle for opening and closing the breaker manually. The operating handle shall protrude through the removable panel and shall have lockout/tagout capability.
- c. Position Indicator: Visual indication of circuit breaker position shall be provided on the front of the case for the circuit breaker and shall be visible from the operating position. The position indicator shall indicate whether the circuit breaker is open, closed, or has been automatically tripped by an overload.
- d. Termination: Copper clamp-type lugs or terminals suitable for copper conductors shall be provided on breakers for the copper conductor sizes as shown on the drawings. Aluminum connectors using aluminum screws will not be acceptable.
- e. Shunt Trip Device: The main circuit breaker, when rated 1,000 amps or more, shall be equipped with a shunt trip device connected to the ground sensor system for ground fault detection required by NEC Sections 239-95 and 240-13.

- 2.3.8 METERING CURRENT TRANSFORMERS:** Metering current transformers, when required shall be furnished and connected as indicated on the drawings. Three window-type current transformers shall be furnished, one on each phase of the primary source. The transformers shall be 60-Hz 600V indoor type with ratio as specified on drawings and ANSI C57.13 metering accuracy class 0.3 B-0.1, 0.2, 0.5, 0.9, 1.8. Each terminal of the window-type current transformers shall be wired to outgoing terminal blocks located in the switchgear assembly enclosure. The terminal blocks shall be short circuiting, General Electric Company Type EB27B06SC or equal.

**WAPA ES 2.3 STANDARD SPECIFICATIONS
OUTDOOR SWITCHGEAR ASSEMBLIES**

2.3.9 GROUND SENSOR SYSTEM:

When a main breaker is rated 1,000 amps or more, a ground sensor system shall be furnished to provide ground fault protection. The system shall be ASEA Brown Boveri Type GRC and TMC (or equal) with one window-type current transformer.

1. The window-type current transformer shall be 60-Hz indoor type and shall have a voltage rating of 600 V. The short-time thermal and mechanical ratings, in accordance with ANSI, shall not be less than 60 and 75 times rated current, respectively.
2. The ground-fault relay shall be of solid state construction and shall initiate tripping of the main breaker and operate an annunciator drop. The relay shall be adjustable from 200 to 1,200 primary amps and shall have several selectable, fixed, time-delay settings over a range of 2 to 209 cycles. The relay output contacts shall operate on 125 V dc. Two spare "Form C" output contacts shall be wired out to terminal blocks for status indication.

2.3.10 SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on the equipment nameplate. A seismic report is not required for the low seismic performance level.

2.3.11 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 2.3 STANDARD SPECIFICATIONS
OUTDOOR SWITCHGEAR ASSEMBLIES**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 2.3.11 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:

- a. Equipment outlines, dimensions, and weights.
- b. Base type, dimensions, and mounting details.
- c. Location, types, sizes, and projections of required embedded anchor bolts and material.
- d. The Government will furnish foundations, anchor bolts, and embedded material as required.
- e. Location and size of required openings in the floors for conduits.
- f. Orientation of all equipment and a complete anchor bolt setting plan.
- g. Seismic qualification report. Data and requirements shall be provided in accordance with ANSI 693.

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:

- a. Include outlines, details, schematic diagrams, wiring diagrams and instructions.
- b. Specifically verify conformance with equipment requirements.
- c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

**WAPA ES 2.3 STANDARD SPECIFICATIONS
OUTDOOR SWITCHGEAR ASSEMBLIES**

4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. Final Drawings: The drawings shall show all changes, and revision dates thereof, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible.

Final drawings shall include the following:

- (1) Outline.
 - (2) Time-current curves.
 - (3) Wiring diagrams, schematic diagrams, and details for any specified component such as ac distribution panelboard, ground sensor system, metering current transformers, transfer switches, safety switches, circuit breakers, and enclosure.
 - (4) Nameplate.
- b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. Sets of manufacturer's instruction covering installation, operation, and maintenance repair for the equipment and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. Certified copies of required test reports shall be furnished prior to shipment of equipment. Any equipment which does not successfully pass testing requirements will be rejected.
5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 2.4
INDOOR AC AND DC DISTRIBUTION BOARDS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 2.4 STANDARD SPECIFICATIONS
INDOOR AC AND DC DISTRIBUTION BOARDS**

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WAPA ES 2.4 STANDARD SPECIFICATIONS INDOOR AC AND DC DISTRIBUTION BOARDS

2.4.1 GENERAL: Distribution boards required to complete low-voltage ac and dc systems shall be in accordance with this standard and applicable Western drawings. The boards shall conform to the following general requirements, unless otherwise stated. Any details not specifically covered by the general requirements shall be subject to approval by Western. All equipment shall be furnished in accordance with the applicable parts of NEMA, ANSI, IEEE, and ASTM Standards, the "National Electrical Code", the Federal Specifications, and the Standards of the Underwriters' Laboratories, Inc. Only new equipment of current manufacture shall be furnished.

In addition to standard tests, the distribution boards shall be factory assembled, and all circuits shall be tested completely before shipment to prove the correctness of the completed wiring connections and the functions of the various devices.

2.4.2 MATERIAL:

1. **CONSTRUCTION:** The distribution panelboards shall be two-piece type suitable for surface mounting. The distribution panelboards shall have the following features:

- a. **Enclosure Box:** The enclosure box shall be one-piece construction and fabricated from No. 14, or heavier, U.S. standard gauge sheet steel. Mounting bolt holes 7/16 inch in diameter shall be provided through the back surface of the box, and raised steel spacers of 1/4-inch thickness shall be provided on the outside back surface of the box. Overall box width shall not exceed 36 inches.
- b. **Enclosure Front:** The enclosure front shall be fabricated from stretcher-leveled, No. 12, or heavier, U.S. standard gauge steel sheets. The front shall be attached to the box with adjustable, indicating-type trim clamps. Overall length and width of the front shall be approximately 1/8 inch more than the overall length and width of the box on which the front is installed. The front shall be provided with a flush door. The door shall have concealed hinges, shall close against a 1/4-inch rabbet, and shall be provided with a lock. The lock shall be flush, brushed stainless steel, cylinder-tumbler type with a catch and spring-loaded door pull. The lock shall be furnished with two keys.
- c. **Circuit Directory Frame:** A circuit directory frame with a clear plastic cover for the directory card shall be provided on the inside surface of the panelboard door. The circuit directory shall not be folded when placed in the circuit directory frame, and all information shall be clearly visible and legible.
- d. **Wiring:** Wiring shall enter the distribution boards from the bottom and be completely accessible. Provide means near the board bottom for supporting incoming cables.
- e. **Circuit Breaker Mounting:** Circuit breakers shall be mounted such that circuit breaker handles are operable from the panel front.

Board assembly shall be designed so that any individual breaker can be removed without disturbing adjacent units.

- f. **Panelboard Duct and Riser:** Panelboard duct and riser shall be two-piece type suitable for surface mounting directly below the panelboard on the wall.
 - (1) **Duct:** Duct shall be one-piece construction, fabricated from 16 gauge, or heavier, steel sheets. Overall duct width and depth shall be the same as that of the panelboard being furnished. Overall length shall be 2 feet 0 inches. Duct shall have 1-inch flanges in front to allow fastening the duct cover.

**WAPA ES 2.4 STANDARD SPECIFICATIONS
INDOOR AC AND DC DISTRIBUTION BOARDS**

- (2) Duct Cover: Duct cover shall be one-piece construction, fabricated from No. 14, or heavier, U.S. standard gauge steel sheets. Cover shall be fastened to the duct by sheet metal screws.
- (3) Painting: Paint duct and riser with manufacturer's standard finish, except finish shall match the finish of the distribution boards. The paint color shall be gray.

2.4.3 ELECTRICAL REQUIREMENTS:

- 1. BUS BARS: Bus bars shall be copper, shall be securely supported by the structural frames, and shall not depend upon breakers for support.
- 2. MAIN AND BRANCH CIRCUIT CONNECTORS: Unless silver-plated, all main and branch circuit connectors shall use copper based on 1,000-amp-per-square-inch current density with contact surfaces not more than 200 amps per square inch. Screws and bolts used for making copper connections shall be equipped with approved lockwashers to prevent loosening. Riveted bus connections are not acceptable.
- 3. MAIN BUSES AND BACK PANS: Main buses and back pans shall be so designed that branch circuits may be changed without additional machining, drilling, or tapping.
- 4. CONNECTORS: Connectors between breaker terminals and buses shall be copper bars designed to prevent excessive stress on the breaker during expansion due to temperature changes.
- 5. LUGS OR TERMINALS: Clamp-type lugs or terminals suitable for copper conductors shall be provided on each breaker for the feeder cables and on each bus for the supply cables. The lugs or terminals shall be sized in accordance with the cable sizes shown on the drawings. Aluminum connectors using aluminum screws are not permitted.
- 6. NEUTRAL BUS: The neutral bus of each ac board shall be provided with a sufficient number of terminals to accommodate a neutral lead in each circuit from each breaker. The neutral bus shall be insulated from the panel enclosure.
- 7. PANELBOARD ENCLOSURES: Furnish with a bolted, solderless-type terminal lug suitable for terminating a No. 4 AWG copper grounding cable.
- 8. MOLDED-CASE CIRCUIT BREAKERS: Circuit breakers shall be furnished in accordance with NEMA Publication No. AB1. Circuit breakers shall be of the manually operated molded-case, arc-blowout type with dual, thermal-magnetic, trip element. Each circuit breaker shall provide thermal overcurrent and instantaneous short-circuit protection in each pole with interrupting capacity in accordance with the NEMA standard or as shown on the drawings. Magnetic trip elements shall be rated 10 times the rating of the thermal elements. Unless otherwise specified in bid item description or on drawings, circuit breakers shall have the following ratings:

Circuit Breaker	Voltage Rating (v)	Interrupting Capacity at Rated Voltage (Amps)
AC Main	600 ac	10,000 rms symmetrical
AC Branch	240 ac	10,000 rms symmetrical
DC Main	250 dc	10,000
DC Branch	250 dc	5,000

WAPA ES 2.4 STANDARD SPECIFICATIONS INDOOR AC AND DC DISTRIBUTION BOARDS

Each circuit breaker shall have a handle that protrudes through the removable panel and shall have a position indicator visible from the operating position. The position indicator shall indicate whether the breaker is open, closed, or has been automatically tripped by an overload.

Each circuit breaker shall have a lockout/tagout device using a standard padlock. The lockout/tagout devices shall be in accordance with a current version of OSHA 1910.269. Add-on or after-market devices such as Seton Name Plate Company / Seton Identification Products or W. H. Brady Signmark lockout/tagout for circuit breakers shall be acceptable if original manufacturer equipment are not available.

The circuit breakers shall be trip free so that the contacts cannot be held closed against an abnormal overcurrent or short-circuit condition.

Western reserves the right to change the cable size or ampere rating of any breaker within its own price range.

9. **AUXILIARY SWITCHES:** An auxiliary switch shall be furnished for each dc breaker in accordance with the drawings. Each switch shall have at least one form "A" and one form "B" contact rated for 125 V dc. All contacts shall be connected to separate terminals on terminal blocks. The "B" contacts shall be connected in parallel on the outgoing side of the terminal blocks to operate a remote annunciator as indicated on the drawings.

2.4.4 NAMEPLATES: Furnish and mount engraved nameplates.

Each device within an enclosure shall be identified with permanent markings on or adjacent to it. The markings shall show the device name or standard NEMA device function number.

2.4.5 SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on the equipment nameplate. A seismic report is not required for the low seismic performance level.

2.4.6 PAINTING: The exterior and interior surfaces of the distribution boards shall be painted ANS1 61 gray with the manufacturer's standard finish.

2.4.7 TOOLS AND ACCESSORIES: Furnishing the boards includes furnishing all special tools and accessories required for normal operation and maintenance of the distribution boards.

2.4.8 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

**WAPA ES 2.4 STANDARD SPECIFICATIONS
INDOOR AC AND DC DISTRIBUTION BOARDS**

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 2.4.8 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Informational drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Final drawings	3.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	3.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	3.c.	21 days prior to shipment	Books	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
 - a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

3. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
 - a. Final Drawings: The drawings shall show all changes, and revision dates thereof, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible.

**WAPA ES 2.4 STANDARD SPECIFICATIONS
INDOOR AC AND DC DISTRIBUTION BOARDS**

Final drawings shall include the following:

Outline.
Wiring diagrams.
Nameplates.

- b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the equipment and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
4. **RIGHT TO USE CONTRACTOR'S DRAWINGS:** Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under a contract.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION – ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 4.3

SINGLE-PHASE DRY-TYPE SHUNT REACTORS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 4.3 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SHUNT REACTORS**

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WAPA ES 4.3 STANDARD SPECIFICATIONS SINGLE-PHASE DRY-TYPE SHUNT REACTORS

4.3.1 GENERAL: This standard is for single-phase, 60 Hz, dry-type, air-core shunt reactors which shall be in accordance with ANSI C57.21 unless otherwise specified. Only new equipment of current manufacture shall be furnished.

4.3.2 DESIGN REQUIREMENTS: Reactors shall be:

1. Designed to operate under conditions that vary from deenergized condition at minimum ambient temperature to continuous operation at 105 percent rated voltage and current at maximum ambient temperature.
2. Designed so that the temperature rise by winding resistance shall not exceed 70°C above ambient temperature when carrying overcurrent caused by continuous operation at 105 percent rated voltage at required elevation (3,300 feet unless otherwise specified).
3. Designed to be impervious to moisture and other weather hazards.
4. Dimensioned to allow for installation and maintenance of electrical and magnetic clearances.
5. Provided with suitable attachments for lifting reactors.

4.3.3 DESIGN LOADING: Reactors, including supporting structures (if required), and supporting insulator assemblies shall be designated to withstand specified service requirements without damage to component parts or impairment to operation. The windings shall be supported by such material and in such a manner that cracks in supporting material will not develop in operation due to loading or temperature variations.

4.3.4 MATERIAL:

1. **INSULATING MATERIAL:** Insulating material in reactors shall be such as to prevent cracking or spalling of insulating material.
2. **INSULATORS:** Porcelain post type insulators (provide extra long insulator if required) with nonmagnetic caps and bases shall be furnished to insulate electrically and isolate magnetically the reactors from ground and supporting structure (if required). Insulators shall be gray in color and in accordance with ANSI C29.9.
3. **SUPPORTING STRUCTURES:** When specified, each reactor shall be furnished with a fiberglass, braced aluminum, or nonmagnetic steel pedestal support. The support shall have a minimum dimension of 102 inches from bottom to top of support.
4. **TERMINAL PADS:** Terminal pads shall be NEMA CCI 4-hole type.
5. **MOUNTING HARDWARE:** Mounting hardware, including adapter plate (if required), shall be nonmagnetic.
6. **BIRD BARRIERS:** Bird barriers shall be furnished.

4.3.5 TESTS: Shunt reactors shall be completely assembled and tested in accordance with ANSI C57.21, Section 6.1, Table 4B, as follows:

1. **ROUTINE TESTS:**
 - a. Dc resistance measurement on all units.
 - b. Impedance measurement on all units at 60 Hz.
 - c. Total loss measurement on each unit of an order and at rated voltage and rated kVA.
 - d. Turn-to-turn test for reactors unit rated 34.5 kV and below.
 - e. Lightning impulse test for reactors rated above 34.5 kV.
 - f. Tests to determine actual kVA rating at rated voltage.

**WAPA ES 4.3 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SHUNT REACTORS**

2. DESIGN TESTS: Design tests are required on one unit of an order of identical units or on a duplicate or essentially duplicate unit as follows:
 - a. Temperature rise test for current at 105 percent of rated voltage.
3. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on the equipment nameplate. A seismic report is not required for the low seismic performance level. A seismic report is not required for the low seismic performance level.

4.3.6 ELECTRICAL DRAWINGS AND DATA:

1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and Western's equipment standards. The design of electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting requirements or for correctness of drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 4.3 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SHUNT REACTORS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 4.3.6 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
*Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Equipment test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. **INSTALLATION DRAWINGS AND DATA:** Installation drawings and data are required for preparing installation drawings for foundations and for Government-furnished equipment support structures. The required delivery time and quantity are listed in Table-A. Drawings and data required include those in the following list that are applicable:

- a. Equipment or reactor equipment and associated support structure outlines, dimensions, and weights.
- b. Base type, dimensions, and mounting details.
- c. Location, types, sizes, and projections of required embedded anchor bolts.
- d. Orientation of all equipment and a complete anchor bolt setting plan.
- e. Seismic qualification report, for equipment specifications requiring a seismic qualification report.

3. **INFORMATIONAL DRAWINGS AND DATA:** The Contractor shall furnish informational drawings and data for electrical equipment supplied by the Contractor. The required delivery time and quantity are listed in Table-A.

The drawings and data shall include equipment outlines, details, schematic diagrams, wiring diagrams, and instructions. The drawings and data shall specifically verify conformance with equipment requirements and shall be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

**WAPA ES 4.3 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SHUNT REACTORS**

4. FINAL DRAWINGS AND DATA: The minimum delivery times and quantities of final drawings and data are listed in Table-A. The required drawings and data shall include the following:
- a. Final Drawings: The drawings shall show all changes, and revisions dates therefor, made up to the time the drawings and data are furnished. Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full size; and be clear, sharp, and legible. Final drawings shall be furnished and shall include the following:
 - Outlines including support structures when furnished.
 - Schematics diagrams.
 - Nameplates.
 - b. Parts Identification Lists or Bills of Materials: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the reactors and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. Test Reports for Outdoor Equipment: The Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.
5. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependant upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 4.4
SINGLE-PHASE DRY-TYPE SERIES REACTORS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 4.4 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SERIES REACTORS**

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**WAPA ES 4.4 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SERIES REACTORS**

4.4.1 GENERAL: This standard is for single-phase, 60-Hz, dry type, air-core series reactors which shall be in accordance with IEEE C57.16 unless otherwise specified. Only new equipment of current manufacture shall be furnished.

4.4.2 DESIGN REQUIREMENTS: Reactors shall be:

1. Designed so that the temperature rise by winding resistance shall not exceed 70°C above ambient temperature when operated at rated current.
2. Designed to be impervious to moisture and other weather hazards.
3. Dimensioned to allow for installation and maintenance of electrical and magnetic clearances.
4. Provided with suitable attachments for lifting reactors.

4.4.3 DESIGN LOADING: Reactors, including supporting structures (if required), and supporting insulator assemblies shall be designed to withstand specified service requirements without damage to component parts or impairment to operation. The windings shall be supported by such material and in such a manner that cracks in supporting material will not develop in operation due to loading or temperature variations.

4.4.4 MATERIAL:

1. **INSULATING MATERIAL:** Insulating material in reactors shall be such as to prevent cracking or spalling of insulating material.
2. **INSULATORS:** Porcelain post type insulators (provide extra long insulator if required) with nonmagnetic caps and bases shall be furnished to insulate electrically and isolate magnetically the reactors from ground and supporting structure. Insulators shall be gray in color and in accordance with ANSI C29.9.
3. **SUPPORTING STRUCTURES:** When specified, reactors shall be furnished with fiberglass, braced aluminum, or nonmagnetic steel pedestal supports. Supports shall have a minimum dimension of 102 inches from bottom to top of support.
4. **TERMINAL PADS:** Terminal pads shall be NEMA CCI 4-hole type.

4.4.5 TESTS: Series reactors shall be completely assembled and tested in accordance with IEEE C57.16, Section 6.1, Table 3, as follows:

1. **ROUTINE TESTS:**
 - a. Resistance measurement on all units.
 - b. Impedance measurement on all units.
 - c. Total loss measurement on all units.
 - d. Turn-to-turn test on all units rated 34.5 kV and below.
 - e. Lightning impulse test on all units rated above 34.5 kV.
2. **DESIGN TESTS:** Design tests, as follows, are required on one unit of an order of identical units or on a duplicate or essentially duplicate unit.
 - a. Temperature rise test.
 - b. Short-circuit test. First cycle asymmetrical peak equal to 2.55 times the rms symmetrical short circuit current.

**WAPA ES 4.4 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SERIES REACTORS**

3. OTHER TESTS:

- a. Seismic Qualification: When seismic qualification is required, data and requirements shall be provided in accordance with IEEE 693. The data required on metal tags to be attached to equipment may be provided on the equipment nameplate.
- b. Radio influence voltage (RIV) tests on units rated 230 kV and above.

4.4.6 ELECTRICAL DRAWINGS AND DATA:

1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and Western's equipment standards. The design of electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting requirements or for correctness of drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 4.4 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SERIES REACTORS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 4.4.6 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
*Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Equipment test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. **INSTALLATION DRAWINGS AND DATA:** Installation drawings and data are required for preparing installation drawings for equipment supports and foundations or foundations for equipment and associated support. The required delivery time and quantity are listed in Table-A. Drawings and data required include those in the following list that are applicable:

- a. Equipment or reactor equipment and associated support structure outlines, dimensions, and weights.
- b. Base type, dimensions, and mounting details.
- c. Location, types, sizes, and projections of required embedded anchor bolts.
- d. Orientation of all equipment and a complete anchor bolt setting plan.
- e. Seismic qualification report, for equipment specifications requiring a seismic qualification report.

3. **INFORMATIONAL DRAWINGS AND DATA:** The Contractor shall furnish informational drawings and data for electrical equipment supplied by the Contractor. The required delivery time and quantity are listed in Table-A.

The drawings and data shall include equipment outlines, details, schematic diagrams, wiring diagrams, and instructions. The drawings and data shall specifically verify conformance with equipment requirements and shall be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

**WAPA ES 4.4 STANDARD SPECIFICATIONS
SINGLE-PHASE DRY-TYPE SERIES REACTORS**

4. FINAL DRAWINGS AND DATA: The minimum delivery times and quantities of final drawings and data are listed in Table-A. The required drawings and data shall include the following:

- a. Final Drawings: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished. Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible. Final drawings shall be furnished and shall include the following:

Outlines including those of support structures when required.

Outlines showing maintenance, electrical, and magnetic clearance requirements.

Nameplates.

- b. Sets of Parts Identification Lists or Bills of Materials: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
- c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the electrical equipment above and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
- d. Test Reports for Outdoor Equipment: Two weeks after completion of tests required on electrical equipment, the Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.

The reports shall be sent to the destinations listed in Table-A.

5. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:

- a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
- b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 4.5
SURGE SUPPRESSORS FOR SHUNT REACTORS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 4.5 STANDARD SPECIFICATIONS
SURGE SUPPRESSORS FOR SHUNT REACTORS**

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WAPA ES 4.5 STANDARD SPECIFICATIONS SURGE SUPPRESSORS FOR SHUNT REACTORS

4.5.1 GENERAL: A surge suppressor for each shunt reactor phase shall consist of an insulator mounted single-phase resistor connected from phase conductor to a single-phase capacitor connected to ground.

4.5.2 MATERIAL:

1. **INSULATORS:** Insulators shall be gray in color and shall be in accordance with ANSI C39. The insulator on which the resistor will be mounted shall be rated 110-kV BIL.
2. **CAPACITORS:** The capacitors shall be single-phase, 60-hertz, outdoor, liquid-filled, hermetically sealed, two-bushing type, and manufactured in accordance with NEMA publication No. CP1.

The solid dielectric material shall be a combination of high quality paper and synthetic film.

The capacitors shall be completely impregnated with the insulating liquid. Insulating liquids containing PCB (polychlorinated biphenyls) are not acceptable.

The units shall include an internal discharge device that will reduce the voltage on the terminals to 50 V or less within 5 minutes after rated voltage is withdrawn from the capacitor.

The capacitors shall be for edge mounting such that the bushings are horizontal.

The bushings shall be gray in color. The capacitors shall have the specified ratings:

4.5.3 TESTS:

1. **RESISTOR TEST:** Each resistor shall be given a dielectric test in accordance with IEEE standard No. 32.
2. **CAPACITOR TESTS:** Each capacitor shall be given the following tests in accordance with applicable NEMA standards.
 - a. Dielectric strength test.
 - b. Capacitance test.
 - c. After sealing, each capacitor shall be tested for leaks to ensure perfect sealing.

4.5.4 PAINTING: The resistor enclosure shall be painted in accordance with the manufacturer's cleaning and painting system.

4.5.5 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standard of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

**WAPA ES 4.5 STANDARD SPECIFICATIONS
SURGE SUPPRESSORS FOR SHUNT REACTORS**

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 4.5.5 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Equipment test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6
Insulating liquid PCB certification	4.e.	Prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Seismic qualification report.

**WAPA ES 4.5 STANDARD SPECIFICATIONS
SURGE SUPPRESSORS FOR SHUNT REACTORS**

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
 - a. Include outlines, details, schematic diagrams, wiring diagrams and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
 - a. Final Drawings: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings are furnished. Final drawings shall be furnished rolled or flat, not folded. Drawings shall be printed on quality bond paper, be full size, and be clear, sharp, and legible. Final drawings shall include the following:
 - Outlines of electrical equipment.
 - Wiring and schematic diagrams.
 - Nameplate drawing.
 - b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing. Separate lists are not required if data is shown on outline drawings.
 - c. Sets of manufacturer's instruction covering installation, operation, and maintenance repair for the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. Test Reports: After completion of those tests required on the equipment and prior to shipment, the Contractor shall furnish certified copies of all test reports, performance curves, and data. All copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.
 - e. Insulation Liquid Certification: Certification shall be furnished showing that insulating liquids used in equipment do not contain polychlorinated biphenyls.

5. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
 - a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 5.1
SHUNT CAPACITOR BANKS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

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**WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

5.1.1 GENERAL: This standard is for outdoor open-rack, stack-type shunt capacitor banks. The capacitor equipment shall be complete with capacitor units, supporting structure bases, racks, insulators, fuses, discharge devices, and potential (voltage) transformers. Each capacitor unit shall be designed, rated, manufactured, and tested in accordance with ANSI/IEEE Standard No. 18 unless otherwise specified. In the event of contradictory requirements between ANSI and these requirements, the terms of these requirements shall apply. Only new equipment of current manufacture shall be furnished.

5.1.2 MATERIAL:

1. **SERVICE CONDITIONS:** The capacitors shall be suitable for operation when energized under all of the normal service conditions as specified in ANSI/IEEE Standard No. 18. In addition to the normal service conditions, the equipment shall meet the following:
 - a. The capacitor equipment shall be designed to withstand repeated earthquake accelerations and windloads on the projected area (non-simultaneous) as specified without damage or impairment of operation.
 - b. The capacitor equipment shall be suitable for installation in the specified NESC loading areas.
 - c. Each capacitor equipment bank shall be suitable for being energized and deenergized at least 700 times per year.
2. **WATT LOSS:** The dielectric watt loss at rated voltage, 60 Hz, and at unit case temperature of 25°C shall not exceed 0.20 watt loss per kilovar verified by loss determination tests in accordance with paragraph 5.1.3. Capacitor units exceeding 0.20 watt per kilovar are not acceptable.
3. **REACTANCE DEVIATION:** The actual kilovar of each rack shall be balanced so that the individual phase impedances of the assembled bank do not deviate more than 0.3 percent from the arithmetical average impedance of all three phases.
4. **CONSTRUCTION:** The capacitor units shall be hermetically-sealed and liquid-filled type. Each capacitor unit shall include an internal discharge device that will reduce the voltage on each unit to 50 V within 5 minutes after rated voltage has been withdrawn.

The solid dielectric of the capacitor unit packs shall be all-film dielectric.

The capacitor units shall be completely impregnated with the insulating liquid. Insulating liquids containing PCB (polychlorinated biphenyls) are not acceptable.

5. **FACTORY ASSEMBLY:** The capacitor equipment bank shall consist of units which are factory assembled and connected on racks and shall be shipped as a package ready for installation. Racks shall include ground lead connections, buses, fuse holders, insulators, and connecting material. The fuse links shall not be installed in the fuse holders during shipment. The fuse links will be installed in the fuse holders after installation at the substation site.
6. **SPARE PARTS:** Spare parts shall be furnished as specified.
7. **INSULATORS:** The insulator units shall be post type only, and in accordance with ANSI C29 and NEMA Publication No. HV1, for high-voltage insulators. Cap and pin insulators are not acceptable. The color of the insulators shall be gray. Insulators between stack racks and between the bottom stack rack and the supporting structure shall have voltage ratings not less than the actual voltage across these insulators when the capacitor equipment is operated at rated bank voltage. The insulators shall have a mechanical safety factor of at least 150 percent of the ANSI insulator mechanical strength values.

**WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

8. FUSES: Indicating-type fuses shall be provided with each individual capacitor unit. The fuses shall be capable of protecting each individual capacitor unit against rupture of the capacitor case.
9. GROUND LEAD: The ground lead shall be designed to permit removal of any one capacitor unit from the rack without disconnecting the ground lead from the other units in the rack.
10. SUPPORTING STRUCTURES: Supporting structures of structural steel or aluminum for the capacitor racks shall provide adequate isolation by elevation to meet the ANSI C2 requirement for clearances to live parts. Steel supporting structures shall be galvanized after fabrication. Galvanizing shall be in accordance with ASTM A 123 and A 153. Supporting structures shall include mounting facilities for protective relaying equipment and the separation between the frame of the bottom rack and the nearest part of the equipment shall not be less than 12 inches.
11. INSTRUMENT TRANSFORMERS: The Contractor shall provide one of the following methods of obtaining the capacitor bank voltage for the purpose of protective relaying (Unbalance Protection or Voltage Differential Protection):
 - a. The Contractor shall furnish and install three conventional voltage devices (one per phase), connected at the midpoint of the series groups of capacitors within each phase of the bank. The voltage device shall be suitable for base mounting on the capacitor bank supporting structures.
 - b. The Contractor shall furnish and install the following:
 - (1) Three low-voltage capacitors (one per phase series connected between the last series group and the capacitor bank neutral).
 - (2) Three conventional wound-type current transformers (one per phase shall be connected with the primary winding series connected to a damping resistor with the combination connected in parallel with the low-voltage capacitor, and with the current transformer secondary winding connected to the protective relay).
 - (3) Three damping resistors (one per phase shall be connected directly to the low-voltage capacitor and series connected to the primary of the current transformer as described above).
12. TERMINALS: Terminals shall be standard 4-hole line terminal pads conforming to the requirements of NEMA CC1.

5.1.3 TESTS:

1. DESIGN TESTS: The Contractor shall furnish test reports that certify that each type, design, size, and rating capacitor unit furnished meets the following test requirements of ANSI/IEEE Standard 18, paragraph 7.1.2:
 - a. Dielectric withstand test.
 - b. Impulse withstand test.
 - c. Bushing tests.
 - d. Thermal stability test.
 - e. Radio influence voltage test.
 - f. Voltage decay test.
2. PRODUCTION TESTS: The Contractor shall perform production tests on each capacitor unit in accordance with ANSI/IEEE Standard 18, paragraph 7.1.1:
 - a. Short time over voltage test.

**WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

- b. Capacitance test.
- c. Leak test.
- d. Discharge resistor test.
- e. Loss determination test.

The production test reports shall include for each capacitor its serial number and data for the above tests.

3. **POTENTIAL (VOLTAGE) TRANSFORMER TESTS:** Each potential transformer shall be tested in accordance with ANSI C57.13. Test instrument requirements shall be in accordance with ANSI C39.1 and 0.25 percent accuracy.

a. Dielectric Tests:

- (1) Applied potential on high- and low-voltage windings at 50 Hz for 72 seconds or 60 Hz for 60 seconds.
- (2) Induced potential.

b. Standard Application Data at 60 Hz: Except as modified herein, data shall be furnished in accordance with ANSI C57.13, paragraph 7.8. Ratio correction factor (RCF) and phase angle curves shall be determined by actual test conducted in accordance with any of the methods described in ANSI C57.13, paragraph 8.1.6, and those power factors and zero burden to the maximum volt ampere listed in the following table which are included in the burden-accuracy class of the voltage devices furnished.

The RCF and phase angle for the standard burdens and for the same numerical burdens but at unity power factor, from zero burden to the maximum volt ampere of the transformer, shall be plotted on the above curves. Typical curves and data will be accepted if they were prepared from actual test performed on identical transformers.

Burden Accuracy Class of 0.3 Percent	Maximum Burden Volt-Amperes	One curve required from zero to maximum burden in accuracy; Rating at each of the following power factors
W, X, Y, Z	200.0	0.10, 0.70, 0.85, and 1.0

4. **CURRENT TRANSFORMER TESTS:** Each current transformer shall be tested in accordance with ANSI C57.13. Test instrument requirements shall be in accordance with ANSI C39.1 for 0.25 percent accuracy.

a. Dielectric Test:

- (1) Applied potential at 50 Hz for 72 seconds or 60 Hz for 60 seconds.
- (2) Induced potential.

b. Mechanical Thermal Ratings: Mechanical short-circuit and thermal rating tests shall be performed in accordance with ANSI C57.13 if certifications confirming the requirements of the ratings are not available for current transformers of the same type and design required by these specifications. Verification of the thermal rating by calculation (in accordance with ANSI C57.13, paragraph 8.6.2) will be accepted in lieu of testing.

c. Standard Application Data at 60 Hz: Except as modified herein, standard application data shall be furnished in accordance with ANSI C57.13, Section 6.10. Typical curves and data for

WAPA ES 5.1 STANDARD SPECIFICATIONS SHUNT CAPACITOR BANKS

ratio-correction-factor and phase-angle data and curves for the metering accuracy type current transformers will be acceptable if prepared from actual test performed on identical transformers. The Contractor shall certify the data and shall furnish it in both tabulated and curve form. If double-secondary transformers are furnished, the same tests and data are required for each secondary. Accuracy required is T 200.

5. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on the equipment nameplates. A seismic report is not required for the low seismic performance level.

5.1.4 PAINTING: After fabrication, the Contractor shall clean and paint the equipment with the manufacturer's standard cleaning and painting system. Coated surfaces shall be protected from abrasion or other damage at all times. Surfaces not to be painted shall be protected by appropriate masking during the cleaning and painting of adjacent metalwork.

5.1.5 ELECTRICAL DRAWINGS AND DATA:

1. GENERAL: Drawings with and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and Western's equipment standards. The design of electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting requirements or for correctness of drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 5.1.5 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Insulating liquid PCB certification	4.d.	Prior to shipment of equipment	Certified Data	6
Equipment test reports	4.e.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:

- a. Outlines, dimensions, and weights of equipment and associated support structure.
- b. Base type, dimensions, and mounting details.
- c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
- d. Orientation of all equipment and a complete anchor bolt setting plan.
- e. Seismic qualification report.

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. Outline drawings of the assembled equipment, including plan, elevation and cross-section, showing:
 - (1) Dimensions.
 - (2) Location of connections to the capacitor equipment.
 - (3) Weight of the individual multi-unit racks.

**WAPA ES 5.1 STANDARD SPECIFICATIONS
SHUNT CAPACITOR BANKS**

- (4) Total weight of the assembled racks, including insulators and bus.
- b. Detail drawing of bank bus and electrical connections.
- c. Circuit diagram showing main and accessory circuits.
- d. Outline drawing of each type of capacitor furnished showing dimensions, weight, bushing details, and terminal connectors.
- e. Outline drawing of instrument transformers, including mounting dimensions, location of terminals, polarity, weight, nameplate and connection diagram.
- f. Coordination curves and information which verifies that the fuses will protect and operate within the safe zone for capacitor cases to prevent rupture.
- g. Insulator outline drawings and data for each type of insulator supplied.
- h. Fuse mounting details and data for each type of fuse furnished.

These informational drawings shall be sufficiently complete to allow Western to prepare final designs and installation drawings. The supplier's drawings shall specifically verify compliance with the equipment requirements and be sufficiently complete to allow preparation of final installation drawings being prepared by others.

- 4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
 - a. Final Drawings for the Equipment: Final drawings shall be furnished, rolled or flat, but not to be folded. Drawings shall be printed on quality bond paper; be full size; and be clear, sharp, and legible. The drawings shall show all changes, and revision dates therefore, made up to the time the drawings and data are furnished. Final drawings shall include the following:
 - (1) Outline drawings of the assembled equipment, including plan, elevation and cross-section, showing:
 - (a) Dimensions.
 - (b) Location of connections to the capacitor equipment.
 - (c) Weight of the individual multi-unit racks.
 - (d) Total weight of the assembled racks, including insulators and bus.
 - (2) Detail drawing of bank bus and electrical connections.
 - (3) Circuit diagram showing main and accessory circuits.
 - (4) Outline drawing of each type of capacitor furnished showing dimensions, weight, bushing details, and terminal connectors.
 - (5) Outline drawing of instrument transformers, including mounting dimensions, location of terminals, polarity, weight, nameplate and connection diagram.
 - (6) Coordination curves and information which verifies that the fuses will protect and operate within the safe zone for capacitor cases to prevent rupture.
 - (7) Insulator outline drawings and data for each type of insulator supplied.
 - (8) Fuse mounting details and data for each type of fuse furnished.

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- (9) Nameplate drawing.
 - b. Sets of Parts Identification Lists or Bills of Materials: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the electrical equipment above and for each device appurtenant to the equipment. A print of each final drawing, as requested above, shall be included with instructions.
 - d. Insulating Liquid Certification: Certification shall be furnished showing that insulating liquids used in equipment do not contain more than 2 parts per million of polychlorinated biphenyls.
 - e. Test Reports for Outdoor Equipment: Prior to shipment of electrical equipment, the Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.
5. RIGHT TO USE CONTRACTOR'S DRAWINGS: The Government expressly reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under these specifications; and
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with the Government shall constitute a license to the Government to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 6.1
VOLTAGE TRANSFORMERS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 6.1 STANDARD SPECIFICATIONS
VOLTAGE TRANSFORMERS**

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**WAPA ES 6.1 STANDARD SPECIFICATIONS
VOLTAGE TRANSFORMERS**

6.1.1 GENERAL: Outdoor, wound-type voltage transformers shall be in accordance with ANSI C57.13 and NEMA where applicable. The transformers shall be suitable for base mounting. Only new equipment of current manufacture shall be furnished.

6.1.2 MATERIAL AND SPECIFICATIONS:

1. **PORCELAIN PARTS:** For voltage transformers furnished with porcelain parts, porcelain shall be wet process, homogeneous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burns, and other defects. The color of the porcelain shall be gray.

Porcelain parts of each voltage transformer shall be of one piece when rated below 450-kV BIL.

When rated at 450-kV BIL and above, porcelain parts of each voltage transformer may be constructed of one piece or of multiple parts provided the multiple parts are assembled by one of the following methods:

- a. By flanged segments;
 - b. By placing firing material in the joints between the segments and the entire porcelain part fired in one piece; or
 - c. By securely holding the parts together with a clamping device through the centerline of the bushing. The joint must be at right angles to the longitudinal centerline of the bushing if this method is used.
2. **CONSTRUCTION:** Voltage transformers shall be constructed of a nontracking insulation such as molded butyl rubber or molded epoxy resin suitable for outdoor use or shall be of the oil-filled type as specified. Voltage transformers shall be completely factory sealed to prevent breathing and absorption of moisture. Expansion tanks external to the main tanks will not be acceptable.
 3. **ACCESSORIES:** The liquid-filled voltage transformers shall be provided with drain and filling valves or plugs and with liquid level gauges or indicators. Any glass through which oil can be exposed to sunlight shall be capable of filtering out those sunrays that cause oil deterioration.
 4. **INSULATING LIQUID:** If insulating liquid-filled voltage transformers are furnished, the insulating liquid used shall be the manufacturer's standard product. The insulating liquid shall not contain polychlorinated biphenyls (PCB.) The unit shall be permanently marked and certification furnished to certify that there are no more than 2 parts per million PCB present when the unit is delivered to Western.
 5. **TERMINALS:** Line terminals shall be NEMA CC1 standard 4-hole terminal pads. A grounding terminal shall be provided which is suitable for connecting from No. 2 AWG up to No. 400-kcmil copper cable.

6.1.3 TESTS: Each voltage transformer shall be tested in accordance with ANSI C57.13. Test instruments requirements shall be in accordance with ANSI C39.1 for 0.25-percent accuracy.

1. **DIELECTRIC TESTS:**

- a. Applied potential on high- and low-voltage windings at 50 Hz for 72 seconds or 60 Hz for 60 seconds.
- b. Induced potential.
- c. **Impulse Test on Primary Winding:** Each voltage transformer shall be tested in accordance with ANSI C57.13, paragraph 8.8.5. Certified impulse test reports will be accepted if they were prepared from actual tests performed on identical transformers.

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- d. Wet 60-Hz 10 Seconds Withstand Test: Bushings shall be tested in accordance with ANSI C57.19. Certified test reports will be accepted if they were prepared from actual tests performed on identical transformers.
 - 2. MECHANICAL RATINGS: Mechanical tests shall be performed in accordance with ANSI C57.13, paragraph 8.6.1. Certified test reports will be accepted if they were prepared from actual tests performed on identical transformers.
 - 3. STANDARD APPLICATION DATA at 60 Hz: Data shall be furnished in accordance with ANSI C57.13, paragraph 7.8. Ratio correction factor (RCF) and phase angle curves shall be determined by actual test conducted in accordance with any of the methods described in ANSI C57.13, paragraph 8.1.6. Typical curves and data will be accepted if they were prepared from actual tests performed on identical transformers.
 - 4. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on equipment nameplate. A seismic report is not required for the low seismic performance level.
- 6.1.4 PAINTING:** After fabrication, the equipment shall be cleaned and painted in accordance with the manufacturer's standard cleaning and painting system. The color shall be ANSI No. 70 light gray for painted surfaces.

6.1.5 DRAWINGS AND DATA:

- 1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 6.1 STANDARD SPECIFICATIONS
VOLTAGE TRANSFORMERS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 6.1.5 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Insulating liquid PCB certification	4.d.	Prior to shipment of equipment	Certified Data	6
Equipment test reports	4.e.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions, and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
 - d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report.

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data:
 - a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

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VOLTAGE TRANSFORMERS**

4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. Final Drawings for the Equipment: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper, be full-size; and be clear, sharp, and legible.

Final drawings shall include the following:

- Outlines.
- Schematic and wiring diagrams.
- Nameplate.

- b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part of the appropriate outline drawing.
- c. Sets of manufacturer's instructions or pamphlets covering installation, operation, and maintenance repair for the equipment and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
- d. Insulating Liquid Certification: Prior to delivery of oil-filled equipment, certification shall be furnished showing that insulating liquids used in the equipment contain no polychlorinated biphenyls.
- e. Test Reports for Outdoor Equipment: Prior to shipment test reports required for the electrical equipment shall be furnished prior to shipment of the equipment. The Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment, which does not successfully pass the testing requirements, will be rejected.

5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:

- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
- b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 6.2
CURRENT TRANSFORMERS



DECEMBER 2000



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WAPA ES 6.2 STANDARD SPECIFICATIONS CURRENT TRANSFORMERS

6.2.1 GENERAL: Current transformers shall be in accordance with this standard and applicable ANSI C57.13 and NEMA. In the event of contradictory requirement, the requirements of these specifications shall prevail. Wound-type transformers shall be for base mounting. Double-ratio current transformers may be of the series-parallel primary or tapped-secondary type. If tapped-secondary-type is furnished, the transformer shall be capable of meeting specified accuracy requirements when operating from either the full secondary winding or the tap position. Wound-type current transformers (other than bar-type primary) shall be equipped with primary bypass devices for protecting the windings from high-voltage surges.

Bushing current transformers shall be multi-ratio type. Turns between any two taps shall be uniformly distributed along the entire core and arranged so that every 20 or 40 turns are fully distributed.

Only new equipment of current manufacture shall be furnished.

6.2.2 MATERIAL AND SPECIFICATIONS:

1. **THERMAL AND MECHANICAL RATINGS:** The short time thermal and mechanical current ratings of wound-type current transformers, in accordance with American National Standard, shall be not less than specified. For transformers with series-parallel primary these ratings shall apply to the series connection).
2. **BUSHING AND PORCELAINS:** Porcelains shall be wet process, homogeneous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burns, and other defects. The color of the porcelain shall be gray.

Porcelain parts of each voltage transformer shall be of one piece when rated below 450-kV BIL.

When rated at 450-kV BIL and above, porcelain parts of each voltage transformer may be constructed of one piece or of multiple parts provided the multiple parts are assembled by one of the following methods:

- a. By flanged segments;
 - b. By placing firing material in the joints between the segments and the entire porcelain part fired in one piece; or
 - c. By securely holding the parts together with a clamping device through the centerline of the bushing. The joint must be at right angles to the longitudinal centerline of the bushing if this method is used.
3. **CONSTRUCTION:** The current transformers shall be constructed of a nontracking insulation such as molded butyl rubber or molded epoxy resin suitable for outdoor use or shall be of the oil-filled type as specified. Current transformers shall be completely factory sealed to prevent breathing and absorption of moisture.

Current transformers of the series-parallel primary type shall be designed and constructed so the series-parallel connections of the primary windings can be changed external to the case without opening or disturbing the main case.

Expansion tanks external to the main tanks will not be acceptable.

4. **ACCESSORIES:** Liquid-filled current transformers shall be provided with drain valves or plugs and with liquid-level gauges or indicators. Glass through which oil can be exposed to sunlight shall be capable of filtering out those sunrays that cause oil deterioration.

WAPA ES 6.2 STANDARD SPECIFICATIONS CURRENT TRANSFORMERS

5. SERVICE CONDITIONS: Seismic, wind, and unusual temperature or elevation conditions shall be as specified.
 6. INSULATING LIQUID: The insulating liquid shall be the manufacturer's standard product. The liquid shall not contain PCB. Each current transformer unit shall be permanently marked and certification furnished to certify that there are no more than 2 parts per million PCB present in the insulating liquid when the unit is delivered to Western.
 7. TERMINALS: Line terminals shall be NEMA standard line 4-hole terminal pad conforming to the requirements of NEMA CC1. A grounding terminal shall be provided which is suitable for connecting from No. 2 AWG up to 400 kcmil copper cable.
- 6.2.3 TESTS:** Each current transformer shall be tested in accordance with ANSI C57.13. Test instrument requirements shall be in accordance with ANSI C39.1 for 0.25 percent accuracy.
1. DIELECTRIC TEST:
 - a. Applied potential at 50 Hz for 72 seconds or 60 Hz for 60 seconds.
 - b. Induced potential.
 2. MECHANICAL THERMAL RATINGS: Mechanical short-circuit and thermal rating tests shall be performed in accordance with ANSI C57.13 if certifications confirming the requirements of the ratings are not available for current transformers of the same type and design required by these specifications. Verification of the thermal rating by calculation (in accordance with ANSI C57.13, paragraph 8.6.2) will be accepted in lieu of testing.
 3. STANDARD APPLICATION DATA AT 60 HZ: Except as modified herein, standard application data shall be furnished in accordance with ANSI C57.13, Section 6.10. Typical curves and data for ratio-correction-factor and phase-angle data and curves for the metering accuracy type current transformers will be acceptable if prepared from actual test performed on identical transformers. The manufacture shall certify the data and shall furnish it in both tabulated and curve form. If double-secondary transformers are furnished, the same tests and data are required for each secondary.
 4. IMPULSE TESTS ON PRIMARY WINDINGS: Each current transformer shall be tested in accordance with ANSI C57.13 paragraph 8.8.5. Certified impulse test reports will be accepted if they were prepared from actual tests performed on identical transformers.

If impulse tests are required, a Government inspector shall witness them. All copies of oscillograms shall be furnished as clear positive film transparencies.
 5. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on equipment nameplates. A seismic report is not required for the low seismic performance level.
- 6.2.4 PAINTING:** After fabrication, the current transformers shall be painted ANSI 70 (gray) in accordance with manufacture's standard cleaning and painting system. The cleaning and painting system shall provide a minimum of 10 years corrosion-free protection.
- 6.2.5 ELECTRICAL DRAWINGS AND DATA:**
1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

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CURRENT TRANSFORMERS**

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and Western's equipment standards. The design of electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting requirements or for correctness of drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 6.2.5 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Insulating liquid PCB certification	4.d.	Prior to shipment of equipment	Certified Data	6
Equipment test reports	4.e.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

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CURRENT TRANSFORMERS**

2. **INSTALLATION DRAWINGS AND DATA:** The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
 - d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report.

3. **INFORMATIONAL DRAWINGS AND DATA:** The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
 - a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

4. **FINAL DRAWINGS AND DATA:** The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
 - a. **Final Drawings:** The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished. Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible. Final drawings shall be furnished and shall include the following:
 - Outlines of equipment and support structures when furnished.
 - Wiring and schematic diagrams.
 - Nameplates.
 - b. **Sets of Parts Identification Lists or Bills of Materials:** Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. **Sets of manufacturer's instructions** covering installation, operation, and maintenance repair for the electrical equipment above and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. **Insulating Liquid Certification:** Certification shall be furnished showing that insulating liquids used in equipment do not contain more than 2 parts per million of polychlorinated biphenyls.
 - e. **Test Reports for Outdoor Equipment:** Prior to shipment, after completion of tests required on electrical equipment, the Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.

**WAPA ES 6.2 STANDARD SPECIFICATIONS
CURRENT TRANSFORMERS**

5. **RIGHT TO USE THE CONTRACTOR'S DRAWINGS:** Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following.
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION – ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 6.3

COUPLING CAPACITOR VOLTAGE TRANSFORMERS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 6.3 STANDARD SPECIFICATIONS
COUPLING CAPACITOR VOLTAGE TRANSFORMERS**

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**WAPA ES 6.3 STANDARD SPECIFICATIONS
COUPLING CAPACITOR VOLTAGE TRANSFORMERS**

6.3.1 GENERAL: Except as stated herein, Coupling Capacitor Voltage Transformers (CCVT) shall be in accordance with latest ANSI C93.1 and NEMA where applicable. CCVT's shall be for base mounting and shall be suitable for connection to high-voltage power circuits between line and ground. Only new equipment of current manufacture shall be furnished.

6.3.2 MATERIAL AND SPECIFICATIONS:

1. **BUSHINGS AND PORCELAINS:** Porcelains shall be wet process, homogeneous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burns, and other defects. The color of the porcelain shall be gray.

Porcelain parts of each voltage transformer shall be of one piece when rated below 450-kV BIL.

When rated at 450-kV BIL and above, porcelain parts of each voltage transformer may be constructed of one piece or of multiple parts provided the multiple parts are assembled by one of the following methods:

- a. By flanged segments;
 - b. By placing firing material in the joints between the segments and the entire porcelain part fired in one piece; or
 - c. By securely holding the parts together with a clamping device through the centerline of the bushing. The joint must be at right angles to the longitudinal centerline of the bushing if this method is used.
2. **CONSTRUCTION:** The oil-filled part of oil-filled type CCVT's shall be completely factory sealed to prevent breathing and absorption of moisture. The base housing shall be of weatherproof construction.
 3. **VOLTAGE TRANSFORMER:** The voltage transformer shall consist of factory-adjusted elements mounted in the base housing of CCVT's. The burden watts, burden power factor, voltage ratio, and phase angle shall be factory adjusted.
 4. **SECONDARIES:** Each coupling voltage transformer shall have two electrically separate secondaries, each capable of supplying voltage at both marked ratios and also a tertiary secondary when specified.
 5. **CARRIER ACCESSORIES:** When specified, furnish CCVT's with carrier accessories consisting of a drain coil, choke coil, grounding switch and gap, carrier lead in bushing, and carrier lead-in cable. When specified, the CCVT's shall be furnished with a wide band carrier filter.
 6. **SAFETY DEVICES:**
 - a. **Potential Grounding Switch:** Provide a potential grounding switch between the capacitor divider intermediate voltage circuit and ground. The switch shall be operable by a hook stick from ground elevation without opening the base housing of the coupling capacitor voltage transformer.
 - b. **Ground Terminal:** Provide on the base of the CCVT's a ground terminal, suitable for connecting from No. 2 AWG up to No. 400-kcmil copper cable.
 - c. **Carrier Ground Switch:** When carrier accessories are specified, provide between the capacitor low-voltage terminal and ground, a carrier grounding switch which may be used to short-circuit the carrier lead. The switch shall be operable by a hook stick from ground elevation without opening the base housing of the coupling capacitor voltage transformer.

WAPA ES 6.3 STANDARD SPECIFICATIONS COUPLING CAPACITOR VOLTAGE TRANSFORMERS

- d. Carrier Protective Gap: When carrier accessories are specified, a protective gap, set for flash over at not more than 2.5 kV, rms at power frequency, shall be provided between the low-voltage terminal and ground to prevent voltage surges across the carrier lead-in conductor.
 - e. Terminals: Line terminals shall be NEMA standard line 4-hole terminal pad conforming to the requirements of NEMA CC1.
7. INSULATING LIQUID: The insulation liquid shall be the manufacturer's standard product. The liquid shall not contain PCB. The unit shall be permanently marked and certification furnished to certify that there are no more than 2 parts per million PCB present when a unit is delivered to Western.
- 6.3.3 TESTS:** Each coupling capacitor voltage transformer shall be tested in accordance with ANSI C93.1. Test instrument requirements shall be in accordance with ANSI C39.1 for 0.25 percent accuracy.
1. PRODUCTION TESTS: Perform the following production tests on each coupling capacitor voltage transformer:
- a. Capacitance and dissipation factor.
 - b. Dielectric.
 - c. Accuracy.
 - d. Polarity.
 - e. Protective gap setting.
- 6.3.4 PAINTING:** CCVT's shall be painted by the manufacturer's standard ANSI 70 (gray), cleaning and shop-applied permanent paint system. The paint system shall provide a minimum of 10 years corrosion-free protection.
- 6.3.5 SEISMIC QUALIFICATION:** When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on nameplates. A seismic report is not required for the low seismic performance level.
- 6.3.6 ELECTRICAL DRAWINGS AND DATA:**
1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and Western's equipment standards. The design of electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting requirements or for correctness of drawings. Revised drawings

**WAPA ES 6.3 STANDARD SPECIFICATIONS
COUPLING CAPACITOR VOLTAGE TRANSFORMERS**

shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 6.3.6 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
*Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Insulating liquid PCB certification	4.d.	Prior to shipment of equipment	Certified Data	6
Equipment test reports	4.e.	7 days prior to shipment of equipment	Certified Data	6

*Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions, and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
 - d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report.

**WAPA ES 6.3 STANDARD SPECIFICATIONS
COUPLING CAPACITOR VOLTAGE TRANSFORMERS**

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
 - a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.

4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
 - a. Final Drawings: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished. Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible. Final drawings shall be furnished and shall include the following:

Outlines of equipment including support structures when furnished.
Schematic diagrams.
Nameplates.
 - b. Sets of Parts Identification Lists or Bills of Materials: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing,
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the electrical equipment above and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. Insulating Liquid Certification: Certification shall be furnished showing that insulating liquids used in equipment do not contain more than 2 parts per million of polychlorinated biphenyls.
 - e. Test Reports for Outdoor Equipment: Prior to shipment of electrical equipment, the Contractor shall furnish certified copies of test reports, performance curves, and data. Copies of oscillograms shall be furnished as clear positive film transparencies. Any equipment that does not successfully pass the testing requirements will be rejected.

5. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
 - a. Installation, maintenance, replacement, and repair of the articles to be furnished under the specifications and these standards.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 8.1
DISCONNECT AND INTERRUPTER SWITCHES



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

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**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

8.1.1 GENERAL: This standard is for outdoor disconnect and/or interrupter switches as specified in the bidding item descriptions. Disconnecting switches (including selector switches) and interrupter switches shall be furnished in accordance with the applicable parts of these specifications, and except as specified herein, shall be manufactured and tested in accordance with applicable NEMA publication No. SG6 for Power Switching Equipment, applicable ANSI C37-30 thru ANSI C37-38, and IEEE C37.34. Only new equipment of current manufacture shall be furnished.

8.1.2 MATERIAL:

1. SWITCHING DUTY: Switches shall be capable of performing the specified duties. No restrike will be permitted under any interrupting requirements. (Note: A restrike is defined as any current conduction between main contacts following an interval of one-fourth cycle or more duration.)
2. SWITCH POLE CONSTRUCTION (GROUP-OPERATED SWITCHES): Switches shall be suitable for the specified ratings.
 - a. Contacts: Main blade and grounding switch contacts shall be self-aligning, self-wiping contacts. Fixed contacts shall be backed by stainless steel, beryllium copper leaf springs, or be of the reverse current loop shape which eliminates contact burning under fault conditions. Current-carrying path shall not be through any spring. If the current path is through a moving pin, means shall be provided to maintain continuous positive contact pressure on the pin. The shape and material used for contacts shall be such that there will be no galling of contact metals when switch is subjected to 1,000 close/open operations.
 - b. Main Switch and Grounding Blades: The blades shall be of hard-drawn copper or aluminum alloy for carrying the specified continuous and short-time currents. Stops, if required on the individual poles, shall be furnished as described in section 3) below. If the blades are attached to castings, the blades and castings shall be connected by welding or by a bolted clamp. A press fit between blade and casting is not acceptable. Main blades of switches shall be counterbalanced to prevent them from falling closed from any position. If spiral springs are used on the hinge end of switch for counterbalancing, the housing shall be designed so that ice cannot build up on spring to impair switch operation. Pressed fits joints shall not be subjected to spring pressure during any part of a switch operation.

The movement of manually group-operated grounding blades shall be in a plane parallel to the main blades. Except for V-type switches, the tip of blades when in the open position shall not extend beyond the base of the switch in a direction parallel to the main blades.

- c. Hinge- and Clip-End Assemblies: Pole unit castings shall be of bronze or aluminum alloy. Bearings in the hinge-end operating levers shall be of the ball, roller, Oilite®-sleeve, plastic, or ball-and-socket type. Bearings shall be firmly fixed in place and shall not require replacement or maintenance before performing at least 1,000 operations. Stops shall be provided in the clips-ends of vertical-break switches, and the switch adjustments shall provide for blades to rest against the stops in the closed position.
- d. Rotating Insulator Bearings: Bearings for the rotating insulator stacks shall be of the tapered-roller or double-ball type. If of the latter type, the bearings shall be of the combination radial and thrust type. Bearings shall be provided with a readily adjustable take-up adjustment.
- e. Bases: The bases of switches shall be of metal members of sufficient stiffness to prevent excessive deflection when mounted and operated on supporting structures. Lattice-girder-type bases will not be permitted. Steel material required for the bases shall be galvanized.
- f. Bearings: Ball or roller bearings shall be the sealed, permanently lubricated type or of the type that does not require lubrication, with stainless steel balls or rollers and races.

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DISCONNECT AND INTERRUPTER SWITCHES**

- g. Construction of Interrupter Switches: The interrupter unit of interrupter switches shall be of the type that confines the arc in an enclosed arcing chamber. If of the oil type, each unit shall be furnished complete with oil, a liquid level gauge, and provisions for filling, draining, and sampling the oil. If of the gas-filled type, each unit shall be furnished with a gas-pressure indicator visible from the ground which will indicate when gas pressure decreases to a point where further loss would impair interrupting performance.
 - h. Assembly: Each pole of each switch without insulators shall be completely assembled at the factory for shipment.
3. OPERATING MECHANISMS (GROUP-OPERATED SWITCHES): Operating mechanisms shall effect a smooth, thoroughly controlled movement throughout the entire opening and closing cycles and all rods, shafts, pipe linkages, connectors, operating levers, supports, and fittings shall show no noticeable deflection. Cable connections in lieu of rigid interphase rods are not acceptable. Means shall be provided on each switch for taking up loose motion in each part of the mechanism and for adjusting the travel of each blade independently. The design of the mechanism shall be such that the main blades are positively toggled when in the fully open or fully closed position. Each switch shall be equipped with adjustable stops for the open and closed positions. The closing stops shall position each blade such that maximum contact pressure will be achieved between the moving and the fixed contacts. When the switch is in the fully closed position, the hinge- and clip-end contacts on each side of the main blades shall be horizontal within plus or minus 5° for vertical-break switches. If stops are required on each pole to meet this limitation, individual, adjustable stops shall be furnished. With the closing stops adjusted for proper closed position of each blade, the three blades of each switch, when fully open, shall conform in position within 5° of the manufacturer's specified open position. The stop adjustment method shall include means, such as by jam nuts or piercing set screws, to prevent unintentional change in the adjustment.

Embossed- or stamped-metal indicators shall be provided on the vertical operating rod showing when the switch is open or closed. The indicators shall be approximately 7 1/2 inches high and 1 1/2 inches wide, the "closed" indicator painted red and the "open" indicator painted green. The indicators shall be mounted at normal eye level and positioned so that the appropriate indicator directly faces the operator when he is in a normal position for operating the switch. If an auxiliary icebreaking handle is furnished, the open-close indicator shall be located above the disconnecting coupling in the vertical operating rod.

Provisions shall be included for locking the switch in either the open or closed position. The outboard or offset bearing of each mechanism shall include: a cast-metal or fabricated steel housing and crank arm, a steel shaft, and either ball or roller bearing.

- a. Manually Group Operated: The length of lever-type operating handles, when furnished shall not exceed 3 feet 0 inch. The force required to operate any manual mechanism shall not exceed 50 pounds. Manually operated main blades, including those using gear mechanisms, shall be capable of being opened and closed under icing conditions when specified, and this capability shall be demonstrated by the ice tests specified in section 8.1.3, paragraph 1.(3). If auxiliary swing handles are required to perform as required under the ice tests, one such handle shall be furnished with each switch. The auxiliary handle shall be readily attachable and detachable and the gearbox disengaged by a method other than removal of driven pins or setscrews when the switch is operate by the icebreaking handle.

The attachment point of operating handles to control rod or pipe and of cranks to operating mechanisms shall be at 40 inches above bottom of the base-supporting structure.

Provisions shall be included for locking the switch in either the open or closed position. The outboard or offset bearing of each mechanism shall include: a cast metal or fabricated steel housing and crank arm a steel shaft, and either ball or roller bearing.

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

- b. Motor Operated: Each 3-pole motor operated switch shall be operated by one motor for use in operating all three phases simultaneously. The switches shall be operable by local and remote electrical control and by manual handle. Limit switches shall be provided to prevent over travel. During operation of a disconnecting switch, the control shall keep the motor loaded continuously to prevent the mechanism from alternately leading and lagging the motor.

The motor and control circuits shall operate from the voltage available at the motor operator, considering conductor voltage drop. Unless specified otherwise, the motor and control voltage is the 125-V dc battery that has a voltage range of 105 to 140 V at the battery terminals. The electric control shall be completely wired.

Motor-operated switches shall be capable of being opened by their motor under ice conditions and this capability shall be demonstrated by the ice test specified in section 8.1.3, paragraph 1.(3). It is desirable that the switches be capable of also being closed by the same mechanism under the iced conditions. However, closing by manual means under iced conditions will be permitted, provided that a readily attachable manual handle is furnished and means provided for easily detaching the motor mechanism.

Indication of the disconnecting switch position shall be readily visible from the ground, and means of preventing false indication if the blade fails to complete the opening or closing operation shall be furnished. A manual handle socket shall be permanently installed, and handle furnished, with means of disengaging the motor mechanism by movement of the manual handle.

The following features shall be included:

- (1) Local control "OPEN", "CLOSE", and "STOP" switches.
- (2) Local-Remote [Device 43] Selector Switches: Each mechanism shall be equipped with a separately mounted, manually-operated, "Local-Remote" selector switch. Each "Local-Remote" switch shall be furnished with the following minimum numbers of electrically separate contacts wired in the control circuits or to outgoing terminal blocks are required:
 - (a) A minimum of six contacts that close in the "Remote" and open in the "Local" position to disconnect the following circuits:
 - 1) One contact in the remote closing circuit.
 - 2) One contact in the remote opening circuit (including remote red lamp). One contact for each opening coil.
 - 3) One contact wired to the "b" contact for the remote green lamp.
 - 4) One contact wired to the auxiliary switch "a" and "b" contacts provided for supervisory control (Scada) position indication. One "a" contact and one "b" contact shall be wired together at one end, and that end connected to the "Remote" contact, allowing the "Remote" contact to disconnect both the "a" and "b" contacts.*

* The "a" and "b" contacts are the auxiliary switches required by section 6. below.
 - 5) Two contacts for future use, wired to external terminal block points.

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

- (b) A minimum of four contacts that close in the “Local” and open in the “Remote” position:
 - 1) One connected to the local close switch.
 - 2) One connected to the local open switch.
 - 3) Two contacts for future use, wired to external terminal block points.
 - (c) A fused knife switch, readily detachable fuse clip assembly, or circuit breaker shall be installed in each cabinet as over current protection and disconnect device for the cabinet heaters, convenience outlet and the motor power circuit.
 - (d) Provide form “C” loss-of-voltage/under voltage alarm contacts to indicate loss of dc and ac control, heater, and motor voltage at the load side of any local fused-knife disconnect switches, detachable fuse clip assembly, or circuit breakers. Separate alarms shall be provided for ac and dc circuits. The ac alarm shall have a time delay of approximately 10 seconds.
 - (e) Operation Counters (Motor Operated Interrupter Switches): Each motor-operated interrupter switch shall be furnished with an electric operation counter mounted inside the cabinet. The counter shall have a minimum 3-digit readout and shall register once for each complete open-and-close cycle.
 - (f) Outlet: Each motor-mechanism cabinet shall contain a convenience outlet. The outlet shall be weatherproof, separately fused, 20 amps, 125 V, 2 pole, 3 wire, polarized duplex, grounded with a built-in ground-fault interrupter. The outlet shall have provisions for test and reset of the ground-fault interrupter. The outlet shall be Pass & Seymour/Legrand Catalog No. 2091, or equal, and mounted so it shall be available for use from outside the cabinet without opening the cabinet door.
 - (g) Cabinet heaters shall be for use on a 230-V, single-phase, ac power supply and be thermostatically controlled. The heaters shall have guards to protect personnel from burns and electrical shock.
4. **SUPPLEMENTAL STEEL MEMBERS:** The Contractor shall furnish supplemental steel members required to secure the switch-operating mechanism to the switch-supporting structure without drilling any tubular member in the supporting structure. The steel members required for mounting the operating handle or gearbox assembly for the switches shall extend the full length of lattice steel supporting structure and shall not be terminated on an intermediate bracing member.
5. **GALVANIZING:** Exposed steel material required for the operating mechanisms and supplemental steel members required to secure the mechanisms to the supporting structures shall be galvanized.
6. **AUXILIARY SWITCHES:** When specified, switches shall be equipped with an auxiliary switch or the equivalent thereof having at least 10 independent single-pole auxiliary switches which can be changed readily to “Circuit opening” or “Circuit closing”. These switches are for use by Western and are in addition to those used by the manufacturer for the motor operator control scheme. Each auxiliary switch shall be mechanically actuated by the operating mechanism of its associated switch and shall follow the position of the switch. Each set of auxiliary switches shall be mounted in a weatherproof metal housing with a conduit entrance for 1 1/2-inch rigid conduit. Auxiliary switches shall be insulated for 600 V, have contacts with a minimum continuous current rating of 10 amps, be readily adjusted without disassembly (either continuously or in not greater than 15° increments) from “circuit opening” to “circuit closing”, and have an interrupting capacity in an inductive circuit of at least 2 amps at 125 V dc and 20 amps at 120 V ac.

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DISCONNECT AND INTERRUPTER SWITCHES**

The furnishing of 16 nonadjustable and two adjustable single-pole auxiliary switches is an acceptable equivalent to furnishing the 10 adjustable single-pole auxiliary switches described above.

7. **INSULATORS:** Unless otherwise specified, all insulators shall be gray in color and in accordance with ANSI Standards C29 and/or NEMA publication No. HV1 for high-voltage insulators.
8. **OPERATING MECHANISM BONDING (GROUP-OPERATED SWITCHES):** A copper braid shall be furnished for bonding operating mechanism to a switch-operating platform.
9. **INTERLOCKS (GROUP-OPERATED SWITCHES):** For other than interrupter switches, a mechanical interlock, arranged so the main blades grounding blades mounted on the same switch base cannot be closed at the same time, shall be provided. The mechanical interlock shall be of the type that is automatically positioned by the relative positions of the operating mechanisms. For interrupter switches a key interlock shall be provided so that grounding blades cannot be closed when main blades or interrupters are closed.

Key interlocks, when specified, shall be located on vertical operating rods above disconnecting couplings for any icebreaking handles and arranged so that the grounding blades on one switch and the main blades on a separately mounted switch cannot be closed at the same time. Key shall be removable in open position only.

Electrical interlocks, when specified, shall be furnished on the operating blade mechanism of all motor operating disconnect switches. The controls of each motor operated disconnect switch shall be wired to external terminal block points to accommodate an electrical interlock with associated power circuit breakers. The electrical wiring to the external terminal block shall require at least four terminal block points, with two points needed for wiring from each of two power circuit breakers. The disconnect switches shall not be electrically operable (opened or closed) locally nor remotely unless the associated power circuit breaker is open. This would be done by using an auxiliary "b" contact from the associated power circuit breakers.

10. **TERMINALS:** Terminals shall be standard line terminal pads conforming to the requirements of NEMA CC1-1993
 11. **GROUNDING:** Grounding pads in accordance with ANSI C37.12 shall be provided. In addition, each grounding pad shall be provided with a clamp-type terminal connector suitable for No. 4/0 to 500 kcmil cable.
- 8.1.3 TESTS (GROUP OPERATED SWITCHES):** Applicable tests listed below shall be performed at the factory or other facilities available to the manufacturer. One switch of each type, voltage, and current rating furnished under these specifications shall be tested per the design tests. Design tests on switches identical to those being furnished under these specifications will be accepted. Ice testing will also be accepted on a higher-voltage-rated switch, provided the switch tested is the same in all the following respects as the switch being furnished:

- Clip- and hinge-end mechanism
- Blade material and cross section
- Interrupter unit type
- Motor operator

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

1. DESIGN TESTS: The basic design of the switch furnished shall have met the requirement of this Subdivision in tests previously performed, or the Contractor shall perform the tests specified in this Subdivision for the switch. If identical switches have been previously tested as below, the Contractor may omit tests and furnish certified copies of reports of results of such previous tests.
 - a. Mechanical Design Life Test for Interrupter Switches: The basic mechanical design of the interrupter switch and operating mechanism being furnished shall be proved by not less than 1,000 close-open operations at the factory, at recommended contact speeds. These operations shall be performed on a completely assembled 3-pole [interrupter] switch with recommended spring and contact adjustments. Certified test reports shall be furnished which shall certify that the operations were accomplished without failure of any component part and without mechanical difficulties. At the successful completion of this design test, the switch shall be capable of being brought within optimum mechanical adjustment and shall be in satisfactory mechanical condition without replacement of component parts. These tests shall be performed on an identical separate test switch for which certified test reports will be acceptable. Such tests shall not be performed on an actual switch to be furnished to Western under this or any other contract.
 - b. Temperature Rise Tests: Temperature rise test in accordance with IEEE C37.34-1994, Section 6. This test shall be performed on the main blade and components and interrupter unit of a single pole. The temperature rise test report shall include a diagram indicating the points on the switch where the temperatures are determined and the composition of the switch material, including type of plating on contact surfaces at these points.
 - c. Ice Test: Ice testing in accordance with IEEE C37.34-1994, Section 10. The test shall be a 3-pole test and shall be performed on an assembled switch including the main blades, interrupter units, and grounding blades when furnished. The switch under test shall be mounted horizontally upright. Interphase connections and connections between the group-operated switch and manual handle or power unit may be shortened to suit conditions. A switch equipped with stacked insulators may be tested with only one unit per stack except switches with ground blades shall be tested with full stacks. The switch shall be tested with the same type operating mechanism and with the use of the same type handle, gear, power unit, etc. as furnished under the contract. Hammering on the blades, operating mechanism, or pipe is not permitted during any part of this test.
2. PRODUCTION TESTS: The switches shall be subjected to and pass the manufacturer's standard production tests, which shall include:
 - a. Leak Test: Each porcelain-clad interrupter unit shall be subjected to a test to disclose leaks.
 - b. Operating Speed Test: Each interrupter unit shall be completely assembled and checked for proper operating speed.
 - c. Dielectric Test: The completely assembled control circuit shall be given a dielectric test in accordance with Industrial Control and Systems, NEMA publication No. ICS 1-109.20.
3. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on equipment nameplate. A seismic report is not required for the low seismic performance level.

8.1.4 DRAWINGS AND DATA:

1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings. Original drawings prepared under this contract will remain the property of the Contractor.

Schematic and wiring diagrams shall have graphical symbols and device function numbers conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 8.1.4 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Equipment test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

2. **INSTALLATION DRAWINGS AND DATA:** The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
- a. Outlines, dimensions and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
 - d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report, in accordance with IEEE 693.
3. **INFORMATIONAL DRAWINGS AND DATA:** The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
- a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.
4. **FINAL DRAWINGS AND DATA:** The minimum delivery time and quantity of final drawings and data are listed Table-A. The drawings and data shall include the following:
- a. **Final Drawings for the Equipment:** The drawings shall show all changes, and revision dates therefore, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible.

Final drawings shall include the following:

Outlines.
Mounting of switches and operating mechanisms.
Control and schematic wiring diagrams.
Control cabinet physical layout drawing (showing the layout of all components in the cabinet).
Nameplate drawing.
 - b. **Sets of Parts Identification Lists or Bills of Materials for the Equipment:** Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. **Sets of manufacturer's instruction books or pamphlets covering installation, operation, and maintenance repair for the equipment and for each device appurtenant to the equipment.** A print of each final drawing as required above shall be included in the instruction book.
 - d. **Test reports required for the electrical equipment shall be furnished prior to shipment of the equipment.** The Contractor shall furnish certified copies of all test reports. Any equipment which does not successfully pass the testing requirements will be rejected.

**WAPA ES 8.1 STANDARD SPECIFICATIONS
DISCONNECT AND INTERRUPTER SWITCHES**

5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 8.2
COMBINATION INTERRUPTER SWITCHES
AND FUSES



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 8.2 STANDARD SPECIFICATIONS
COMBINATION INTERRUPTER SWITCHES AND FUSES**

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WAPA ES 8.2 STANDARD SPECIFICATIONS COMBINATION INTERRUPTER SWITCHES AND FUSES

8.2.1 GENERAL: Combination interrupter switches and fuses shall be in accordance with these specifications and the applicable parts of ANSI C37.40 series, NEMA Publication Nos. SG2, and SG6. In the event of contradictory requirements, the requirements of these specifications shall prevail.

Only new equipment of current manufacture shall be furnished.

8.2.2 MATERIAL: Combination interrupter switches and fuses shall have the following features:

1. **SWITCH POLE CONSTRUCTION:** The switch shall be suitable for the ratings specified and as follows:
 - a. **Contracts:** Fixed contacts shall be backed by stainless-steel, or beryllium-copper leaf springs, or be of the reverse current loop shape which eliminates contact burning under fault conditions. The current-carrying path shall not be through any spring. If the current path is through a moving pin, means shall be provided to maintain continuous positive contact pressure on the pin. The shape and type of material used for the contacts shall be such that there will be no galling of the contact metals when the switch is subjected to 500-open plus 500-close operations.
 - b. **Switch Blades:** The blades shall be of hard-drawn copper or aluminum alloy for carrying the specified continuous and short-time currents. Stops, if required on the individual poles, shall be furnished as described in paragraph 2. below. If the blades are attached to castings, the blades and castings shall be connected by welding or by a bolted clamp. A press fit between blade and casting is not acceptable.
 - c. **Hinge- and Clip-End Assemblies:** Pole unit castings may be a bronze or aluminum alloy. Bearings in the hinge-end operating levers shall be of the ball, roller, oilite-sleeve, plastic, or ball-and-socket type. Such bearings shall be firmly fixed in place and shall not require replacement or maintenance before performing at least 500 close-open operations.
 - d. **Bases:** The bases of the switch shall be of metal members of sufficient stiffness to prevent excessive deflection when mounted and operated on a steel supporting structure. Lattice-girder-type bases will not be permitted. Steel material required for the bases shall be galvanized.
 - e. **Bearings:** Ball or roller bearings shall be of the sealed, permanently lubricated type, with stainless-steel balls or rollers and races.
2. **OPERATING MECHANISMS:** Operating mechanisms shall effect a smooth, thoroughly controlled movement throughout the entire operating and closing cycles and rods, shafts, pipe linkages, connectors, operating levers, supports, and fittings shall show no noticeable deflection. Cable connections in lieu of rigid interphase rods are not acceptable. Means shall be provided on each switch for taking up loose motion in each part of the mechanism and for adjusting the travel of each blade independently.

Each switch shall be equipped with adjustable stops for the open and closed positions. The closing stops shall position each blade such that maximum contact pressure will be achieved between the moving and the fixed contacts. When the switch is in the fully closed position, the hinge- and clip-end contacts on each side of the blades shall be horizontal within plus or minus 5°. If stops are required on each pole to meet this limitation, individual adjustable stops shall be furnished. With the closing stops adjusted for proper closed position of each blade, the three blades of each switch, when fully open, shall conform in position within 5° of the manufacturer's specified open position.

WAPA ES 8.2 STANDARD SPECIFICATIONS COMBINATION INTERRUPTER SWITCHES AND FUSES

Operating handles shall be mounted on the base-supporting structure at a height of 3 feet 4 inches, above the bottom of structure. Embossed or stamped metal indicators shall be provided on the vertical operating rod showing when the switch is open or closed. The indicators shall be approximately 7 inches high and 1 inch wide, the "closed" indicator painted red, and the "open" indicator painted green. The indicators shall be mounted at normal eye level and positioned so that the appropriated indicator directly faces the operator when the operator is in the normal position for operating the switch.

Provisions shall be included for locking the switch in either the open or closed position. The outboard or offset bearing of each mechanism shall include: a cast metal housing and crank arm, a steel shaft, and either ball or roller bearing.

- a. **Manually Group-Operated:** The length of lever-type operating handles, when furnished, shall not exceed 3 feet 0 inches. The force required to operate any manual mechanism shall not exceed 50 pounds.
 - b. **Supplemental Steel Members:** The Contractor shall furnish supplemental steel members required to secure the switch operating mechanism to the switch supporting structure without drilling any tubular member in the supporting structure.
 - c. **Galvanizing:** Exposed steel material required for the operating mechanisms and supplemental steel members required to secure the mechanisms to the supporting structure shall be galvanized.
3. **INSULATORS:** Insulators shall be gray in color and in accordance with ANSI C29 and/or NEMA Publication No. HV1 for high-voltage insulators.
 4. **OPERATING MECHANISM BONDING:** A copper braid shall be furnished for bonding the operating mechanism of the interrupter switch to the operating platform.
 5. **SEISMIC QUALIFICATION:** When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on equipment nameplate. A seismic report is not required for the low seismic performance level.

8.2.3 TESTS FOR INTERRUPTER SWITCHES: Test results shall be furnished of the following tests performed on switches being furnished or performed on identical switches:

1. Temperature rise tests in accordance with ANSI C37.34-4.
2. Load current tests in accordance with ANSI C37.34-6.1.
3. Seismic qualification test, when required, shall be in accordance with the latest IEEE Standard 693.

8.2.4 CORROSION PROTECTION: Steel parts of interrupter switches and fuse disconnecting switches shall be galvanized.

8.2.5 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Schematic and wiring diagrams shall have graphical symbols and device functions conforming with the latest applicable standards of ANSI Y32.2/IEEE 315, ANSI/IEEE 315A, and ANSI C37.2.

**WAPA ES 8.2 STANDARD SPECIFICATIONS
COMBINATION INTERRUPTER SWITCHES AND FUSES**

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 8.2.5 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings	3.	Within 60 days after date of contract award	Blackline Prints	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6
Equipment test reports	4.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.

**WAPA ES 8.2 STANDARD SPECIFICATIONS
COMBINATION INTERRUPTER SWITCHES AND FUSES**

- d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report.
3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
- a. Include outlines, details, schematic diagrams, wiring diagrams, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.
4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:
- a. Final Drawings: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished.
- Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper, be full-size; and be clear, sharp, and legible.
- Final drawings shall include the following:
- Outlines.
 - Time-current characteristic curves on any type of readable material.
 - Mounting of switches and operating mechanisms.
 - Nameplate drawing.
 - b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the equipment and for each device appurtenant to the equipment. A print of each final drawing as required above shall be included in the instruction book or with the pamphlets.
 - d. Test reports required for the electrical equipment shall be furnished prior to shipment of the equipment. The Contractor shall furnish certified copies of test reports and data. Any equipment which does not successfully pass the testing requirements will be rejected.
5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 8.3
FUSE DISCONNECTING SWITCHES



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 8.3 STANDARD SPECIFICATIONS
FUSE DISCONNECTING SWITCHES**

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**WAPA ES 8.3 STANDARD SPECIFICATIONS
FUSE DISCONNECTING SWITCHES**

8.3.1 GENERAL: Fuses shall be in accordance with these specifications and the applicable parts of ANSI C37 and NEMA publication No. SG2. In the event of contradictory requirements, the requirements of these specifications shall prevail.

Only new equipment of current manufacture shall be furnished.

8.3.2 MATERIAL:

1. FUSE UNITS: Each fuse disconnecting switch shall be furnished complete with one fuse unit and one spare fuse unit. Each fuse unit shall be of a type that can be re-fused readily in the field.
2. FUSE ASSEMBLY: Each fuse assembly shall be capable of interrupting the rated interrupting current or of limiting the fault current through the fuse to a value that the fuse unit can interrupt.
3. SWITCH-OPERATING HOOK AND FUSE REMOVER: Each fuse disconnecting switch shall be furnished complete with one combination switch-operating hook and fuse remover of a length equal to fuse mounting height minus 2 feet.
4. EXPOSED METAL PARTS: Exposed ferrous metal parts shall be galvanized.
5. INSULATORS: Insulators shall be gray and in accordance with ANSI C29.

8.3.3 SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required for metal tag to be attached to equipment may be provided on the nameplate. A seismic report is not required for the low seismic performance level.

8.3.4 DRAWINGS AND DATA:

1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 8.3 STANDARD SPECIFICATIONS
FUSE DISCONNECTING SWITCHES**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 8.3.4 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
*Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. **INSTALLATION DRAWINGS AND DATA:** The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of support structures. Drawings and data required include the following:

- a. Equipment outlines, dimensions, and weights.
- b. Base type, dimensions, and mounting details.
- c. Seismic qualification report.

3. **INFORMATIONAL DRAWINGS AND DATA:** The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:

- a. Specifically verify conformance with equipment requirements.
- b. Be sufficiently complete to allow preparation of final design and installation drawings.

4. **FINAL DRAWINGS AND DATA:** The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. **Final Drawings:** The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible.

Final drawings shall include the following:

- Outlines.
- Time-current curves.
- Nameplate.

**WAPA ES 8.3 STANDARD SPECIFICATIONS
FUSE DISCONNECTING SWITCHES**

- b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing. Separate lists are not required if data is shown on outline drawings.
 - c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the equipment. A print of each final drawing as required above shall be included with the instructions.
 - d. Seismic qualification data.
5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 9.1
SURGE ARRESTERS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 9.1 STANDARD SPECIFICATIONS
SURGE ARRESTERS**

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**WAPA ES 9.1 STANDARD SPECIFICATIONS
SURGE ARRESTERS**

9.1.1 GENERAL: Surge arresters shall be metal-oxide type and meet the requirements of these specifications and applicable requirements of ANSI C62.1. In the event of contradictory requirements, the requirements of these specifications shall prevail. Only new equipment of current manufacture shall be furnished.

9.1.2 MATERIAL: Each surge arrester shall have the following features:

1. **PRESSURE-RELIEF DIAPHRAGM:** Pressure-relief diaphragm shall rupture to prevent explosive shattering of porcelain housing in the event of excessive current causing high internal pressure.
2. **PORCELAIN HOUSING:** Porcelain housing color shall be gray.
3. **CORONA RINGS:** Corona rings may be furnished at any voltage but are required for systems with rated maximum voltages above 121 kV.
4. **LINE TERMINAL PADS:** Line terminal pads shall be NEMA CC1 standard 4-hole pads.
5. **GROUNDING TERMINAL CONNECTORS:** Grounding terminal connectors shall be suitable for No. 2 AWG to 400-kcmil copper cable.

9.1.3 TESTS: Testing and retesting in accordance with ANSI C62.11 to verify arrester ratings.

9.1.4 SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required for metal tag to be attached to equipment may be provided on the nameplate. A seismic report is not required for the low seismic performance level.

9.1.5 DRAWINGS AND DATA:

1. **GENERAL:** Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 9.1 STANDARD SPECIFICATIONS
SURGE ARRESTERS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 9.1.6 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings and data including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Informational drawings and data	3.	Within 60 days after date of contract award	Blackline Prints/Data	3
Final drawings	4.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	4.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	4.c.	21 days prior to shipment	Books	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INSTALLATION DRAWINGS AND DATA: The required delivery time and quantity of installation drawings and data are listed in Table-A. The installation drawings and data are required to prepare final design of foundations and, when applicable, support structures. Drawings and data required include all of the following that are applicable:
 - a. Outlines, dimensions and weights of equipment and, when applicable, associated support structure.
 - b. Base type, dimensions, and mounting details.
 - c. Location, types, sizes, and projections of required embedded anchor bolts or material. The Government will furnish the foundations, anchor bolts, and embedded material.
 - d. Orientation of all equipment and a complete anchor bolt setting plan.
 - e. Seismic qualification report.

3. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:
 - a. Include outlines, catalog data, and instructions.
 - b. Specifically verify conformance with equipment requirements.
 - c. Be sufficiently complete to allow preparation of final design and installation drawings.

**WAPA ES 9.1 STANDARD SPECIFICATIONS
SURGE ARRESTERS**

4. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. Final Drawings: Final drawings shall show all changes and revision dates therefor, made up to the time the drawings are furnished. Final drawings shall be furnished rolled or flat, not folded, be printed on quality bond paper, be full size, and be clear, sharp, and legible.

Final drawings shall include the following:

- Outlines of associated support structures, when applicable.
- Outlines of arresters.
- Nameplate drawing.

- b. Sets of Parts Identification Lists or Bills of Materials for the Equipment: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing. Separate lists are not required if data is shown on outline drawings.
- c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the equipment. A print of each final drawing as required above shall be included with the instructions.

5. RIGHT TO USE CONTRACTOR'S DRAWINGS: Western expressly reserves the right to use, to reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:

- a. Installation, maintenance, replacement, and repair of the articles to be furnished under this contract.
- b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary, for fabricating and furnishing articles connected with or dependent upon information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.



EQUIPMENT STANDARD

SUBSTATION - ELECTRICAL
EQUIPMENT SPECIFICATIONS
WAPA ES 9.3
GROUND FAULT DETECTOR RESISTORS



DECEMBER 2000



**WESTERN AREA POWER ADMINISTRATION
WAPA ES 9.3 STANDARD SPECIFICATIONS
GROUND FAULT DETECTOR RESISTORS**

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**WAPA ES 9.3 STANDARD SPECIFICATIONS
GROUND FAULT DETECTOR RESISTORS**

9.3.1 GENERAL: The resistors used with distribution transformers for detection of ground faults shall be in accordance with IEEE No. 32 for NEUTRAL GROUNDING DEVICES.

9.3.2 MATERIAL: Resistors shall be outdoor, weatherproof, 60 Hz type provided with and mounted in a weatherproof enclosure and as follows.

1. EDGE WOUND, CAST IRON, OR ALLOY TYPE.
2. GRIDS: Grids shall be completely insulated from mounting rods, and from ground, and shall be supported to prevent breakage or excessive vibration.
3. NAMEPLATE: Nameplates on resistors shall show the manufacturer, complete rating, and maximum temperature rise.
4. TERMINAL BLOCK: Resistors shall be wired to a terminal block containing a minimum of six points to allow the connection of external circuits.
5. ENCLOSURE: Weatherproof enclosures shall have two conduit entrances for 2-inch rigid conduit. One entrance shall be at the top and one at the bottom. One grounding pad and clamp-type terminal for No. 2 AWG to 400-kcmil bare copper cable shall be furnished with the enclosure. The enclosure shall be painted gray in accordance with manufacturer's standard painting system.
6. SEISMIC QUALIFICATION: When seismic qualification is required, data and requirements shall be provided in accordance with the latest IEEE 693. The data required on metal tags to be attached to equipment may be provided on equipment nameplates. A seismic report is not required for the low seismic performance level.

9.3.3 TESTS: Resistors shall be given a dielectric test in accordance with IEEE Standards No. 32 paragraph 32-2.31-1.

9.3.4 ELECTRICAL DRAWINGS AND DATA:

1. GENERAL: Drawings and technical data required to be furnished by the Contractor shall be in English, with dimensions in feet and inches, weight in pounds, and volume in cubic feet or cubic inches.

The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using drafting equipment, shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Western will require 40 calendar days to answer correspondence pertaining to each submittal of data or drawings.

Reproducible prints shall be of such quality as to permit clear, sharp, legible prints or other reproductions to be made by direct contact methods.

Western shall have the right to require the Contractor to make any changes in the drawings and data that may be necessary to show the equipment furnished conforms to the requirements of the specifications and these standards. The design and coordination of this electrical equipment shall be the responsibility of the Contractor and Western assumes no responsibility to approve or review drawings and data that are submitted. Western's review of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of his drawings. Revised drawings shall show revision dates and all changes and revisions circled on the drawings. Drawings shall not exceed 22 inches in height by 36 inches in width.

Procurement and construction specifications include the delivery times, quantities, and destinations for drawings and data submittals. The following Table – A shows the normal delivery time and quality requirements.

**WAPA ES 9.3 STANDARD SPECIFICATIONS
GROUND FAULT DETECTOR RESISTORS**

TABLE-A
DRAWINGS AND DATA SCHEDULE

Type of Drawings and Data	Section 9.3.4 Paragraph	Delivery Time (Calendar Days)	Type of Material	QTY
Installation drawings including seismic qualification report	2.	† Within 60 days after date of contract award	Blackline Prints/Data Reports	3
Final drawings	3.a.	21 days prior to shipment	Bond Drawing Prints	1
Parts identification lists and bills of material	3.b.	21 days prior to shipment	Lists	6
* Manufacturer's operation and maintenance instructions	3.c.	21 days prior to shipment	Books	6
Equipment test reports	3.d.	7 days prior to shipment of equipment	Certified Data	6

* Furnish one print of each final drawing with each copy of instructions.

† Seismic qualification report may be submitted within 150 calendar days after date of contract award, if equipment not previously qualified per latest IEEE 693. A seismic report is not required for the low seismic performance level.

2. INFORMATIONAL DRAWINGS AND DATA: The required delivery time and quantity of informational drawings and data are listed in Table-A. The drawings and data shall:

- a. Include outlines, details, wiring diagrams, and instructions.
- b. Specifically verify conformance with equipment requirements.
- c. Be sufficiently complete to allow preparation of final design and installation drawings including wiring diagrams.
- d. Include seismic qualifications report.

3. FINAL DRAWINGS AND DATA: The minimum delivery time and quantity of final drawings and data are listed in Table-A. The drawings and data shall include the following:

- a. Final Drawings for Resistors: The drawings shall show all changes, and revision dates therefor, made up to the time the drawings and data are furnished.

Final drawings shall be furnished, rolled or flat, not folded. Drawings shall be printed on quality bond paper; be full-size; and be clear, sharp, and legible.

Final drawings shall include the following:

- Outlines and details of resistors.
- Schematic and wiring diagram.
- Nameplate drawing.

- b. Sets of Parts Identification Lists or Bills of Materials: Each part shall be assigned an identifying number which can be used for ordering replacements, and a reference number that locates the part on the appropriate outline drawing.

**WAPA ES 9.3 STANDARD SPECIFICATIONS
GROUND FAULT DETECTOR RESISTORS**

- c. Sets of manufacturer's instructions covering installation, operation, and maintenance repair for the resistors. A print of each final drawing as required above shall be included with the instructions.
 - d. Test Reports: Certified copies of test reports, and data. Any equipment that does not successfully pass the testing requirements will be rejected.
4. RIGHT TO USE THE CONTRACTOR'S DRAWINGS: Western reserves the right to use, reproduce in whole or in part, to distribute, and to reuse any and all such drawings, whether copyrighted or not, in connection with the following:
- a. Installation, maintenance, replacement, and repair of the resistors to be furnished.
 - b. Making any and all such drawings and reproductions thereof available to subsequent bidders and the Contractors, where necessary for fabricating and furnishing articles connected with or dependent upon, information shown on the drawings and duplicating the drawings to be furnished hereunder.

The depositing of all such drawings with Western shall constitute a license to Western to use said drawings in the manner hereinabove stated.