ROCKY MOUNTAIN POWER
A DIVISION OF PACIFICORP

Attachment 1A

Rocky Mountain Power

Electronic Project Document Formatting and Requirements

Thermal Generation Support
January 2017

ATTACHMENT 1A					
Document Revision Record					
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0	04/04/2013	Gen Support	Rand Clawson	-	-
1	07/28/2014	Allisha Lester	Rand Clawson	-	-
2	09/09/2014	Allisha Lester	Lon Udy	-	Modified to contractual language, verbiage and formatting
3	09/30/2014	Allisha Lester	Lon Udy	4	1.2.2 Added "Consultant" per Procurement
4	11/04/2015	M. Dearden		-	Updated document
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CONTENTS

1.0 General Requirements

The purpose of Attachment 1A is to provide Contractor with format requirements of all listed items selected in Attachment 1B and shall be provided as deliverables under this scope of work.

Contractors and their Subcontractors (hereafter referred to as Contractor) shall comply with the documentation and formatting requirements outlined in this document. Contractor shall direct all requests for exception through Company representative (project manager). Exceptions must be approved in written form by Company drafting support and document management groups.

All documents (printed and electronic) shall be provided in English. Documents delivered to Company by Contractor shall clearly identify the following information on each drawing (including all sheets) and the first page of all other documents:

- Plant Name
- Plant Unit
- Document Title
- Document Number* – according to plant numbering standards
- Document Issue Date
- Revision Number
- Revision Date
- Contract Number
- Project Number - PacifiCorp WBS (provided by Company)
- Equipment Tag Numbers** – according to plant tagging and labeling standard
- System
- Sub-system

*All documents shall be given numbers per plant numbering standard.
**All equipment shall be given a tag number per plant tagging and labeling standard. Tag numbers shall be used to reference all instruments on drawings, instrument indexes and data sheets.

2.0 Terms and Definitions

The terms and definitions below are used throughout this document and pertain to Attachment 1A and Attachment 1B:

- As-Built/As-Installed – Documents submitted by Contractor reflecting all changes at the completion of the project
- Company – Rocky Mountain Power Thermal Generation (RMP Thermal Generation)
- Contractor – Refers to all Contractors, Subcontractors and/or Vendors
- OEM – Original Equipment Manufacturer
- O&M – Operation and Maintenance

3.0 Transmittal Indexes

Contractor shall provide two complete indexes of all project document deliverables in a functional (unprotected) Microsoft Excel format.

One index shall list drawings and one index shall list non-drawing documents. The non-drawing index should include, but it is not limited to the following: equipment manuals, operation and maintenance manuals, as-built manuals, reports, procedures, data books, specifications and preventative maintenance documents. Contractor shall update and maintain each index throughout the duration of the project each time it is submitted to Company. These indexes will be used by Company to track documents received from the Contractor during each phase of the project (preliminary, construction, as-built/as-installed, etc.). Company will use the indexes as a basis for document management and database entry. Index templates are provided by Company in the AutoCAD support.zip File.

4.0 Deliverables

4.1. AutoCAD Support File

The AutoCAD Support File contains supporting files specific to this project scope of work. These supporting files provide tools and standards for drafting or document turnover to assist Contractor in conforming to Company standards. This zip file contains, but is not limited to, the following:

- Additional Notes and Views
- Cable and Conduit Schedule (samples) – contact plant drafting representative for plant-specific templates
- Circuit Schedule (samples) – contact plant drafting representative for plant-specific templates
- Drafting Procedures
- Drafting Standards - Engineering Handbook Volume 9 (9A and 9B.10)
- Drawing Index Template
- Non-Drawing Index Template
- Panel Schedule (samples) – contact plant drafting representative for plant-specific templates
- Pen Settings
- Borders and Templates

4.2. Drawings

Drawings shall contain details indicating, but not limited to, the following: equipment, dimensions, arrangement, weight of each component, operation of component material and devices, external connections, anchorages and required supports. Dimensions needed for installation and correlation with other materials and equipment are required. Contractor as-built drawings shall be included in all equipment installation, operation and maintenance manuals.

During construction of the project, Contractor shall maintain updated files in the field. This includes current mark-ups of all drawings and data sheets to agree with actual work undertaken. The mark-ups shall be clear and legible in full size and B size reduction. Contractor shall provide new versions of Subcontractor drawings if Company judges originals to be too damaged, deteriorated, or illegible.

4.2.1. Drawing Standards

Drawings created specifically for this project shall be prepared according to Company's AutoCAD/Drafting Standards, also known as 9A and 9B.10. Company document management group is available through the project's duration to field any compliance or drawing-related issues or questions. Contractor shall be responsible for any discrepancies, errors or omissions on the drawings.

The measurement system shall be U.S. Customary System and all drawings and dimensions shall be to scale. Not-to-Scale (NTS) dimensions on drawings shall not be permitted on scalable drawings. A scale bar shall be included to permit use following image reduction.

4.2.2. Submission of Drawings

Contractor shall submit drawings for review, comment, or approval to Company according to the project schedule as identified in Attachment 1B. Drawings shall be updated as the design progresses so they continuously reflect the current designs. Revisions shall be identified according to AutoCAD/Drafting Standards 9A and 9B.10.

Company shall review the drawings for conformance with the Contract and will red-line or comment to indicate necessary changes or corrections. Contractor shall resubmit the corrected drawings according to AutoCAD/Drafting Standards 9A and 9B.10.

Once drawings meet requirements, Company will submit written approval to Contractor. Contractor shall supply one (1) hard copy and one (1) electronic copy of each approved drawing to Company for record. Company will inform the Contractor when these drawings have been received.

4.2.3. AutoCAD Review by Company

Early in the design process, as new AutoCAD drawings are produced Contractor shall provide to Company a minimum of three (3) AutoCAD drawings from each discipline for review and verification of compliance with the AutoCAD/Drafting Standards 9A and 9B.10. When document management confirms Contractor understands, complies with, and is meeting the drawing standard requirements, no other formal AutoCAD review will be required. The final as-built drawing package will be reviewed by Company for compliance. Work completed before the review of drawings shall be at Contractor's risk and any necessary design changes to comply with the requirements and objectives of the Contract shall be made at no additional cost to Company or delay to the project.

4.2.4. Final Drawings

Contractor shall provide as-built drawings representing the as-constructed condition of the entire project. These drawings would consist of, but are not limited to, the following: plan and profile sheets, foundation detail, mechanical, electrical, civil, one-line, schematic, control logic, wiring, raceways, conduit, isometric piping and duct banks. Contractor shall revise applicable drawings to incorporate all as-built information until Company is satisfied that the drawings are correct and the AutoCAD/Drafting Standards 9A and 9B.10 have been met. Drawings shall be prepared in such a way that image reduction to B size shall result in a legible and useable drawing. Marked-up sketches, references, other field markings or red-lines are not acceptable. All cloud, revision diamonds, and other interim control markings shall be removed. Final drawings shall state as-built conditions according to the schedule.

One electronic copy for each drawing shall be supplied in AutoCAD format. Any exception to this must be approved in written form by Company drafting support and document management groups.

4.2.5. Drawings within Manuals

Contractor must provide all drawings within the manuals in two ways: 1) as part of the manual, and 2) as separate, single page pdf copies (generic OEM drawings may be excluded from this requirement). The drawings shall be current with no field markings or red-lines, legible (if scanned, 300 dots per inch (dpi) minimum) and properly oriented. Contractor shall identify file names by drawing number and sheet number. They shall also provide the drawings in numerical order and include them on the index. Below is a typical file name example:

Drawing #

Example: XXXX-001.pdf **Sheet #**
XXXX-002.pdf
XXXX-003.pdf

4.3. Non-Drawings

Contractor shall provide all non-drawing documents as individual files limited to 40 megabytes (MB). All documents shall reflect final or as-installed condition and cannot include marked-up sketches, references or other field markings. Files must be organized and delivered so that each file may be accessed independently. The content in each document must match the table of contents, and the pages must be legible, oriented properly and bookmarked for accessibility. Bookmarks/links are acceptable only if they reference existing sections within the same document. Bookmarks/links to websites or other external documentation are unacceptable. If documents are scanned, resolution must be 300 dpi or greater. Each document shall be titled, including file name, as it corresponds to the content equipment name and tag number. If a file is larger than 40 MB, it must be separated by chapter, tab, or section according to the table of contents.

4.3.1. Non-Drawing Descriptions and Requirements

Non-drawings include, but are not limited to the following:
- Data Book/System Turnover Package/System Description
- Forms (Blank Templates)

- Lists (Shall be furnished in an Excel compatible file format)
    - Accessories
    - Bill of Materials
    - Circuit
    - Conduit
    - Drawings
    - Equipment
    - Instrument
    - Piping
    - Preventative Maintenance
    - Raceway
    - Spare Parts
- Manuals
    - Maintenance Bulletin/Technical Information Letter
    - Original Equipment Manufacturer (OEM)
    - Installation, Operation and Maintenance (IO&M)
    - Service and Repair
    - Training
- Procedures
- Reports
    - Critical Lift Plan
    - Engineering
    - Geotechnical
    - Inspection
    - Performance
    - Relay
    - Testing
- Specifications
    - Construction Specification
    - Design Criteria
    - Equipment Specification
    - Standard Specification
    - Scope of Work
    - Turn-Key Specification

4.3.2. List Requirements

- Instrumentation Lists and Data Sheets:
    - Instrument list and data sheets for each instrument shall reference vendor, model numbers, conditions of service, construction material, specifications, tag number, etc.
    - Multi-conductor signal wire scheme shall match the existing specific plant system.
- Equipment Lists:
    - All equipment shall be given a tag number identifying the type of equipment, the media that it services and a numeric reference according to existing specific plant standard.
    - Equipment indexes shall reference service location, drawing references, ratings, manufacturers, data sheet locations, etc.

- Electric Circuit Schedule:
  - All electrical cables shall be given a circuit number that meets specific plant standards. Information on existing system will be provided upon Contractor selection.
  - Multi-conductor signal wire scheme shall match the existing specific plant standard.
  - The circuit numbers will be used to reference all equipment on drawings, instrument indexes and data sheets.
  - Circuit indexes shall reference service location, drawing references, rating, manufacturers, data sheet locations, etc.
- Piping Line List:
  - All piping shall be given a line number that matches the existing specific plant standard.
  - The line number will be used to reference all pipes on area/routing drawings, indexes and line lists.
  - The line list shall contain line sizes, description of starting and ending locations, operating design and design location, insulation, drawing references, etc.

4.3.3. Manual Requirements

All manuals shall be supplied by Contractor. Large project manuals containing a collection of manuals for multiple systems are not acceptable. Manuals shall contain relevant equipment-specific data applying to system design and installation, operation, maintenance, and repair, but not for alternative or optional equipment. If generic documents are included, the non-applicable portions shall be crossed out.

Contractor shall be responsible for working with plant representatives (i.e. Management of Change (MOC) Coordinator, MOC committee, and/or Plant Designer) to ensure manuals meet plant needs. Should plant requirements for manuals differ from those listed here, the plant representative's instructions shall supersede section 4.3.3.

Contractor shall also be responsible for supplying additional information or replacing information to keep the manual complete and updated, including as-built or certified drawings. If field inspections of equipment indicate omissions or inaccuracy of the manuals, they must be updated. Incomplete manuals will be unacceptable and returned to Contractor for completion and re-submittal.

Note: *For drawings within manuals, see section 4.2.5.*

4.3.4. Submission of Non-Drawings

Non-drawing documents shall be submitted to Company for review, comment, or approval according to the project schedule as identified in Attachment 1B. Non-drawings shall be updated as the design progresses.

Company shall review the non-drawings for conformance with the Contract and will red-line or comment to indicate necessary changes or corrections.

Contractor shall resubmit the corrected documentation. Once non-drawings meet requirements, Company will submit written approval to Contractor.

5.0 Software Requirements

Contractor shall provide all document deliverables to Company in the required file formats listed in the Table 1 below, or as directed by Company representative. This requirement applies to both Contractor and/or OEM provided deliverables. All Contractor deliverables shall be provided in a data format that allows Company to input documents into existing applications. Company will provide Contractor with formatting information as requested. Contractor shall provide electronic submittals and "as-built" or "as-installed" documents in the following software formats:

Software Function	**Software Name**
Word processing	***Microsoft Word**
Spreadsheets	***Microsoft Excel**
Lists	***Microsoft Excel**
Design/Construction & Original OEM Drawings	***AutoCAD (Company will provide current AutoCAD version information)
Project Schedules	Primavera/Microsoft Project as directed by Company.
Scanned Material and OEM Documents	Adobe Acrobat (.pdf) Image (.tif)
***version should not be newer than that currently being used by Company**	

Table 1

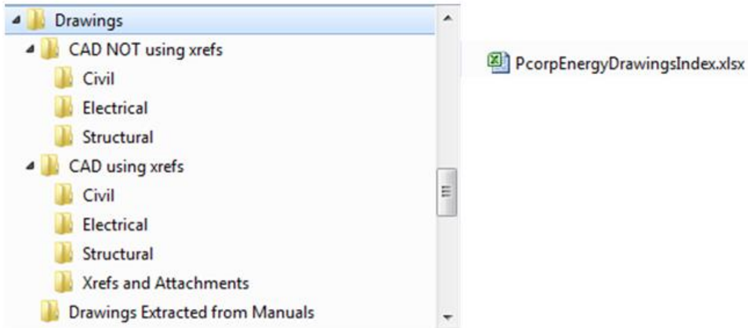
6.0 Document Turnover CD Format

File names and paths combined cannot exceed 175 characters.

6.1. Drawing Compact Discs (CDs)

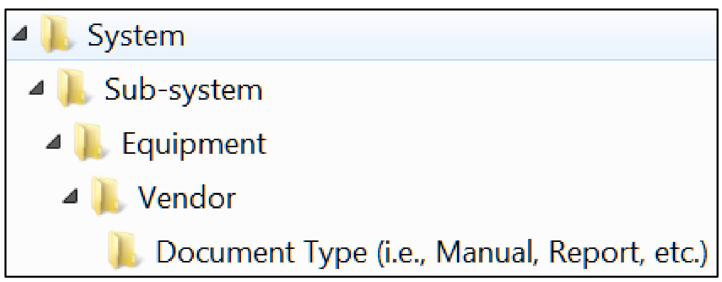
Contractors shall provide drawings on a separate set of CDs and identify them as "As-Built." The first disc shall include the most current index. All file content shall be organized in folders and structured by three basic groups:

1) CAD drawings using external references (xref'd) indicating disciplines and a separate folder for all xrefs and attachments.
2) CAD drawings not using external references (non-xref'd) indicating disciplines.
3) Drawings extracted from manuals. An example is shown below:



6.2. Non-Drawing CDs

All final/complete non-drawing documents listed in Attachment 1B shall be submitted to Company representative. Contractor shall provide non-drawings on CDs separate from drawings, and identified as final ”as-installed”. The first disc shall include the most current index. All file content shall be organized in folders and structured by system, sub-system, equipment and document type (report, manual, specification, etc.). An example is shown below:



Note: Company representative may request Contractor to provide a hard copy of non-drawing documents as designated in Attachment 1B.

6.3. CD Identification

Each disc shall be identified with the following:

- Plant Name
- Plant Unit Number
- Project Name
- Date
- Disc Number
- Drawings/Non-Drawings
- Status – As Built (for drawings)
- Status – As-Installed (for non-drawing documents)
- WBS Project Number (provided by Company)

Lightscribe, legible handwriting, or direct printing to record this information on discs is acceptable. Adhesive labels are ***not*** acceptable.

ROCKY MOUNTAIN POWER
A DIVISION OF PACIFICORP

Attachment 1B - Project Document Deliverables

Project Description:
Plant:
Unit No.:
WBS No.:

Project Manager:
Plant Project Team:
Project Start Date:
Project End Date:

No. of Hard Copies	No. of Electronic Copies	COMPANY: Plant to provide EXAMPLE	COMPANY: Corporate to provide EXAMPLE	Required	STAGE			Deliverable			Description	Company Submittal Schedule	Contractor Proposed Submittal Schedule	Submittal Folder / Disc(s)	Review				
					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Project	Management and Control	1	Billing and payment procedures	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Communications plan	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Compliance and understanding agreement to Company drawing and documentation standards See Attachment 1A	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Document control, project filing system, distribution and action tracking (including sub-contractors) See Attachment 1A	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Drawing and document numbering scheme- see Attachment 1A	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Engineering procedures	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Minutes of meetings records and follow up procedure	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Notice of termination	1D		Non-drawing					
				X				Project	Management and Control Procedures	1	Procedure for design, review, comment and approvals			Non-drawing					
				X				Project	Management and Control Procedures	1	Procedure for professional engineer sealing of drawings	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Procurement specification, procedures and log	8AA		Non-drawing					

No. of Hard Copies	No. of Electronic Copies	COMPANY: Plant to provide EXAMPLE	COMPANY: Corporate to provide EXAMPLE	Required	STAGE			Deliverable			Description	Company Submittal Schedule	Contractor Proposed Submittal Schedule	Submittal Folder / Disc(s)	Review				
					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Project	Management and Control Procedures	1	Progress report plan	8AA plan / reports monthly		Non-drawing					
				X				Project	Management and Control Procedures	1	Project organization with individuals areas of responsibility and contact information	8AA		Non-drawing					
				X				Project	Management and Control Procedures	1	Punch list and close out plan			Non-drawing					
				X				Project	Management and Control Procedures	1	Scheduling plan to include engineering, procurement, construction and integrated path schedule	8AA plan / reports monthly		Non-drawing					
				X				Project	Management and Control Procedures	1	System list and equipment numbering schemes - see Attachment 1A	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	All performance guarantee test plans and procedures including correction curves	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	As-builds policy and procedure	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Calibration of instruments policy and procedure	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Constructability reviews	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Construction permits	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Electrical test programs and acceptance test procedures	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Erection specifications	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Field changes policy and procedure	8AAplan / ?D report		Non-drawing					
				X				Construction	Plan and Procedures	2	Inspections policy and procedure	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Installation specifications	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Notice of intent	10DBF		Non-drawing					
				X				Construction	Plan and Procedures	2	Punch list and close out policy and procedure	8AA		Non-drawing					
				X				Construction	Plan and Procedures	2	Reference to contract statement of work	8AA		Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Construction	Plan and Procedures	2	Reporting non-conformance policy and procedure	8AAplan / ?D report		Non-drawing					
				X				Construction	Plan and Procedures	2	Testing requirements / policy and procedure (including performance guarantee test plans)	8AA		Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start up organization chart			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up administrative procedure			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up safety clearance procedure			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up schedule- Primavera and Microsoft Project			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up test procedures for each mechanical completion, performance and equipment demonstration test items			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up turn over sequences and procedures			Non-drawing					
				X				Start-Up	Plan and Procedures	3	Start-up work responsibility matrix			Non-drawing					
				X				Safety	Plan and Procedures	4	Construction safety reports			Non-drawing					
				X				Safety	Plan and Procedures	4	Hot Work Permit	?DBF		Non-drawing					
				X				Safety	Plan and Procedures	4	Plant Excavation Plans or Permits	8DBF		Non-drawing					
				X				Safety	Plan and Procedures	4	Safety Data Sheets	4BD		Non-drawing					
				X				Environmental	Plan and Procedures	5	Environmental permits	12BF		Non-drawing					
				X				Environmental	Plan and Procedures	5	Fugitive dust plan	12AA		Non-drawing					
				X				Environmental	Plan and Procedures	5	Hazardous material plan	12AA		Non-drawing					
				X				Environmental	Plan and Procedures	5	Scrap removal management plan and procedure	12AA		Non-drawing					
				X				Environmental	Plan and Procedures	5	Storm water management runoff / detention (pollution prevention)	12AA plan / 12BF report		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Acceptance procedure	8AA plan / 6BF record		Non-drawing					
								QA / QC	Plan and Procedures	6	All performance guarantee test plans and procedures including correction curves	8AA ?		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Cleaning, painting and packaging procedures	8AA		Non-drawing					

No. of Hard Copies	No. of Electronic Copies	COMPANY: Plant to provide EXAMPLE	COMPANY: Corporate to provide EXAMPLE	Required	STAGE Review	STAGE Construction	STAGE As-Built/As-Installed	Deliverable Use filtering buttons below to narrow down the list of items you need to look through by group			Description	Company Submittal Schedule	Contractor Proposed Submittal Schedule	Submittal Folder / Disc(s)	Review Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				QA / QC	Plan and Procedures	6	Deviation records and approved deviation reports	8AA plan / 10BF		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Inspection and non-destructive examination records	8AA plan / 10D record		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Interior and exterior finish and color paint samples	4AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Manufacturer's data reports	8AA plan / 10D record		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Material certifications, including filler metal certifications and test reporting	8AA plan / 4BF record		Non-drawing					
				X				QA / QC	Plan and Procedures	6	NERC CIPS equipment specifications			Non-drawing					
				X				QA / QC	Plan and Procedures	6	Non-destructive examination procedures and personnel qualifications	8AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Plan for handling, storage and pre-operational and operational maintenance of equipment	8AA / 8BD record		Non-drawing					
								QA / QC	Plan and Procedures	6	Pressure vessel requirements and certification plan	8AA plan / 10D		Non-drawing					
				X				QA / QC	Plan and Procedures	6	QC inspection point program	8AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Special handling procedures for stainless steel or other sensitive materials	8AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Special process i.e., heat treating, plating, cladding, shot peening, etc.	8AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Test procedures as per ASME, ANSI, IEEE, API, HEI, NEMA, ASTM, etc.	8AA		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Test records plans to submit for owner review and acceptance	8AA plan / 10D record		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Third party QA/QC analysis and reporting	8AA plan		Non-drawing					
				X				QA / QC	Plan and Procedures	6	Welding and qualification procedures	8AA		Non-drawing					
				X				Training	Plan and Procedures	7	Preliminary operations procedures (provided in Company format)			Non-drawing					
				X				Training	Plan and Procedures	7	Training material	submit 9 months prior		Non-drawing					
				X				Training	Plan and Procedures	7	Written training program	12B		Non-drawing					
				X				Design	Data	8	Access requirements	8AA		Non-drawing					
				X				Design	Data	8	Cable specification and codes			Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Design	Data	8	Cable tray specifications and codes			Non-drawing					
								Design	Data	8	Complete design calculations for all in-line flow	8AA		Non-drawing					
				X				Design	Data	8	Control system specification			Non-drawing					
								Design	Data	8	Critical pipe stress analysis and support design	8AA		Non-drawing					
				X				Design	Data	8	DCS graphics and logic design and implementation process plan	8AA		Non-drawing					
								Design	Data	8	Demolition plans of any existing equipment or structure to be removed			Non-drawing					
								Design	Drawings	8	Demolition scope drawings (including markups of existing plant drawings)			Drawing					
								Design	Data	8	Ductwork specification			Non-drawing					
				X				Design	Data	8	Electrical load list	8AA		Non-drawing					
				X				Design	Data	8	Equipment descriptions			Non-drawing					
				X				Design	Data	8	Erection information including lifting points, loads and storage requirements			Non-drawing					
				X				Design	Data	8	Fire suppression specification			Non-drawing					
				X				Design	Data	8	General calculation approval	4BP		Non-drawing					
								Design	Data	8	Heat, material and power balance diagrams	8AA		Non-drawing					
				X				Design	Data	8	HVAC specification			Non-drawing					
				X				Design	Data	8	Instrumentation specifications			Non-drawing					
								Design	Data	8	Insulation specifications and codes			Non-drawing					
				X				Design	Data	8	Material lists including equivalent standard if different than those initially specified	8AA		Non-drawing					
				X				Design	Data	8	Overall design concept per tenant design considerations, concept, criteria and calculations	4AA		Non-drawing					
				X				Design	Data	8	Overall performance data	8AA		Non-drawing					

No. of Hard Copies	No. of Electronic Copies	COMPANY: Plant to provide EXAMPLE	COMPANY: Corporate to provide EXAMPLE	Required	STAGE			Deliverable			Description	Company Submittal Schedule	Contractor Proposed Submittal Schedule	Submittal Folder / Disc(s)	Review				
					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
								Design	Data	8	Pipe insulation specification			Non-drawing					
								Design	Data	8	Pipe specification sheets to included material, installation and design criteria	8AA		Non-drawing					
								Design	Data	8	System descriptions including principle and mode of operation, required interlocks, hydraulic gradients, etc.	8AA		Non-drawing					
								Design	Data	8	System design requirements	4AA		Non-drawing					
								Design	Data	8	System flow and elementary diagrams-preliminary	8AA		Non-drawing					
								Design	Data	8	Valve design specifications			Non-drawing					
				X				Surveys	Studies	9	Arc flash labels			Non-drawing					
				X				Surveys	Studies	9	Arc flash study	8BP		Non-drawing					
				X				Surveys	Studies	9	Aux power system analysis (SKM)	8BP		Non-drawing					
				X				Surveys	Studies	9	Breaker coordination study	2W		Non-drawing					
				X				Surveys	Studies	9	General survey	8AA		Non-drawing					
				X				Surveys	Studies	9	Geotechnical investigation report	8AA		Non-drawing					
				X				Surveys	Studies	9	Noise study	8AA		Non-drawing					
								Surveys	Studies	9	Water balance	8AA		Non-drawing					
				X				Project	Documents	10	all certificates warranties and test reports			Non-drawing					
				X				Project	Documents	10	all maintenance instruction pm's with index per 1A.			Non-drawing					
				X				Project	Documents	10	all vendor manuals documentation with index per 1A.			Non-drawing					
				X				Equipment and	Documents	10	Anchor bolt / base pattern, mounting information, etc.			Non-drawing					
				X				Equipment and	Documents	10	Bill(s) of material listing (BOM)	8BD		Non-drawing					
								Equipment and	Documents	10	Cleaning and conservation procedures			Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Equipment and	Documents	10	Description / design criteria (equipment and instrumentation data sheets as required with lists)	4BP		Non-drawing					
								Equipment and	Documents	10	Dismantling and assembly procedures for equipment with associated tests and checks prior to returning equipment to			Non-drawing					
								Equipment and	Drawings	10	Drawing showing space needed for equipment maintenance and any fixed facilities such as trolley beams, etc.			Drawing					
				X				Equipment and Instrumentati	Documents	10	Effect of loss of normal power			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Equipment Alignment specification			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Equipment and material instruction bulletins and cut sheets			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Equipment start-up and commissioning plan	6 months prior to start-up		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Erection information, including lifting points, loads, overall dimensions, etc.			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Final performance curves (include test data and test curves)			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Inspection and test data (to include shop test data)	8BF		Non-drawing					
				X				Equipment and Instrumentation	Drawings	10	Installation instructions drawings and details			Drawing					

					STAGE			Deliverable							Review				
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				X				Equipment and Instrumentation	Documents	10	Instrument vibration requirements and procedures			Non-drawing					
				X				Project	Documents	10	Issued as "as-installed" procedures (engineering, environmental, maintenance, operations, safety, etc.) (provided in Company format) with index per 1A.			Non-drawing					
				X				Project	Documents	10	Issued as "as-installed" project overview "turnover books" with index per 1A.			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	List of maintenance tools furnished with equipment			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Listing of any start-up prerequisites			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Lubrication schedule (showing initial fill levels, requirements and specifications for lubricants)	4BD		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Manufacture's product sheet	4BP		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Methods for trouble shooting			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Nameplate information and shop order numbers for each item of equipment and components			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Normal range of system variables			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Notice of shipment	8BD		Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Equipment and Instrumentation	Documents	10	Operating limits and hazards for all equipment and the system including alarm and trip set points for all devices			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Operating procedures and instructions for commissioning, startup, normal operation, shut downs, standby, emergency conditions and special safety precautions for individual items of equipment or system			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Operating, maintenance and installation instruction manuals and materials from manufacturer to include complete operations, troubleshooting and maintenance instruction	6 months prior to start-up		Non-drawing					
				X				Equipment and Instrumentation	Drawings	10	Other vendor / manufacturer's drawings as appropriate with index per 1A.			Drawing					
				X				Equipment and Instrumentation	Documents	10	Performance warranty data			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Preventive maintenance schedule and maintenance instruction for equipment including standard and safety precautions	6 months prior to start-up		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Protective coatings and preservatives	4BD		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Receiving, handling and storage	8BD		Non-drawing					
				X				Project	Documents	10	Reports: critical lift plan, engineering, EPA, geotechnical, final inspection, noise dosimetry, system turnover packages,			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Setting and running clearances and tolerances			Non-drawing					

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				X				Equipment and Instrumentation	Documents	10	Spare parts list (with OEM references, part numbers and pricing)	6 months prior to start-up		Non-drawing					
				X				Project	Documents	10	Specifications			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Specifications	4BP		Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Testing and checking requirements			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Thermography specification			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Tolerance of electrical supply frequency variation			Non-drawing					
				X				Project	Documents	10	Training documents / manuals			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Vendor specification sheets			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Vendor supplied certifications and inspections			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Vendor supplied data sheets			Non-drawing					
				X				Equipment and Instrumentation	Documents	10	Vendor supplied test information			Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				General Arrangement	Drawings	11	General arrangement drawings- Site Plan, Detail, Arrangement, Assembly drawings.	4AA		Drawing					
				X				Architectural	Drawings	12	Elevation drawings	8BF		Drawing					
				X				Architectural	Drawings	12	Floor plan interior layout and details	4AA		Drawing					
				X				Architectural	Drawings	12	Foundation plan drawings	8BF		Drawing					
				X				Architectural	Documents	12	HVAC	8BF		Non-drawing					
				X				Architectural	Drawings	12	HVAC	8BF		Drawing					
				X				Architectural	Drawings	12	Lighting and electrical plan	8BF		Drawing					
				X				Architectural	Drawings	12	Plumbing and sanitary drain piping	8BF		Drawing					
				X				Architectural	Drawings	12	Siding and roofing details	8BF		Drawing					
				X				Civil	Drawings	13	Aerial surveys	4BF		Drawing					
				X				Civil	Drawings	13	Construction site development including fences, gates, lay down and fabrication area, crane placement and temporary roads buildings and facilities, etc.	4BF		Drawing					
				X				Civil	Documents	13	Construction storm water management, drainage and sediment control plan	4BF		Non-drawing					
				X				Civil	Drawings	13	Construction storm water management, drainage and sediment control plan	4BF		Drawing					
								Civil	Drawings	13	Pond / basin drawings	4BF		Drawing					
				X				Civil	Drawings	13	Sanitary and waste drain piping	4BF		Drawing					
				X				Civil	Drawings	13	site plan including paved and graveled roads, paved areas, parking, curbs, bollards, fences, gates and structures, etc.	4BF		Drawing					
				X				Civil	Drawings	13	site storm water management and drainage plan including underground storm water piping, catch basins, manholes and interconnects to existing piping systems	4BF		Drawing					
				X				Civil	Drawings	13	Survey, grading and contour plot locating structures and monuments referenced to plant and state plane coordinates	4BF		Drawing					
								Civil	Drawings	13	Underground oily and sanitary waste drain piping including interconnects to existing piping systems	4BF		Drawing					
								Civil	Drawings	13	Underground process piping and drains including interconnects to existing piping systems	4BF		Drawing					
				X				Structural	Drawings	14	Elevated slabs	4BF		Drawing					
				X				Structural	Drawings	14	Enclosure details roof, siding, insulation and framing, etc.			Drawing					
				X				Structural	Drawings	14	Equipment foundations	4BF		Drawing					
				X				Structural	Documents	14	Foundation / support loading information	2BF		Non-drawing					
				X				Structural	Drawings	14	Foundation / support loading information	2BF		Drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Structural	Drawings	14	Foundation and substructure design and locations including caissons / piles and loadings	4AA		Drawing					
				X				Structural	Documents	14	Foundation loading design calculations including dynamic analyses	2BF		Non-drawing					
				X				Structural	Drawings	14	Foundation loading design calculations including dynamic analyses	2BF		Drawing					
				X				Structural	Drawings	14	Ground floor slabs, sumps, trenches, trench covers, containments	4BF		Drawing					
				X				Structural	Documents	14	Paving and containment plans	4AA		Non-drawing					
				X				Structural	Drawings	14	Paving and containment plans	4AA		Drawing					
				X				Structural	Drawings	14	Proposed building plans, elevations and interior layout	4AA		Drawing					
				X				Structural	Drawings	14	Rebar design, anchor bolts and patterns	2BF		Drawing					
				X				Structural	Documents	14	Settlement records			Non-drawing					
				X				Structural	Drawings	14	Settlement records			Drawing					
				X				Structural	Drawings	14	Stair, platform and ladder location and design	4BF		Drawing					
				X				Structural	Documents	14	Structural loading design calculations including dynamic analyses	2BF		Non-drawing					
				X				Structural	Drawings	14	Structural loading design calculations including dynamic analyses	2BF		Drawing					
				X				Structural	Drawings	14	Structural steel design / fabrication and loading	2BF		Drawing					
								Structural	Drawings	14	Tank foundations and valve boxes	4BF		Drawing					
				X				Structural	Documents	14	Test reports and certifications	1AC		Non-drawing					
				X				Structural	Drawings	14	Test reports and certifications	1AC		Drawing					
								Structural	Drawings	14	Wall, pier and grade beams	4BF		Drawing					
								Mechanical	Documents	15	Conveyor systems			Non-drawing					
								Mechanical	Drawings	15	Conveyor systems			Drawing					
				X				Mechanical	Documents	15	Ducting			Non-drawing					
				X				Mechanical	Drawings	15	Ducting			Drawing					
				X				Mechanical	Documents	15	Equipment data sheets to include type and technical requirements	4BP		Non-drawing					
				X				Mechanical	Documents	15	Equipment lists to include tag ID	4AA		Non-drawing					
				X				Mechanical	Drawings	15	Fabrication and erection drawings			Drawing					
				X				Mechanical	Documents	15	Fabrication and erection support documentation			Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Mechanical	Drawings	15	HVAC drawings			Drawing					
				X				Mechanical	Documents	15	Outline and arrangement of mechanical equipment including outline plan and elevation, dimensions, clearance requirements, terminal connector locations, sizes ratings, empty and full weights, etc.	4AA		Non-drawing					
				X				Mechanical	Drawings	15	Outline and arrangement of mechanical equipment including outline plan and elevation, dimensions, clearance requirements, terminal connector locations, sizes ratings, empty and full weights, etc.	4AA		Drawing					
				X				Mechanical	Documents	15	Specialty list including manufacture and model number (expansion joints, etc.)	4AA		Non-drawing					
				X				Mechanical	Drawings	15	Specialty list including manufacture and model number (expansion joints, etc.)	4AA		Drawing					
								Mechanical	Documents	15	Tanks and vessels			Non-drawing					
								Mechanical	Drawings	15	Tanks and vessels			Drawing					
				X				Electrical	Drawings	16	Battery pack location drawing	WD		Drawing					
				X				Electrical	Documents	16	Battery test reports	WD		Non-drawing					
				X				Electrical	Documents	16	Cable insulation test reports	WD		Non-drawing					
				X				Electrical	Documents	16	Cable list tabulation (Cable and circuit schedules) to included to and from, tag number, size, length, routing and schematic references	4AA / monthly		Non-drawing					
				X				Electrical	Drawings	16	Cable list tabulation (cable and circuit schedules) to included to and from, tag number, size, length, routing and schematic references	4AA / monthly		Drawing					
				X				Electrical	Documents	16	Cable tray and conduit lists and routing (Cable tray and conduit schedule)			Non-drawing					
				X				Electrical	Drawings	16	Cable tray and conduit lists and routing (Cable tray and conduit schedule)			Drawing					
				X				Electrical	Documents	16	Cable tray, tray hanger / support location and conduit routing	12AA		Non-drawing					
				X				Electrical	Drawings	16	Cable tray, tray hanger / support location and conduit routing	12AA		Drawing					
				X				Electrical	Drawings	16	Cathodic protection	4BF		Drawing					

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				X				Electrical	Documents	16	Communications	8BP		Non-drawing					
				X				Electrical	Drawings	16	Communications	8BP		Drawing					
				X				Electrical	Documents	16	Duct bank and underground conduit	12AA		Non-drawing					
				X				Electrical	Drawings	16	Duct bank and underground conduit	12AA		Drawing					
				X				Electrical	Documents	16	Electrical load list (total connected and total coincidental)	8BP		Non-drawing					
				X				Electrical	Drawings	16	Electrical load list (total connected and total coincidental)	8BP		Drawing					
				X				Electrical	Drawings	16	Electrical schematics and logic, point-to-point wiring diagrams and interconnection diagrams between electrical / control components	8BF		Drawing					
				X				Electrical	Documents	16	Electrical trench and underground conduit plan			Non-drawing					
				X				Electrical	Drawings	16	Electrical trench and underground conduit plan			Drawing					
				X				Electrical	Documents	16	Fiber and LAN connections	4BF		Non-drawing					
				X				Electrical	Drawings	16	Fiber and LAN connections	4BF		Drawing					
				X				Electrical	Documents	16	Fiber optic cable tests	WD		Non-drawing					
				X				Electrical	Documents	16	Grounding	12AA		Non-drawing					
				X				Electrical	Drawings	16	Grounding	12AA		Drawing					
				X				Electrical	Documents	16	Hazard classification			Non-drawing					
				X				Electrical	Drawings	16	Hazard classification			Drawing					
								Electrical	Documents	16	Heat tracing	4BF		Non-drawing					
								Electrical	Drawings	16	Heat tracing	4BF		Drawing					
								Electrical	Documents	16	Heat tracing schedule			Non-drawing					
								Electrical	Drawings	16	Heat tracing schedule			Drawing					
				X				Electrical	Drawings	16	Internal schematics and point-to-point wiring diagrams of all panels, instrument racks and junction boxes	8BF		Drawing					
				X				Electrical	Documents	16	ISO phase bus duct arrangement	12AA		Non-drawing					
				X				Electrical	Drawings	16	ISO phase bus duct arrangement	12AA		Drawing					
				X				Electrical	Drawings	16	Key diagrams for each bus (480v and above)	8AA		Drawing					
								Electrical	Drawings	16	Lighting and welding receptacle locations	12AA		Drawing					
				X				Electrical	Drawings	16	Lighting plan and area illumination levels	4BP		Drawing					

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								Electrical	Documents	16	Motor data sheets	WD		Non-drawing					
								Electrical	Drawings	16	Motor data sheets	WD		Drawing					
								Electrical	Documents	16	Motor list with tag ID	8BP		Non-drawing					
								Electrical	Drawings	16	Motor list with tag ID	8BP		Drawing					
								Electrical	Documents	16	Motor speed-torque and acceleration time curves (250 hp and larger)	WD		Non-drawing					
								Electrical	Drawings	16	Motor speed-torque and acceleration time curves (250 hp and larger)	WD		Drawing					
				X				Electrical	Documents	16	Nameplate wording	4BP		Non-drawing					
				X				Electrical	Drawings	16	Nameplate wording	4BP		Drawing					
				X				Electrical	Drawings	16	Outline and arrangement drawings of electrical equipment including outline plan and elevation dimensions; physical arrangements including EEB internal layout; clearance requirements; terminal connection locations, sizes and ratings; empty and full weights, etc.	12AA		Drawing					
				X				Electrical	Drawings	16	Power system single line drawings	8AA		Drawing					
				X				Electrical	Drawings	16	Power system three line drawings	12AA		Drawing					
				X				Electrical	Documents	16	Switchgear test reports	WD		Non-drawing					
				X				Electrical	Drawings	16	Switchgear, MCC nameplate drawings	8BF		Drawing					
				X				Electrical	Drawings	16	Terminal block arrangements	8BF		Drawing					
				X				Electrical	Drawings	16	Transformer outline and nameplate drawings	8BF		Drawing					
				X				Electrical	Documents	16	Transformer test reports	WD		Non-drawing					
				X				Electrical	Documents	16	Unit Auxiliary Transformer (UAT) and Reserve Auxiliary Transformer (RAT) location	8AA		Non-drawing					
				X				Electrical	Drawings	16	Unit Auxiliary Transformer (UAT) and Reserve Auxiliary Transformer (RAT) location	8AA		Drawing					
				X				Electrical	Drawings	16	Yard electrical plot plan			Drawing					
				X				I&C	Drawings	17	Control logic diagrams	16BF		Drawing					
				X				I&C	Documents	17	Control system architecture	20BF		Non-drawing					
				X				I&C	Drawings	17	Control system architecture	20BF		Drawing					

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				X				I&C	Documents	17	DCS factory acceptance test (FAT) procedure	4BF		Non-drawing					
				X				I&C	Documents	17	DCS functional description including operating, indication and alarm philosophies, graphic screens and control and alarm set points	16BF		Non-drawing					
				X				I&C	Drawings	17	DCS functional description including operating, indication and alarm philosophies, graphic screens and control and alarm set points	16BF		Drawing					
				X				I&C	Documents	17	DCS graphic displays	12BF		Non-drawing					
				X				I&C	Drawings	17	DCS graphic displays	12BF		Drawing					
				X				I&C	Documents	17	DCS graphic layout sketches	16BF		Non-drawing					
				X				I&C	Drawings	17	DCS graphic layout sketches	16BF		Drawing					
				X				I&C	Documents	17	DCS interface details	20BF		Non-drawing					
				X				I&C	Drawings	17	DCS interface details	20BF		Drawing					
				X				I&C	Documents	17	Input / output list (including set point and alarm)	8BP		Non-drawing					
				X				I&C	Documents	17	Input/output quantities (I/O list)	8BP		Non-drawing					
				X				I&C	Documents	17	Instrument / device / test port location	8BF		Non-drawing					
				X				I&C	Drawings	17	Instrument / device / test port location	8BF		Drawing					
				X				I&C	Documents	17	Instrument data sheets including materials of construction, pressure and temperature ratings, range or calibration, set points, type of housing and mounting, power consumption, supplier, tag and documentation reference(s)	8BP		Non-drawing					
				X				I&C	Drawings	17	Instrument installation details	8BF		Drawing					
				X				I&C	Documents	17	Instrument list	10BP		Non-drawing					
				X				I&C	Drawings	17	Panel arrangements			Drawing					
				X				I&C	Drawings	17	Physical location and layout drawings			Drawing					
				X				I&C	Documents	17	PLC device list (programmable logic controller device list)			Non-drawing					
								Process Piping	Documents	18	Complete description of the insulation system including descriptions of the materials and attachment methods	4BP		Non-drawing					
								Process Piping	Documents	18	Control valve data sheets	4BP		Non-drawing					

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					Review	Construction	As-Built/As-Installed	Use filtering buttons below to narrow down the list of items you need to look through by group							Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
								Process Piping	Documents	18	Heat tracing list	4BP		Non-drawing					
								Process Piping	Documents	18	Inspection and test plan addressing all shop tests, examination and testing	4BF		Non-drawing					
								Process Piping	Documents	18	Material certifications and test reports	1AC		Non-drawing					
								Process Piping	Documents	18	Pipe insulation spec sheets			Non-drawing					
								Process Piping	Documents	18	Pipe line list (pipe schedule) with reference to material spec insulation spec and drawing references: P&ID and physical routing	10AA		Non-drawing					
								Process Piping	Documents	18	Pipe material spec sheets	10AA		Non-drawing					
								Process Piping	Drawings	18	Pipe support details showing location, hot and cold loads and movements and bill of material	4BP		Drawing					
								Process Piping	Drawings	18	Piping & instrumentation diagrams	10AA		Drawing					
								Process Piping	Drawings	18	Piping isometrics (per line)	4BP		Drawing					
								Process Piping	Drawings	18	Piping physical drawings	4BP		Drawing					
								Process Piping	Documents	18	Piping specialty data sheets (i.e. flow element, orifice plate, etc.)	4BP		Non-drawing					
								Process Piping	Documents	18	Piping specialty list	10AA		Non-drawing					
								Process Piping	Drawings	18	Process flow diagrams			Drawing					
								Process Piping	Documents	18	Safety / relief valve data sheets	4BP		Non-drawing					
								Process Piping	Documents	18	Test results	1AC		Non-drawing					
								Process Piping	Documents	18	Valve list	10AA		Non-drawing					
								Process Piping	Documents	18	Valve spec sheets	10AA		Non-drawing					
								Process Piping	Documents	18	Welding procedure specifications (WPS) and procedure qualification record (PQR)	2BC		Non-drawing					
				X				Project	Drawings	19	Drawing index per Attachment 1A.			Drawing					

No. of Hard Copies	No. of Electronic Copies	COMPANY: Plant to provide EXAMPLE	COMPANY: Corporate to provide EXAMPLE	Required	STAGE: Review	Construction	As-Built/As-Installed	Deliverable: Use filtering buttons below to narrow down the list of items you need to look through by group			Description	Company Submittal Schedule	Contractor Proposed Submittal Schedule	Submittal Folder / Disc(s)	Review: Comment (1st Issue)	Construction Rev 0	Construction Rev 1	Construction Rev 2	Construction Rev 3
				X				Transmittal	Documents	19	Transmittals for documents			Non-drawing					
				X				Transmittal	Drawings	19	Transmittals for drawings			Drawing					
				X				Relay	Documents	20	Relay Specifications	2AC		Non-drawing					
				X				Relay	Documents	20	Relay setting orders	2AC		Non-drawing					
				X				Relay	Documents	21	As Built Documentation Checklist for Generator Interconnections	2AC		Non-drawing					

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

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As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

As Built / Record

Legend for Documentation and Deliverables Punch List	
#BP	Number # of weeks Before Procurement
Proc.	Procurement
#AA	Number # of weeks After Award
#BF	Number # of weeks Before Fabrication or before construction when no fabrication is required
#DBF	Number # of working Days Before Fabrication, or before construction if no fabrication is required
Fab.	Fabrication
Con.	Construction
#AC	Number # of weeks After Construction
#BD	Number # of weeks Before Delivery
WD	With Delivery
#B	Number # of weeks prior to performing task
#H	Number # of working Hours after completion of task
#D	Number # of working Days after completion of task
#W	Number # of working Weeks after completion of task
SPEC	See referenced specification section for additional requirements
CTS	Contractor to Supply
PTFP	Prior to Final Payment

Rev No.	Rev Date
0	March 5, 2013
1	April 4, 2013
2	April 3, 2014
3	July 2, 2014
4	July 28, 2014
5	September 9, 2014
6	November 6, 2015
7	December 31, 2015

Rev Description
Ready for use
Added header information and new items to list
Removed Auxiliary from Single & Three Line (Rows 230 & 231). Added row 264, (Process Flow Diagrams.)
Added "Trench covers" & "Containments" to current line 192. Removed line 199 "Trench covers" and added current line 209, "Fabrication and erection drawings and supporting documentation".
Modified to contractual language
Modified Main Heading
Major changes
Merged original green area to rest of list.

Selection list for List tab

Submittal Disk entries

Drawing

Non-drawing

ROCKY MOUNTAIN POWER

PACIFIC POWER

Engineering Handbook

Volume 9

Computer-Aided Design (for Rocky Mountain and Pacific Power)

Engineering Publications

Revision Date: 4 Nov 15

9A—Computer-Aided Design (for Rocky Mountain and Pacific Power)

Contents

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9A.1—General

1. Scope

This section of the company's Engineering Handbook contains general drafting standards applicable to all disciplines. For discipline-specific drafting standards, see Engineering Handbook Volume 9B.

The requirements described in this handbook and in 9B shall apply to all engineering design drawings created or revised either by internal personnel or by external engineering firms.

9A.2—Borders

1. Scope

This document standardizes the border format, which includes consistent drawing areas, revision block layout, and title block, for company engineering drawings. Multiple drawing sizes are provided to accommodate various needs. Modifications may not be made to standard company title blocks.

With company approval, any consultant's logo or insignia placed on the company's standard border shall remain as an independent block. The location of the consultant's logo or insignia on other types of standard company borders shall be evaluated on a case-by-case basis. All consultant logos or insignias shall be removed from electronic files prior to plotting the "FINAL" or "AS-BUILT" drawings (to be signed prior to the distribution and return of the files to the company).

2. General

Company standard AutoCAD borders shall be used during the creation of a new drawing or the editing of an existing drawing. These border template files contain standard layouts with the attributed title block.

All borders will have a border revision date in the lower left corner, just outside the border line. Each AutoCAD drafter/designer is responsible for ensuring that the most current version of the company border template is used. The most current borders are located in AutoCAD Support\Borders and the template files are located in the AutoCAD Support\Templates folder.

3. Border Insertion Point

All borders are to be inserted on layer zero at coordinates 0,0 in the paperspace layout environment. This configuration will set up the drawing area to conform to company standard printing and plotting capabilities.

4. Border and Paper Size

The borders shown below in Table 1 have been developed for use on all company drawings. Where possible, they are in conformance with ANSI Y14.1 standards to utilize the maximum paperspace.

Table 1 lists each border file name and provides drawing size, paper size, revision date, and suggested use.

Table 1—Borders and Sizes

File Name	Size	Rev. Date	Paper Size	Orientation	Suggested Use
CORP-A.dwg	A	11/01/06	8-1/2″ × 11″	portrait	Sketches and details
CORPA-TRAN.dwg	A	05/02/14	11″ × 8-1/2″	landscape	Sketches and details For Transmission use only
CORP-ECA.dwg	A	05/02/14	11″ × 8-1/2″	landscape	Communication block and level diagram
CORP-B.dwg	B	03/12/15	17″ × 11″	landscape	Sketched conductor details
CORPB-TRAN.dwg	B	11/01/06	17″ × 11″	landscape	Sketched conductor details For Transmission use only
CORP-D.dwg	D	05/02/14	34″ × 22″	landscape	Recommended for project size and all new standards drawings and XREF files
CORPD-TRAN.dwg	D	09/18/15	34″ × 22″	landscape	Recommended for plans & profiles and all new standard drawings For Transmission use only
CORP-C3D.dwg	D	05/02/14	34″ × 22″	landscape	For Civil 3D drawings only
SPCC 11X17	B	03/12/15	17″ × 11″	landscape	Sketches and details. For SPCC use only
SPCC 8X11	A	03/12/15	11″ × 8-1/2″	landscape	
CORP-B-GEN	B	09/16/15	17″ × 11″	landscape	Sketch details conductor and cable list For Generation Thermal use
CORP-B2-GEN	B	09/16/15	17″ × 11″	landscape	Sketch, details conductor and control wiring diagrams For Generation Thermal use (Dave Johnston Plant only)
CORP-D-GEN	D	09/16/15	34″ × 22″	landscape	For Generation Thermal use
CORP-E-GEN	E	10/21/15	44″X 34″	landscape	For Generation Thermal use

5. Layer Control

Standard layers are contained in various template files. They can be imported via discipline-specific AutoCAD palettes, or through the design center by accessing them in the AutoCAD support directory. These are standard layers and are not to be modified. Layers can be created on a case-by-case basis at the discretion of the CAD manager. Layers should be named in full without abbreviation and fitting to the entity, (e.g., “EASEMENT” rather than “ESMT”). Layer colors should be chosen so as to result in the appropriate line weight. See Table 7. Layers should not be turned off, but may be frozen so the LAYER ISOLATE command can be used. Never freeze or turn off the DEFPOINTS layer.

Use colors corresponding to company’s color table to differentiate objects, dimensions, and other lines. SeeTable 7 for weights and screening.

6. Revision Block

See Engineering Handbook 9B.10, for revision block procedures that apply to generation thermal.

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An area to record drawing revisions is provided within each border. Any changes made to a drawing must be recorded in this area by inserting the revision block appropriate to that border. Revision blocks corresponding to the various border sizes are located at AutoCAD Support\Borders. Revision blocks may also be accessed via company tool palettes. Revision blocks are not to be modified, burst, exploded, or replaced with floating single line text. Editing to remove the hard text "WO#" is not permitted, nor is stretching/moving an attribute off its original X, Y location. Text shall not hover over the revision area of the title block. If multiple WO#'s are used, then the additional numbers are added to prompt 4 (REV-1 tag) followed by the revision description. Each revision block includes the following nine attribute prompts which must be completed when a revision is made to the drawing:

Prompt 1 REVISION NUMBER — The record starts with the first revision being "1". Each additional revision assumes the next higher number. The latest revision information shall always be placed in the next available space, with prior revisions noted in ascending order. When space is needed for another revision, delete the oldest revision and move the others up. Do not place the new revision in front of older revisions. Revision zero drawings may have a blank revision block.

Prompt 2 DATE — The date the revision is made (mo/dd/yy); the date must be consistent and current on all newly-issued, rev'd up project drawings.

Prompt 3 WO (work-order) NUMBER — company charge number. In certain circumstances where a number is not provided, or the WO number has closed, please follow these procedures:

1. If the number has expired, effort shall be made to have asset accounting reopen it.
2. If it cannot be reopened, the number is still used in the revision block, but time is charged to a capital number under the appropriate cost center.
3. If a modification is not associated to a WO number, then FM (Field Modification) is used as the WO number in the revision block. Time is charged to a capital number under the appropriate cost center.

Prompts 4&5 REVISION — A description/summary of changes to the drawing. This may be two lines if necessary. The description shall be specific for each drawing, including notes on what has been removed or added. For as-builts, the description shall be preceded by "AS-BUILT," followed by a detailed description of the change if possible. If it is not possible, a description such as "AS-BUILT MISC. WIRING CORRECTIONS" is sufficient. Descriptions are not used on communication block & level drawings.

Prompt 6 ENGINEER — The first initial and last name of the engineer (or consulting firm, if applicable).

Prompt 7 DESIGNER/DRAFTER — The first initial and last name of person (or consulting firm, if applicable) who drafted the changes.

Prompt 8 CHECKED — The first initial and last name of the person (or consulting firm, if applicable) responsible for checking the drawing

Prompt 9 APPROVED — The first initial and last name of the person who approved the changes to the drawing. If approvals are provided by an external engineering firm, the firm's acronym shall follow the signature with a forward slash ("/") separating the approver name and firm acronym.

7. Drawing Numbers

Company document control shall use the following procedures when assigning new drawing numbers:

7.1. When to Assign New Numbers

New drawing numbers shall be assigned when the need arises for new drawings to be created for new or existing company facilities. For new substation drawing numbers, contact PacifiCorp document control at Document Control Substation; for new transmission drawing numbers contact document control at Document Control Transmission Design.

7.2. How to Use New Numbers

Once the user has determined how many new numbers are needed, he or she shall contact PacifiCorp document control. The user will be given new numbers (the next in the drawing number series). New numbers are six digits with a suffix indicating the sheet number or the type of file. See Engineering Handbook 9B.10 for generation thermal numbering conventions for plant facilities.

7.3. Numbering Convention

The numbering convention shown in Figure 1 consists of a document number, a sheet number, and a drawing type number. It must appear as indicated in the drawing title block and the drawing file name. Table 2 contains some examples of drawing/document numbers for various types of files. Example title blocks are shown in Figure 2 and Figure 3. Instructions for non-AutoCAD files used in design projects (e.g. Excel files) may be found at AutoCAD Support\Forms. See Engineering Handbook 9B.10 for generation thermal numbering conventions.

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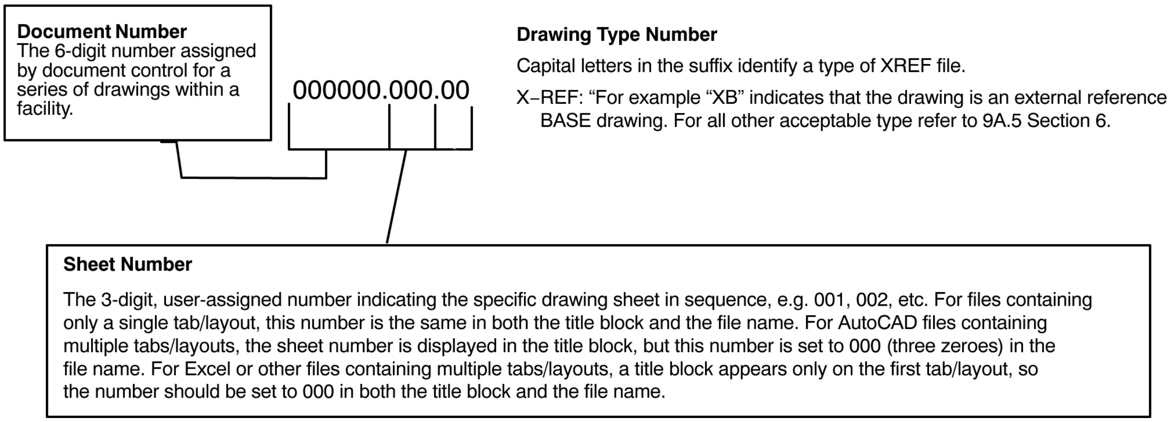

Figure 1—Drawing Number Diagram

Table 2—Borders and Sizes

Description	File Name	Title Block Name
Single sheet stand-alone drawing	100366.001.dwg	100366.001
Drawing with multiple tabs/layouts (see Engineering Handbook 9B.3):		
Layout 1	110273.000.dwg	(Tab name) 001
Layout 2	110273.000.dwg	(Tab name) 002
Layout 3	110273.000.dwg	(Tab name) 003
Layout 4	110273.000.dwg	(Tab name) 004
Multi-tab Excel file (e.g. drawing list, bill of materials, conduit & cable list, RTU list, etc.):		
Layout	109639.000.xls	109639.000
Sheet 10 of a Transmission line plan drawing	100012.010.dwg	100012.010
Sheet A for Transmission line plan for plan drawing #100012.001	100012.001A.dwg	100012.001A
Sheet B for Transmission line profile for plan drawing #100012.001	100012.001B.dwg	100012.001B
Substation Base XREF for foundation plan #123459.001	123459.000.XB.dwg	123459.000.XB
Substation Topo XREF for grading plan #123457.001	123457.000.XT.dwg	123457.000.XT
Raster image file for #100205.001	100205.001.tif	

Note: This table does not apply to generation thermal.

The "base" drawing will have its own drawing number series, with the appropriate file extension.

A raster file will have the same number as the drawing to which it is attached, with the appropriate file extension.

7.4. Legacy Numbering Systems

Drawings created prior to the use of the six-digit numbering system that have new XREFs or raster images attached shall retain the legacy drawing number.

If necessary, new drawings may be added to an existing legacy drawing number series. For example, if sheet 10 is added to a series of nine sheets, the total number of sheets shall be updated on sheet one (from "1 OF 9" to "1 OF 10"). The new, sheet-10 drawing shall use the legacy drawing number, and shall have all new information in the title block, even if the drafting is taken in part from one of the other sheets. The new sheet shall be revision zero.

This procedure does not apply to transmission or generation drawings; see Engineering and Asset Management Procedure 097, *Transmission Documentation* and Engineering Handbook 9B.10.

The examples in Section 7.5 show one legacy numbering system but may be applied to other legacy numbering in a similar manner.

7.5. XREF Drawing Numbers

General plans, foundation plans, grounding plans, and conduit & cable plans shall always have XREFs attached. Drawings and XREFs shall be numbered as follows:

52362A01.dwg (General Plan), XREF name = 52362A00.XE
52363A01.dwg (Foundation Plan), XREF name = 52363A00.XB
52364A01.dwg (Grounding Plan), XREF name = 52364A00.XG
52365A01.dwg (Conduit & Cable Plan), XREF name = 52365A00.XC

A new XREF shall use a legacy number if no XREFs exist for drawings with legacy numbers. For example, a new base plan for existing drawing 52363A01 shall be numbered 52363A00.XB.

Raster images shall be titled with the same number as the associated drawing. For example, 52351A00.XB.tif for drawing 52351A00.XB.dwg.

1. The foundations will become the XB and effort will be made to extract existing entities that belong to the XB such as:

   a. Foundations

   b. Fence

   c. Property lines

   d. Roads

These XREFs will follow the criteria in 9A.5, Section 6.2, *Building the XREF File*, which includes baselines (if the location is known). The insertion point will be at 0,0.

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8. Title Blocks

Title blocks are attributed for use with the electronic drawing management system (DM). The attributed title blocks have been designed to be inserted into new or existing drawings and are required in all company engineering AutoCAD files. See Engineering Handbook 9B.10 for generation thermal title blocks.

The following is a list of the attributes that AutoCAD prompts when the title block is inserted:

1. DISCIPLINE — The discipline name should be chosen from the controlled vocabulary list (CVL) provided in DM. For a complete list of discipline names available for entry at this prompt, please see Engineering Documentation Policy 104, *Indexing of Discipline and Document Type*.

1.A. FACILITY NAME AND TYPE — This field shall display the facility name and the type without voltage. An exception to this is that Dixonville 500 (without the KV) is a valid name and 500 is not to be removed

2. FACILITY NAME/EDMS (D-style title block only) — For DM indexing purposes only; the facility name is not visible in drawing.

   LINE NAME/FACILITY NAME (CORPD-TRAN title block only)

3. FACILITY TYPE/EDMS (D-style title block only) — For DM indexing purposes only; the facility type is not visible in the drawing.

   VOLTAGE/FACILITY TYPE (CORPD-TRAN title block only)

4. FACILITY LOCATION (CORP-D title block only) — City, State (if the location is in a city); County, State (if the location is in a county).

5. DOCUMENT TYPE — The document type should be chosen from the controlled vocabulary list provided in DM. For a complete list of allowable document types, please see Policy 104, *Indexing of Discipline and Document Type*.

6. DRAWING TITLE — No entry is required. This field may be used for additional drawing information, such as substation voltage.

7. DRAWING NUMBER — Five- or six-digit drawing number with the appropriate sheet number suffix.

8. REVISION NUMBER — Current revision number. If the drawing hasn't yet been revised, the default revision (or "rev") number is zero. The revision block for rev-zero drawings shall remain blank. Drawings under review shall have a letter designation entered behind the proposed revision number; the alpha character shall be removed once the design is approved. See Engineering Procedure 211, *Substation Engineering AutoCAD Review for External Consultants*, for more details.

9. SHEET NUMBER — The first drawing of a set should indicate the current sheet number ("1") and the total number of drawings in the set, e.g. sheet "1 OF 4"
   (or "1 OF 1" if sheet 1 is the only sheet). All other sheets in the set should indicate only the current sheet number, e.g. "2," "3." If new drawings are added to the set, the total number of

sheets must be revised on the first sheet. For transmission plans & profiles, each sheet shall indicate the total number of drawings. For example, “1 OF 4,” “2 OF 4,” etc..

10. DRAWING SCALE — As noted, none, or a valid scale.

    e. HORIZONTAL SCALE (CORPD-TRAN title block only) — horizontal scale, e.g., HOR. 1″=400′.

    f. VERTICAL SCALE (CORPD-TRAN title block only) — vertical scale, e.g., VER. 1″=40′.

11. PROJECT/ER NUMBER — Department-specific
12. PL NUMBER — Plant locality number. This is required on all drawings.
13. DRAWING DATE — The issue date of the ORIGINAL drawing (“revision 0”), in the format MM/DD/YYYY. The date must be consistent and current on all newly-issued revision zero project drawings. Once issued, the date in the title block shall remain unchanged for the life of the drawing.

13A.LINE CODE (CORPD-TRAN title block only) — alphanumeric transmission line designation

14. ENGINEERED BY — The engineer’s first initial and last name, e.g. “J. DOE.”
15. DESIGNED BY — The designer’s first initial and last name, e.g. “J. DOE.”
16. DRAWN BY — The drafter’s first initial and last name, e.g. “J. DOE.”
17. CHECKED BY — The checker’s first initial and last name, e.g. “J. DOE.”
18. DISCIPLINE ENGINEER — The discipline engineer’s full name. This field may sometimes be blank.
19. PROJECT ENGINEER — The project engineer’s full name.
20. APPROVAL ENGINEER — The approval engineer’s full name.

NOTE: If signatures are from an external engineering firm, signature fields 14 through 19, above, shall contain signatures, and shall also be followed by the acronym of the firm separated by a forward slash, for example, “J. DOE/CRA.”

Names shall be entered consistently (including spacing) in order for the BAD audit tool to review common attributes. No leading or trailing spaces shall be inserted within the attribute fields.

8.1. Converting Legacy Title Blocks to New Title Blocks

See Engineering Handbook 9B.10 for converting generation thermal title blocks

All legacy drawings being modified shall have the title blocks updated to the latest D-style title blocks. The nomenclature of existing title blocks is transferred to the new title block. Certain missing fields or incorrect nomenclature shall be placed or corrected; other missing nomenclatures remain unchanged. See Volume 9B.2, Section 3.1 for further information on which nomenclatures shall be placed or corrected.

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It is not necessary to transfer the legacy revision information when converting the title blocks. The drawing is rev'd up to the next number with a description of the current modifications.

9A.3—Font and Text Style

1. Scope

This engineering handbook document specifies the font and the codes for symbols and fractions used
in AutoCAD drawings.

2. General

Text on new company drawings shall use the simplex1.shx font as supplied by the company. Company AutoCAD technical support will provide this font for in-house personnel and for consultants who develop or edit AutoCAD drawings for the company. Before simplex1.shx can be used, the font file must be copied to the user's font directory.

The generation thermal group does not use the simplex1.shx or allow the use of custom fonts. See Engineering Handbook 9B.10 for generation thermal font preferences.

3. Use of Text, Symbols, and Fraction Codes

The simplex1.shx font contains all standard keyboard characters, fractions, and other special characters. Smaller-sized characters, subscripts, underscoring, special expanded ASCII characters and fractions can be provided using %% codes, as described in Sections 3.1 and 3.2.

3.1. Special Characters

The following table below gives %% codes for commonly used symbols.

Table 3—Codes for Special Characters

Symbol	Code	Symbol	Code	Symbol	Code
° *(degree)*	%%127 or D	±	%%128 or P	∅	%%129 or C
℞	%%168	℄	%%169	⊠	%%199

Note: This table does not apply to generation thermal.

3.2. Fractions

The table below lists the %% codes for fractions. Fractions can also be typed into MTEXT and tables with stacked properties, set to diagonal at 70 percent of text size.

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Table 4—Codes for Common Fractions

Character	Code	Character	Code	Character	Code	Character	Code
1/4	%%130	5/16	%%138	5/32	%%146	21/32	%%154
3/4	%%131	7/16	%%139	7/32	%%147	23/32	%%155
1/8	%%132	9/16	%%140	9/32	%%148	25/32	%%156
3/8	%%133	11/16	%%141	11/32	%%149	27/32	%%157
5/8	%%134	13/16	%%142	13/32	%%150	29/32	%%158
7/8	%%135	15/16	%%143	15/32	%%151	31/32	%%159
1/16	%%136	1/32	%%144	17/32	%%152	1/2	%%160
3/16	%%137	3/32	%%145	19/32	%%153		

Note: This table does not apply to generation thermal.

4. Text Size

Regular text shall plot at a height of 3/32″, or 1/8″ for headings/subheadings.

For communication drawings only, on D-size sheets regular text shall plot at a height of 1/8" and headings/subheadings at 3/16″. On A-size, block and level drawings regular text and headings/subheadings shall plot at a height of 1/16″.

Single-line text (DTEXT) is preferred throughout drawings where single strings of text are used. The company has predefined text styles S1 through S8 for use when the text needs to be narrowed. The text style shall be changed in lieu of manually modifying the text width through Chprop or the attribute editor.

Multiline text (MTEXT) is preferred where multiple lines of text are needed, such as notes.

5. Tables

AutoCAD tables may be used where applicable for notes, charts, and legends. Predefined table styles specific to power delivery are accessed from the standard palette. Tables shall not be exploded.

9A.4—Drawing Revision

1. Scope

This section of the company engineering handbook lists the procedures to be followed when revising drawings.

2. Revision Clouds

2.1. General

All engineering groups, contractors, and consultants shall use revision clouds to identify changes on drawings for construction purposes.

Revision clouds from previous revisions are to be removed and only the clouds for current revisions shall be shown. If construction for the previous revision is still ongoing, the construction crew(s) will be required to work from two or more prints of the same drawing. It is not acceptable to show multiple revisions on the same drawing.

2.2. Revision Cloud Command

The company encourages the use of AutoCAD's REVCLOUD command for creating revision clouds. The arc sizes of revision clouds shall appear consistent throughout the drawing, and shall be relative to the size of the object being clouded. Rev clouds shall be placed on the rev layer, and broken when necessary to avoid crossing through text or obstructing the design.

In general, ORTHO shall be turned off to avoid linear clouds running parallel to the object being clouded. The clouds are to be placed around entities in their current space (e.g., entities in modelspace will have the cloud also in modelspace). The calligraphy option of the cloud command shall not be used. Any text or leaders associated with the clouds are to be on the rev layer.

Triangles shall not be used to label revision clouds when different work order numbers occur at the same time. In such cases, a string of text or the dynamic rev-block may be used to associate clouds to the appropriate number. Such labels and leaders are to be placed on the rev layer.

Note: Generation thermal continues to use triangles to denote areas of revision where clouds interfere with the drawing content.

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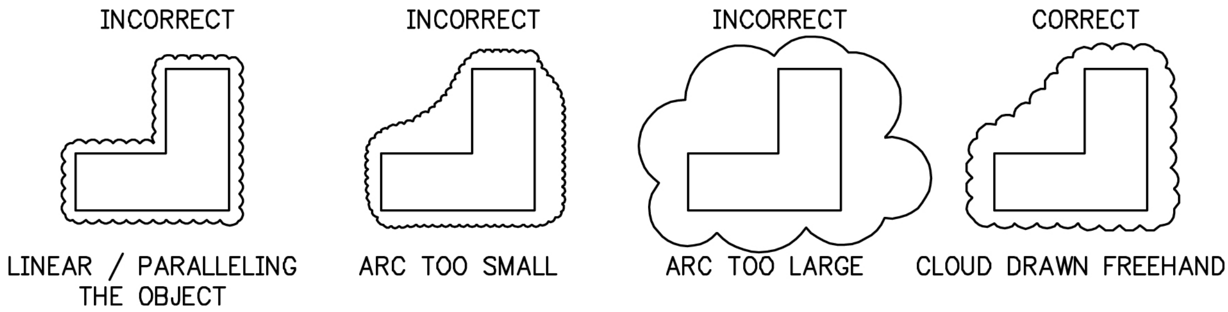

Figure 4—Revision Clouds

3. Updating with Revisions

3.1. Update Drawing Process

Changes may be made to drawings in two ways: 1) in project design prior to construction, or 2) in as-builts provided after construction. In project design, revision clouds shall be used to highlight changes on the drawings. In as-builts, construction revision clouds from all previous designs shall be removed.

If an existing drawing is being modified by 40 percent or more, it is recommended that the whole file be brought up to current drafting standards.

When creating or modifying drawings with content is derived from another drawing, the use of a “taken-in-part” note is used to create a reference. These notes are taken from the standard palette and tailored to the circumstance. The note is placed in the drawing that receives the content and the information in the note comes from the drawing that gives it up. For example:

1. THIS DRAWING TAKEN IN PART or TAKEN FROM DRAWING ____, REV ____, DATE____

   a. The drawing that the content was taken from would have some reference noted in the revision block as to what drawing the content was moved to. The content moved would have a cloud place around the area where the content was.

2. THIS DRAWING BASED ON or IN PART FROM DRAWING ___, REV ___, DATE___

   b. This would be used where a drawing type did not exist and a new one was created based on another drawing type.

This process is used when creating key sheets where the existing drawings are moved up one drawing number and a note is needed in each sheet following the key sheets.

3.2. Revisions and Versions

See Engineering Procedure 211, *Substation Engineering AutoCAD Review for External Consultants*, for further detail.

3.2.1. Versions

Versions are modifications that are being reviewed prior to issuing. The current revision will be incremented to the next revision number with a sequential alpha designation placed behind it for review purposes (e.g., 0A, 0B, or 1A, 1B, etc.). The alpha character shall be removed when the project is issued. These alpha/numeric notes shall also be placed near the clouded design change to delineate various design reviews. Place all text, leaders associated with the revision cloud on the rev layer with a text height of 3/32″. Versions are not used on communication drawings.

3.2.2. Revisions

When a design change becomes an approved revision, the version labels and associated revision blocks used for the versions shall be removed, leaving only one revision block. The final revision description will denote all the changes to the drawing. Revision numbers shall be numeric, whole-digit numbers. All current, finalized revision changes shall be clouded without a revision label.

Newly-created revision zero drawings do not have revision blocks and typically do not contain clouds. However, in certain circumstances (for example, revision zero manufacturer drawings with wiring being added) revision zero drawings shall contain revision clouds.

Each time a drawing has a new, approved change its revision number is incremented. The newest revision block shall appear beneath the previous revision block. If room at the bottom is needed, the oldest revision(s) shall be removed and the remaining revisions shifted upward such that the newest revision is always listed at the bottom.

One revision description line is preferred. Therefore, the descriptions should use abbreviations, if necessary, to accommodate the parameters of the first attribute field.

3.3. As-Builts

The marked-up as-builts are prepared by the field after construction is complete. The revision cloud shall not be removed until the marked-up as-builts are reviewed and approved by the engineer responsible for the work and the files have passed a drawing quality control check. After approval and quality control check, the revision clouds shall be removed and the file rev'd up. Additional changes without revision clouds may be added to the as-builts by an internal reviewer.

All construction notes are to be removed while all other remaining notes, legends, and layering or line types that indicate proposed shall be converted to existing.

Drawings in a construction package that have not been marked up by the field shall not be considered “as-built” or “rev'd up”.

All drawings shall be returned to the company's document management system in the native AutoCAD .dwg file format. The format shall be that of the same release of AutoCAD currently used by PacifiCorp. Pdf files will not be accepted in lieu of editable CAD files and are not to be issued as final drawings.

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All final as-built drawings shall contain final approval signatures, both wet and electronic.

3.4. Update of Revision Block

Upon removing the revision cloud or inserting changes from the as-builts, the AutoCAD user shall update the provided revision block in the standard border template as described in 9A.2, Section 6.

3.5. Redlining Drawings

The originator of any drawing changes must provide the drafter/designer with a color-coded drawing and the name of a contact person if there are any questions. Details should include:

- Updated information in the revision block such as revision number, description of change, work order or project number
- Date of change
- Name of individual responsible for the change

The drafter/designer shall make the changes as requested and print the revised drawing. Upon completion, the drafter/designer will then return the marked-up drawing and a print of the revised drawing to the originator for review.

3.6. Color Code Key

Field markups in as-builts or in project design are to follow the below criteria.

Legible penmanship shall be used so the drafter can properly interpret the red lines. Eights that look like “B,” and fives that look like “S” are not acceptable.

When changes or corrections are being sketched on a drawing, the following color codes shall be used to assist the drafter:

- Additions: red
- Deletions: green
- Area checked, no change made: yellow
- Notes to drafter: blue (no black or pencil)

All changes to drawings must be clearly marked with the appropriate color code. This provides the drafter/designer with precise, detailed information regarding the changes requested.

3.7. Voiding & Superseding CAD or Image Files

See Engineering Handbook 9B.10 for generation thermal voiding and superseding procedures.

3.7.1. Voiding CAD Files

Void Stamps: Drawings being voided shall have the void stamp placed in the lower right-hand area of the drawing with the attributes completely filled in. If the drawing is being superseded by another drawing, the drawing number(s) shall be referenced in the void stamp. The drawing that supersedes the voided drawing shall have a string of text placed along the lower right edge of the title block stating, for example, “THIS DRAWING SUPERSEDES DRAWING 123456.001, REV 3, DATE 6/11/03.” The revision number and revision date shall be that of the latest revision of the voided drawing.

If a drawing is partially superseding another drawing, the superseded note shall state this accordingly:

THIS DRAWING PARTIALLY SUPERSEDES DRAWING...

If the drawing is just being voided and not superseded, “N/A” shall be placed in the attribute field of the void stamp and the drawing shall not be rev'd up.

Transmission plans & profiles may be an exception to this rule; contact transmission document control for guidance.

Communications drawings do not use void stamps in the drawing file, but will be marked as void in the document management system.

Drawings can only be voided if the entire drawing series is voided. If the whole drawing series is being voided, the drawings are not updated or rev'd up and normal void/ superseding procedures are to be followed.

If the entire series is not voided, then the affected drawings will have the content removed, clouded, and a description placed in the revision block stating ”DRAWING LEFT BLANK FOR FUTURE USE, CONTENT MOVED TO 123456.XXX,” or if the series is not superseded or the content moved, the description shall read “DRAWING LEFT AS PLACE HOLDER FOR FUTURE USE.” The drawing is rev'd up and the title block updated to current standards for future use. As-builts will not have a cloud placed where the content was removed.

The 4th line (Attribute tag 6) of the title block should have "FUTURE USE" added to the existing nomenclature.

The new rev 0 drawing that replaces the one being voided or left as a place holder shall have a supersede note taken from the standard palette and placed in the lower right-hand corner of the drawing. The fields of the note shall have the following taken from the drawing that is being removed:

1. The full drawing number.
2. The revision number of the last revision of the voided or the blank drawing that contained the content before it was removed or voided, not the revision that it will become if left as a place holder, i.e., the note should not refer back to a blank place holder.
3. The date, unless it is a rev zero, is the date of the revision block, not the earlier date of the title block.

THIS DRAWING SUPERSEDES DRAWING ----, REV ----, DATE ----

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A partial supersede note is placed if two or more drawings are superseding one drawing. The note shall read:

THIS DRAWING PARTIALLY SUPERSEDES DRAWING ----, REV ----, DATE----

A taken-in-part note is placed in drawings where the content is taken from an existing drawing and a portion of that existing drawing will continue to be used and not voided or left blank for future use.

THIS DRAWING TAKEN IN PART FROM DRAWING ----, REV ----, DATE ----

3.7.2. Voiding Image Files

To void a stand-alone image file, the file should be temporarily attached to a CAD file as a means of editing and saving the image file through Raster Design or other image editing software. In AutoCAD, attach the image, bring in the void stamp, and fill it in. Using raster design, use the command IVMERGE to merge the block into the image. Save the image file, not the CAD file, and detach it. Use this method only if the image is not already attached to a CAD file.

The following process is performed where a .tif image is part of a drawing series that cannot be voided. When the drawing content is either removed or transferred to another drawing, the drawing number is retained with the original title block history for future use as described below.

1. The title block information of the .tif image will be transferred to appropriate D size title block, and the new title block will be rev'd up and reserved for new drawing content.
2. The old legacy revision information from the .tif is not transferred over to the REV-D blocks. The drawing is rev'd up and not backward to a rev 0 drawing. The 4th line (attribute tag 6) of the title block should have “FUTURE USE” added to the existing nomenclature.
3. The revision block will read "DRAWING SUPERSEDED BY DRAWING(S) 123456.XXX or if not superseded, the description shall read ”DRAWING VOIDED AND LEFT AS PLACE HOLDER FOR FUTURE USE.”
4. The image is not attached, but a cloud is placed where the image would have been placed, representing that the content was removed.
5. The drawing that will supersede the old .tif will not inherit any of the old title block or revision history. It will be a new rev 0 drawing with only the drawing content transferred from the old drawing, and a supersede or partially taken note is placed in the lower right-hand corner of the drawing.

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9A.5—Drawing Practices

1. Scope

This section details drawing practices required to provide uniformity and ease of use.

2. Quality and Neatness

All drawings created or modified for the company must be neat and professionally-drafted, clearly illustrating the necessary detail for the proposed construction or for producing final as-built drawings.

Some practices to abide by include:

- Object lines should meet at corners.
- Dimension extension line nodes should be snapped to the object being dimensioned. They shall not lay over the top of line types making the line type appear continuous, nor shall the node snap to the center of circles or arcs giving the appearance that the extension line is tangent to the circle or the dim gap is buried within the circle.
- All drawing content shall be shown within the paperspace border.
- Objects in modelspace should be drawn to the actual scale. Do not “free pick” object lines.
- Details drawn in modelspace that can be shown through a single viewport with the same scale shall be grouped together so they can be shown through a single viewport and not multiple viewports with the same scale. Viewports should not be drawn on a layer that plots so as to frame in the details. The detail frames, if used, should reside in modelspace with the details and be shown through the viewport.
- Use appropriate text justifications when placing or modifying text.
- Standard layers are to be used to depict line weights, linetypes, and color. All CAD entities are to be “bylayer” and are not to be modified by individually changing the linetype scale, color or linetype by entity.
- The drawing units are to be Architectural, with a minimum precision of 1/32″, and the insertion set to “inches.” The only exceptions to this rule are civil survey files, generation, and transmission files. The units of the survey file are to remain decimal. The units for these drawings shall have a length precision of 0.0000, an insertion scale in feet, angle type of deg/min/sec, and angle precision of 0d00’00”.
- New drawings shall use the company blocks placed in AutoCAD’s palette system.
- Legacy drawings saved as new drawings shall have the modified content converted to current CAD standards as required by 9A.7 *CAD Standards and Template Files*. In case-by-case scenarios, a 'taken from' or 'taken in part' note may need to be placed in the lower right-hand corner of the drawing stating where the drawing originated. This note shall relieve the burden of bringing certain portions of the drawing up to current standards, leaving important non-standard scenarios in place. The note shall follow the procedures in Handbook 9A.4, Section 3.7.1, *Voiding CAD Files*.

- New drawings shall not use certain existing non-standard entities within the drawing that are then copied to other areas for use in the new design.
- Drawing files shall not contain embedded VBA macros.

3. Drawing Scale

All modelspace objects are to be drawn to actual scale (1:1). In some instances it is necessary to plot the drawing in a manner that will allow users to scale off dimensions from a paper copy. Care should be taken when doing this to avoid confusion when copies or reductions of the original plot are made.

Table 5—Table of Drawing Scales (in feet)

Drawing		Text Factor	
Scale	Scale Factor	Size 0.09375	Size 0.125
1′=10′	10	0.9375	1.25
1′= 20′	20	1.875	2.5
1′=30′	30	2.8125	3.75
1′=40′	40	3.75	5
1′=50′	50	4.6875	6.25
1′=100′	100	9.375	12.5
1′=200′	200	18.75	25
1′=400′	400	37.5	50
1′=600′	600	56.25	75
1′=800′	800	75	100

Table 6—Table of Drawing Scales (in inches)

Drawing		**Text Factor**	
Scale	Scale Factor	Size 0.09375	Size 0.125
3/4″=1″	1.33	0.125	0.17
5/8″=1″	1.6	0.15	0.2
1/2″=1″	2	0.1875	0.25
3/8″=1″	2.67	0.25	0.33
1/4″=1″	4	0.375	0.5
1/8″=1″	8	0.75	1
1/16″=1″	16	1.5	2
1″=1″	1	0.09375	0.125
1/16″=1′	192	18	24
3/32″=1′	128	12	16
1/8″=1′	96	9	12
3/16″=1′	64	6	8
1/4″=1′	48	4.5	6
3/8″=1′	32	3	4
1/2″=1′	24	2.25	3
3/4″=1′	16	1.5	2
1″=1′	12	1.125	1.5
1–1/2″=1′	8	0.75	1
2″=1′	6	0.5625	0.75
3″=1′	4	0.375	0.5
1″=10′	120	11.25	15
1″=20′	240	22.5	30
1″=30′	360	33.75	45
1″=40′	480	45	60
1″=50′	600	56.25	75
1″=100′	1200	112.5	150
1″=200′	2400	225	300
1″=400′	4800	450	600
1″=600′	7200	675	900
1″=800′	9600	900	1200
1″=1000′	12000	1125	1500

Example: (for all text):
Text size (3/32″ text): Scale factor x 0.09375
Text size (1/8″ text): Scale factor x 0.125
Block Insertion Scale = 1 / Scale factor

4. Paperspace / Modelspace

Paperspace layouts shall be used in all power delivery drawings in the following manner, excluding generation thermal. All non-scalable entities such as one-lines, schematics, block and level diagrams, etc. shall be drawn in the paperspace layout tab with the border unless an image is being used. All entities associated with the image shall reside in modelspace. The following steps detail the procedures for utilizing paperspace / modelspace for scaled drawings requiring a viewport:

1. Draw the objects in modelspace at full scale using true measurements.
2. Typically, only one viewport is used and should be traced along the inner edge of the title block using the rectangular (not polygonal) viewport command. Viewports shall be placed on the DEFPOINTS layer.

   If needed, multiple viewports can be cut in the paperspace environment, as long as they fit within the 1:1 border. If multiple viewports are used with different scales, the scale of the detail is noted within the subtitle block and "AS NOTED" is placed in the title block. Details shown in one viewport shall have the scale noted in the title block and not beneath each detail.
3. Use the ZOOM command to precisely scale each view, or use the scale dropdown in the viewports toolbar to set the desired scale.
4. The layer properties manager can be used to set the appearance in a drawing with multiple viewports by freezing the layers within them.
5. All viewports shall be locked to avoid accidental changes.
6. Set the LTSCALE to .25 and PSLTSCALE to 1 to ensure that all line types plot the same in multiple viewports.
7. Fill out the title block and/or add the revision block, or other notes and legends. All notes, legends, and the reference drawing block shall be placed in the lower right-hand corner of the drawing in paperspace. Vertical lines of these notes and legends are to line up with each other. See Engineering Handbook Volume 9B for discipline-specific drafting standards related to the orientation of notes and legends.

5. Multiple Paperspace Layouts (Tabs) Within One File

See Engineering Handbook 9B.3, *Civil Drafting Standards*, regarding multiple paperspace layouts within one file.

6. External Reference Drawings

See Engineering Handbook Section 9B for discipline-specific XREF procedures.

6.1. XREF Naming

Below are examples of the suffixes used for XREF file names. XREFs are not permitted on transmission drawings.

New Numbering File Name	Legacy Numbering File Name
*.000.XT (topographic file)	*.A00.XT (topographic file)
*.000.XB (base file)	*.A00.XB (base file)
*.000.XE (electrical file)	*.A00.XE (electrical file)
*.000.XCH (control house file)	*.A00.XCH (control house file)
*.000.XG (grounding file)	*.A00.XG (grounding file)
*.000.XC (conduit file)	*.A00.XC (conduit file)
*.000.XL (landscape file)	*.A00.XL (landscape file)
*.000.XI (irrigation file)	*.A00.XI (irrigation file)
*.000.XEC (erosion control file)	*.A00.XEC (erosion control file)
*.000.UXE (future electrical use)	*.A00.UXE (future electrical use)
*.000.UXB (future base file)	*.A00.UXB (future base file)
*.000.UXC (future conduit file)	*.A00.UXC (future conduit file)

6.1.1. XT Topo Drawing Names (Civil Discipline)

The XT topo drawing name (i.e., the 5 or 6 digit number that precedes the suffix shown above) is the same number as the grading plan sheet file. This XT file contains surveyed land contours and features and base lines. This drawing is set to decimal rather than architectural units, and keeps its world coordinates. This file is based on civil survey data and is not to be modified without first consulting with the civil group.

With the use of Civil 3D, the XT file is not used.

The XT drawing is XREFed into the following sheet files:

- Grading Plan
- Topographic Survey
- Landscaping Plan

6.1.2. XB Base Drawing Names (Foundation Discipline)

The XB base drawing name (i.e., the 5 or 6 digit number that precedes the suffix shown above) is the same name as the foundation plan sheet file. This XB file contains existing and proposed property features (e.g., fence, road, property line, control house foot print, foundations, cable trench, ground mats, and base lines). This file is not to be created or modified without first consulting with the civil group.

The XB is XREFed into the following sheet files:

- General Plan
- Conduit & Cable Plan
- Grounding Plan
- Foundation Plan
- Fence Plan
- Landscaping Plan
- Grading Plan
- Plans & Elevations

6.1.3. XE Electrical Drawing Names (Electrical Discipline)

The XE electrical drawing name (i.e., the 5 or 6 digit number that precedes the suffix shown above) is the same name as the general plan sheet file. This XE file contains existing and proposed electrical facilities, bus layout, connections, and base lines.

The XE is XREFed into the following sheet files:

- General Plan
- Plans & Elevations

6.1.4. XCH Control House Drawing Names (Electrical Discipline)

The XCH control house drawing name (i.e., the 5 or 6 digit number that precedes the suffix shown above) is the same name as the control house arrangement and wiring sheet file. This file contains detailed control house facilities such as cable tray, lighting and equipment. AutoCAD's layer manager is used to toggle between cable tray, lighting plan, and equipment drawings.

6.1.5. XG Grounding Drawing Names (Electrical Discipline)

The XG grounding drawing name (i.e., the 5 or 6 digit number that precedes the suffix shown above) is the same drawing number as the grounding plan sheet file. This XG file contains only the grounding grid network without ground mats.

The XG is XREFed into the following sheet files:

- Grounding Plan

6.1.6. XC Conduit Drawing Names (Electrical Discipline)

The XC conduit drawing name (the 5 or 6 digit numbers that precedes the suffix shown above) is the same name as the conduit & cable plan sheet file.

The XC is XREF'ed into the following sheet files:

- Conduit Plan

6.1.7. XL Landscape File Names (Electrical Discipline)

The XL (landscape file) shall follow the same naming conventions as the landscape plan.

6.1.8. XEC Erosion Control Drawing Names (Civil Discipline)

The XEC erosion control drawing name (i.e., the 5 or 6 digit numbers that precedes the suffix shown above) if needed, is part of the grading plan. The file name should follow that naming convention. The XEC is a civil drawing, and in the title block, the third line document type will read “grading plan.” “Erosion control” is entered on the fourth line of the title block.

XREFs are created only to show the plan view of various portions of a site. Entities not to be included in an XREF are dimensions, text, details, elevations, section views, or anything specific to a sheet file.

If an electrical XREF file (XE) is to be created for an existing substation, and if there were an existing general plan of 12345A01, the new XE would follow the name of the old legacy number of 12345A00.XE, not the new six digit naming convention of 123456.000.XE.

6.2. Building the XREF File

All XREF files, except the .XCH, are to contain vertical and horizontal baselines with the intersection of these baselines placed at 0,0. All XREF files will now have the CORP-Z block replaced with the appropriate, discipline-specific D-size title block, and undergo the same placement and revision procedure as any other sheet file.

The D-size title block is placed in paperspace and filled in just as the sheet files. The scale shall be 1:1 and the sheet number shall be "1 OF 1."

The document type will be “X-REF” and the fourth line, (attribute tag #6) will describe the type of base file.

The XREF file will only be rev’d up if the file is checked out for modifications. All revision clouds will be shown in the sheet files and not in the XREF file.

To keep from twisting the views of the viewports of the sheet files we do not keep the real world coordinate of all XREFs with the exception of the XT. The XT shall remain at real world coordinates and the baselines are to coincide with the baselines of the other drawings within the yard.

Dimensions and text are not to be used within XREFs. These entities are placed within the individual sheet files.

When establishing baselines in new facilities, care should be taken so as to not cross through any existing or proposed foundations or equipment. If moving foundations and equipment during the design phase of the project is necessary, and in doing that, they cross through any baselines, then adjusting the lines becomes necessary. The adjustment of the baselines in one file requires the adjustment in all the other files. The drafter will then need to move the entire drawing back to 0,0 via the intersection of the two baselines. The AutoCAD command BASE is not to be used in lieu of repositioning the entire file. Be aware of any layers that are locked or frozen before moving all.

If the XREF files exist with baselines, the baselines may not be moved even if they interfere with new design. This is due to these baselines being set with a marker in the yard.

If a new XREF is being created from existing drawings where the baselines are not present and a field-check or survey cannot be performed, the lower left-hand corner of the yard or fence corner shall be at 0,0.

6.3. XREFs in Sheet Files

All XREFs are to be placed in modelspace on the XREF layer at a coordinate of 0,0, attached with the NOPATH option. The XREF files are not to be moved, aligned, or rotated off this coordinate. Use DVIEW and TWIST, or ROT, to orient the viewport. An exception to this is when the XB is aligned to the XT in its real-world coordinate. The baseline layers from the multiple attached XREFs are frozen in all but one XREF so as not to have overlapping line types.

Attachments are to be one level deep (i.e., no nesting). Building an XREF by attaching another to it, and then attaching that file to a sheet file creates a nesting situation. To alleviate this, use the overlay option when one XREF file is attached within another.

XREF files are not to be bound to the sheet file and exploded or inserted as a block rather than attaching as an XREF.

6.4. Revising XREFs

When modifications are made to an XREF, it shall be rev'd up using a revision block with a description of what was modified. If modifications are made and the title block is not "rev'd-up," the file will not be uploaded to the company's Document Management system.

6.5. Unacceptable Attachments

- Sheet files into other sheet files
- Blocks from block libraries
- Details

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7. Hybrid Drawings

7.1. Attached Raster Drawings

The purpose of attached raster images is to reduce drafting time and eliminate redrafting of existing manual drawings. Rasters should only be used when it is not feasible to produce a full CAD re-draw. Raster images should always be attached in modelspace, on layer "IMAGE,", color 7, with "retain path" unchecked, transparency set to ON, and frame turned OFF. Any CAD entities added to the image are to be located in modelspace.

Attached raster images may be used when the revision being performed affects 30-60% of the drawing. However, the entire drawing may be redrawn in AutoCAD at the drafter/designer's discretion instead. Remember, when creating composites, the goal is to work toward a fully-vectorized drawing. The only type of raster edit that should be performed is erasing. Eventually, all drawings will be converted to AutoCAD. The drafter should, if time and budget allow, convert raster images whenever possible.

Before the raster image may be used, it must be scaled, despeckled, deskewed, and otherwise prepared to ensure that all portions are legible. Areas that cannot be successfully repaired by such methods shall be redrawn in AutoCAD.

Only the pertinent title block information is transferred from the image to the current title block. The revision is incremented to the next revision, but the previous revision descriptions are not transferred, nor are they retained in the image file. If any of the existing title block nomenclature is incorrect, it is to be corrected to standard. See Vol. 9B 3.1.1 regarding nomenclature revision.

Raster images may only be linked to drawings using AutoCAD. The company's preferred raster editing software is Raster Design. However, any image-editing software capable of saving the file as a stripped CCITTG4 compressed "tif" image is acceptable.

Note: Raster Design versions later than 2010 have a known issue with the degradation of the image after modification and a save is performed: therefore, these versions should be avoided by using other image editing software or version 2010 should be used for the modifications.

Raster images may be attached to XREFs and be referenced as part of the XREF into multiple sheet files. In this case, the raster image file name shall match the XREF file name (e.g., 123456.000.XB.dwg = 123456.000.XB.tif). In cases where it is necessary to use multiple images to assemble one XREF, those images shall be combined into one image with a consistent DPI density across all images. The command IDENSITY in AutoDesk's raster design can be used to accomplish this by setting the pixels/inch density to a higher number (e.g., from 300 to 600).

Images used in tabbed drawings and shown through multiple viewports must be combined into one image file as described above. The one attached image shall not be copied to other areas within modelspace and shown through multiple viewports. Raster Design is used to reposition or copy different details within a single image frame to show them in drawings with multiple layouts.

Only pixelated .tif images that can be edited with Raster Design shall be attached. File types such as .bmp or .jpg files are not to be attached to the AutoCAD drawing file.

Attached raster images may only be referenced to one parent. If more than one parent drawing uses the raster image, and the image is not inordinately large, copies of the image file will be referenced to each parent. The raster file name and the CAD file name must be the same (e.g., 123456.001.dwg = 123456.001.tif or 12345A01.dwg = 12345A01.tif).

If an image file name is the generic scanned file name, such as 01390073.tif, it shall be renamed to the correct document number that will match the CAD file. This shall be done even if the image is not attached to a CAD file and is being voided. If the image is attached to a CAD file and needs to be renamed, the image will need to be re-pathed or reattached.

7.2. Compound Externally-Attached Raster Drawings

Compound raster drawings are created when it is desirable to provide a topological or other land-base image behind the actual drawing, and there is no intent to vectorize this image in the future. This normally occurs only with transmission lines, although other special cases may be defined. Multiple layouts may be used to fit raster images across the file.

8. Plotter Setup - Line Color to Line Width Assignment

All AutoCAD drawings shall use the PacifiCorp.ctb color table file for plotting and line weight control. The company's color table is designed for full-size plots (i.e., D-size); therefore, plotting on smaller paper sizes may require toggling the linetype scaling.

Below is a table of modified line widths and screening. All other colors of AutoCAD's 250 colors are a standard width of .012 with screening set to 100 percent. No modifications to the company's color table file are permitted. Colors not shown in Table 7 are a standard weight of 0.0120 with no screening.

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Table 7—Line Color to Line Width Assignment

CTB COLOR TABLE FILE		
NO.	WEIGHT	SCREENING %
1	0.0220	
2	0.0120	
3	0.0071	
4	0.0280	
5	0.0120	
6	0.0120	
7	0.0120	
8	0.0120	20
9	0.0059	
10	0.0177	
11	0.0197	
13	0.005	
15	0.0071	70
30	0.0236	
32	0.0071	
34	0.0157	
41	0.0098	
52	0.0098	
54	0.0098	
61	0.0079	
63	0.0079	
140	0.0220	
151	0.0157	
190	0.0138	
201	0.0050	10
211	0.0138	
213	0.0059	
215	0.0059	
230	0.0256	
242	0.0050	30
251		15
252		25
253		35
254		45

9. Exiting a Drawing

When exiting a drawing, use the following procedure to ensure that the drawing is in a clean state for other users and that the drawing file size has been reduced to saving disk space.

1. Before exiting a drawing, the user should execute a ZOOM EXTENTS command to display all drawing entities in both paper and modelspace.
2. If there are any entities outside of the border other than the date stamp, they should be erased.
3. Use purge command to clean up all unwanted, unreferenced data.

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4. Set the current layer to “0”.
5. Cursor is to be current in paperspace and not within the viewport.
6. All loose entities, found by entering Ctrl-A and shift to deselect all visible entities, either in paperspace or modelspace shall be deleted as with any entities not shown through a viewport.

10. SNAP, OSNAP, and ORTHO Settings

These settings should be used to ensure alignment, closure, and accuracy of lines or objects created by AutoCAD.

The tools used to control drawing alignment and accuracy are SNAP, OSNAP, and ORTHO:

- If SNAP is used to accurately place lines, blocks, and text in a drawing, it should be set to a minimum value of .03125 inches or (1/32") and must be in multiples of .03125 inches multiplied by the scale factor.
- OSNAP allows users to quickly and easily find the most commonly-used pick points on a drawing object and to ensure that lines, arcs, and circles meet accurately.
- ORTHO is used to create or align drawings, lines, and text that are horizontal or vertical.

11. Associative Dimensioning

11.1. General

Dimensions are to be associative or real unless they are being used for a note or text string. (Stick-building dimensions by assembling lines, text, and arrowheads or architectural tics is prohibited.) This will ensure that the dimensioning is consistent and dynamic throughout the drawing. DIM styles are obtained via the appropriate discipline’s tool palette, or through the appropriate template files found in the AutoCAD Support\templates folder.

Place dimensioning on a dim layer, color bylayer (color 3). The dim style naming convention should be associated with the scale factor. For example, if the scale factor is 48, then the dim style used should be 48, with the viewport scale set to 48.

No modification of existing dim styles or the creation of new styles is permitted (i.e.: modifying existing style 48 (1/4″ = 1′0″) to accommodate a change of scale in the viewport from a 48 to 32 (3/8″ = 1′0″) is not acceptable drafting practice). The style of 48 is to be replaced with the style of 32. The dim style STANDARD is not one that should be used or tailored to fit the scale of the drawing.

Where the STANDARD style is in use, it shall be updated to the correct style based on the scale of the drawing.

11.2. Guidelines for Associative Dimensioning

When dimension arrowheads of continuous linear dimensions are forced outside, the dimension is to be offset from the other dimensions so as not to have overlapping arrowheads. The text of the dimension is then moved and centered (not above) between either side of the outward dimension. Additional guidelines for dimensioning variables are outlined below:

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- Layer: DIM, color 3, line type continuous. (All bylayer)
- Location of text is always above or off to the side and centered. Never below or centered on the dimension line.
- Be sure variable DIMASO is set to on (turns associative dimensioning on).
- Do not override dimension values. The exception to this is the addition of a note or text string within the dimension.
- Variable DIMASSOC should be set to the two (2) to keep dimensions linked to their objects.

11.3. Leaders

All leaders (QLEADER or MLEADERS) shall be associative, and drawn using the dimension style matching the scale factor of the viewport. Leaders should be drawn with no more than three points (i.e., two line segments). Leaders associated to text are placed on the same layer as the text.

When using QLEADERS, the operator should escape out of the "place text" option so the text and the leader can be oriented correctly.

11.4. Drawing Units

See Engineering Handbook 9B.10 for discipline-specific unit types.

Drawing units are to be architectural with a minimum precision of 1/32" and the insertion set to inches. An exception to this is the civil survey file, grading plan, and transmission drawings where the units are decimal with an insertion scale of feet.

12. Line-Type Scale

The LTSCALE command sets the scale factor to be applied to all line types within the drawing. A global line–type scale factor is provided for each new drawing with a default value of 1.0. To maintain a consistent line type appearance on drawings the line–type scale (LTSCALE) is set at 0.25. The PSLTSCALE SETVAR should be set to 1.

13. North Arrows

North arrows are to be placed in the upper right hand corner of the title block in paperspace. When working with twisted views or changing the rotation in the viewport, be sure that the north arrow is also rotated correctly. In a twisted viewport (likely in the grading plan), where the survey file is kept in its real-world coordinate, the north arrow is aligned with the crosshairs with the UCS set to WORLD. The north arrow is then brought to the paperspace environment via CHSPACE and the viewport is locked.

The orientation of the north arrow should be true north and not what is referred to as substation north.

An exception to this is that transmission and generation thermal will use Plant North and the north arrow is placed in modelspace.

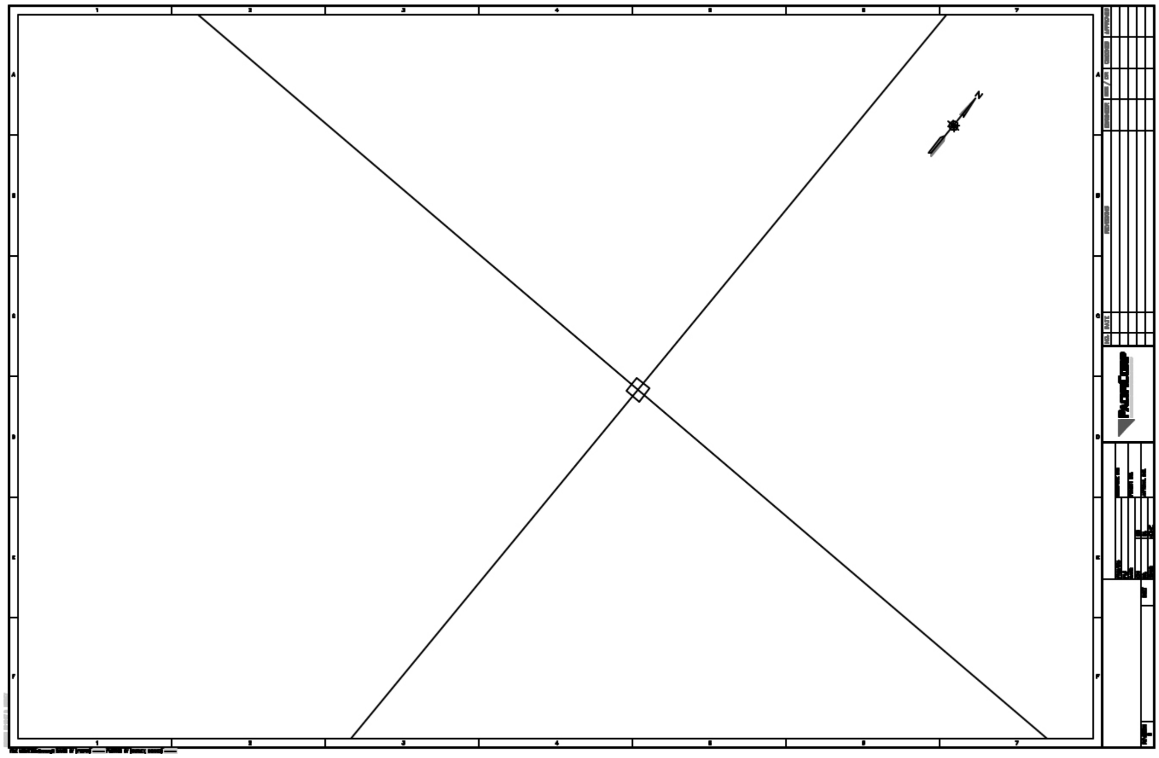

Figure 5—North Arrow With Twisted Viewport

North arrows are used in the following sheet files which show the plan views of the yard. Such sheet files will also use a scale bar:

- General Plan
- Conduit & Cable Plan
- Grounding Plan
- Foundation Plan
- Fence Plan
- Landscaping Plan
- Grading Plan
- Plans & Elevations
- One-Line Diagram (no scale bar)
- Landscape Plan
- Erosion Control Plan

14. Scale Bars

Architectural scale bars found on the Standard palette and are to be placed in the lower middle to right-hand area of the drawing. Decimal scale bars are found on the civil palette, and are to be used in the civil drawings that require a scale bar. The grading plan drawings using decimal units shall use the decimal units scale bars, i.e., 1″ = 20′ and not 1″ = 20′-0″.

Transmission drawings do not use scale bars.

The creation of non-standard scale bars in which field personnel cannot place a standard engineering scale to, such as 1/12″ = 1′-0″ is prohibited.

15. Manufacturer Drawings

When placing manufacturer drawings within company title blocks:

Using the appropriate standard D-size title block, place the manufacturer's drawing into modelspace by copying/pasting from the original file then show it through a viewport. The viewport is given a scale that allows the entire manufacturer's drawing to be shown with the text plotting at or near a height of 3/32". If the drawing is too large to accomplish this, then zoom extents and reduce the scale, leaving a margin of approximately 1" between the company's title block and the manufacturer's title block.

Manufacturer files are not to be opened and "saved-as" a project file. These files are often developed with software other than an Autodesk product, or come from other countries, which can bring in hidden issues that cannot be purged out.

In the Layer Properties Manager, group any layers that are using the color cyan, red, #30, #140, and #230, and change those colors to white so they will not plot heavy. Change any entity that has the colors forced to those colors, back to color bylayer.

If adding any wiring or other information to the manufacturer's file, use company drafting standards. These modifications should have revision clouds even on revision zero drawings.

16. Vicinity Maps

1. Vicinity maps are to be created and modeled after the example vicinity map block found on the standard palette.
2. The map should not be an attached image such as a .bmp or .jpg. It may be temporarily attached, then duplicated by using the entities found within the template block.
3. The new vicinity map is then made into a block so the audit routine will not recognize the forced layer properties. The block is then placed on the vicinity map layer.

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9A.6—Block Usage and Development

1. Scope

This section of the Engineering Handbook contains a general description of block usage and development.

Blocks are no longer kept as individual CAD files, but are categorized by type and placed within various files where they can be brought in using AutoCAD's design center or from shared palettes (palettes being the preferred method). Blocks provided by the company shall not have the properties altered without approval.

2. General Guidelines

All entities that reside in blocks are to be developed on layer 0 using company standards (i.e., text style, height, and justification). If a block is intended to be placed on the steel layer, then all entities considered to be steel within the block are to be on layer 0, color and line type bylayer. Other entities such as hidden lines, center lines, holes, or fittings can be on their respective layers. The attributes and text within a block, even though on layer 0, should be forced to color 7 (white), and not placed on the text layer, so as to always appear white when placed on various layers.

Blocks should be created with insertion point at a position where it will be useful in snapping the block to neighboring objects.

The command MINSERT shall not be used when placing blocks.

3. Insertion Point

The insertion point is the reference point for subsequent insertions of the block. It is also the point about which the block can be rotated during insertion. When inserted, blocks are to be placed on designated layers and should not be xclipped.

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9A.7—CAD Standards and Template Files

1. Standard Files

The company has compiled hundreds of standard files that are available upon request. Many of these files were drafted years ago and should be brought up to current drafting standards, including:

- Current title block and its proper placement
- Correct dimension styles
- Correct text styles, uniform heights, and justifications
- Drawing units
- Layers
- Correct LTSCALEs and PSLTSCALEs
- Entities bylayer and not forced to a color and line type
- Entities in their proper paperspace or modelspace environment.

To ensure the above are within the guidelines of the Volume 9A, use the following procedures in an effort to provide the company with clean CAD files:

1. Use AutoCAD's LAYER WALK to ensure entities are on their proper layers.
2. Use company-provided routines to correct and standardize CAD files. See company engineering procedure 240, *AutoCAD BAD (Batch Drawing Audit) Procedure* for the use of audit tools.

2. Template Files

Template files are available that contain standard settings of layers, text and dimension styles, units, and various title blocks used by the company. These files are discipline-specific for substation/civil, communications, generation, and transmission and are located within the AutoCAD Support/Templates folder.

3. Checking Out Files for Modification

Active drawings intended to be modified are to be checked out of Document Manager. Modifications shall not be made to copies if original drawings are not available for checkout.

4. Final Issue For Construction (IFC) Procedures

The following requirements apply to files returned by consultants:

1. All internal and external modifications to company -owned drawings shall adhere to Engineering Handbook Volume 9, *Computer-Aided Design* and all other supplemental procedural documents or discipline-specific publications.

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2. Drawings to be modified shall be legitimately checked out of DM. Modifications made to copies of drawings, or to drawings from private libraries not obtained from a document control employee is prohibited.

3. All internal and external drafters, designers, or checkers will be responsible for ensuring that CAD standards are being met, prior to submitting to the company, at all review stages.

4. Outside firms shall be pre-approved vendors. They shall insure that all CAD files are submitted to the company at each step in the review process. See item 5 below.

5. To ensure CAD standards are adhered to for company-owned CAD files, review procedures are outlined in company Procedure 211, *Substation Engineering AutoCAD Review for External Consultants*. This publication is referenced in EPC Exhibit A, Section 1 General.

6. The final issuing dates on new rev zero title blocks and revision blocks are to be the same on all drawings being signed and issued. These dates should be on or around 10 days from the issue date. This can be accomplished using the batch routine provided by the company. The Void stamp should also have matching dates. Please contact PacifiCorp AutoCAD Technical Support at (503) 331-4392 or (503) 813-6615.

7. Upon delivery to the company's document control, CAD files associated with AutoCAD's sheet sets and standards checks are to be disassociated.

8. It is advisable to use AutoCAD's ETRANSMIT to ensure all files are bundled together when returning a completed project for final issue. This will minimize missing XREF and image attachments.

9. Files that are returned, checked in, and issued are then available for others to check out for modification. Backup copies shall not be retained in private libraries for future use.

10. Project files for external engineering are re-checked out to consultants to ensure that the files are available for as-builting. These files, not backup copies, must be used. Minor corrections are occasionally made to the files upon check in; those changes are lost when as-built modifications are made to files from private libraries.

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5. CII (Critical Infrastructure Information) Drawings or Documents

See separate CII Procedure V1.05.

6. Handbook Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to Dennis Hurley, substation engineering, (503) 331-4392. This handbook document shall be used and duplicated only in support of company projects.

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9B.1—Transmission

1. Scope

This section of the company's Engineering Handbook provides transmission-specific drafting standards for plan and profile drawings. Other types of transmission drawings are not covered. For examples of the elements described in this document, refer to the transmission sample plan and profile drawing. The sample plan and profile can be obtained internally via the AutoCAD support directory at *J:\Shared Data\AutoCad Support\TEMPLATES\transmission*, or externally at https://pcorpstandards.com/www/w-CAD.html.

For an overview of general company drafting standards, see Engineering Handbook volume 9A, *Computer-Aided Design*. For details on company transmission document control practices, see Procedure 097, *Transmission Documentation*.

2. PLS-CADD Export

Plan and profiles created from PLS-CADD shall be exported to AutoCAD and inserted into an existing plan and profile or in a new plan and profile using the CORPD-TRAN.dwt template border.

3. General Revision Practices

If more than ¾ of a raster image needs to be revised then redraw the entire file in AutoCAD.

Whenever possible, the plan and profile views shall be on the same sheet with the profile portion located above the plan view. If there are more than four breaks in the profile, it is appropriate to have the plan and profile views on separate pages. When plan and profile drawings are on separate pages, the profile sheet shall have an "A" suffix for the sheet number, for example, "12345T01" for the plan and "12345T01A" for the profile.

4. Layer Control

a. Use only standard layers that come in the CORPD-TRAN.dwt template file. See Table 1 for a list of standard layers for plan and profile drawings.

b. If a new layer seems appropriate, it must be approved by the transmission group. Submit new layers for consideration with the following naming convention: "PRO-XXXXX" for profile view layers or "PL-XXXXX" for plan view layers.

c. Assign color and line type by layer for all lines, objects, blocks, and text.

d. Before a drawing is sent to document control to be checked-in, it should be purged of all non-standard entities and standard entities that are not in use. Purge all unused layout tabs

Table 1—Plan & Profile Layers

NAME	COLOR SETTINGS		LINETYPE		USE
	COLOR	WIDTH	LINETYPE	SAMPLE LINE	
0	(7) WHITE	.012"	CONTINUOUS		BLOCKS
DEFPOINTS	(7) WHITE	.012"	CONTINUOUS	THIS LAYER IS SET NOT TO PLOT	DEFPOINTS
DIM	(3) GREEN	.0071"	CONTINUOUS		DIMENSION LINES & DIMENSION TEXT
IMAGE	(7) WHITE	.012"	CONTINUOUS		RASTER IMAGES
LOCKED Tran-Stamp	(7) WHITE	.012"	CONTINUOUS		LOCALITY NUMBER, LINE CODE, DRAWING #
PHASING	(7) WHITE	.012"	CONTINUOUS		PHASING CONFIGURATION
PL-40-SEC	(3) GREEN	.0071"	TFORTY		FORTY ACRE LINES
PL-BUILDING	(5) BLUE	.012"	CONTINUOUS		BUILDINGS
PL-CL-STA	(7) WHITE	.012"	CONTINUOUS		HIGHWAY CENTERLINE STATION TICKS & TEXT
PL-COND1	(1) RED	.022"	CONTINUOUS		MAIN TRANSMISSION LINE ROUTE
PL-COND2	211	.0138"	CONTINUOUS		OTHER TRANSMISSION & DISTRIBUTION LINES
PL-COUNTY LINE	(7) WHITE	.012"	TCENTER		COUNTY LINE
PL-CURB & GUTTER	9	.0059"	CONTINUOUS		CURB & GUTTER
PL-FENCE	(3) GREEN	.0071"	TFENCE	—x—x—x—x—x—	FENCE
PL-GUY	(7) WHITE	.012"	CONTINUOUS		DOWN GUYS
PL-N-ARROW	(7) WHITE	.012"	CONTINUOUS		NORTH ARROW
PL-OTHER UTILITIES	190	.013"	CONTINUOUS		OTHER UTILITY FACILITIES
PL-OWNER	(7) WHITE	.012"	CONTINUOUS		OWNERSHIP
PL-PIPELINE	(3) GREEN	.0071"	TPIPE		OWNERSHIP
PL-POLE	(7) WHITE	.012"	CONTINUOUS		TRANSMISSION MAIN LINE ROUTE POLES
PL-PROPERTY LINE	(3) GREEN	.0071"	TDASH		PROPERTY LINES
PL-QU-SEC	(7) WHITE	.012"	TQUARTER		QUARTER SECTION LINES
PL-RAILROAD	(7) WHITE	.012"	TRACKS		RAILROAD TRACKS
PL-ROAD-DIRT	9	.0059"	TDASH-		EDGE OF DIRT ROADS
PL-ROAD-PAVED	9	.0059"	CONTINUOUS		EDGE OF PAVED ROADS
PL-RWLINE	(3) GREEN	.0071"	TPHANTOM		RIGHT-OF-WAY LINES
PL-SECTION	(7) WHITE	.012"	CONTINUOUS		SECTION LINES
PL-SIDEWALK & DRIVEWAY	9	.0059"	CONTINUOUS		SIDEWALKS & DRIVEWAYS
PL-STATE LINE	(4) CYAN	.028"	TPHANTOM2		STATE LINE
PL-TOPO	(3) GREEN	.0071"	CONTINUOUS		MISC TOPO
PL-VEGETATION	(3) GREEN	.0071"	CONTINUOUS		TREES, BUSHES, GRAIN FIELDS
PL-WATER FEATURES	(5) BLUE	.012"	TCREEK2		LAKES, RIVERS, CREEKS, PONDS, SWAMPS
PRO-ARM	(7) WHITE	.012"	CONTINUOUS	THIS LAYER IS SET NOT TO PLOT	ATTACHMENT POINT ON POLES IN PROFILE
PRO-CLEARANCE	(7) WHITE	.012"	TPHANTOM		GROUND CLEARANCE LINE
PRO-DAMPER	(7) WHITE	.012"	CONTINUOS		DOGBONE AND SPIRAL VIBRATION DAMPERS
PRO-GRID	250	.0071"	TDOT		PROFILE MINOR GRID LINES
PRO-GRND-CEN	(1) RED	.022"	CONTINUOUS		CENTERLINE GROUND ELEVATION
PRO-GRND-LT	(3) GREEN	.0071"	TDASH		LEFT SIDE SHOT GROUND ELEVATION
PRO-GRND-RT	(3) GREEN	.0071"	TDASHDOT		RIGHT SIDE SHOT GROUND ELEVATION
PRO-MILE-MARKER	(7) WHITE	.012"	CONTINUOUS		MILES FROM STARTING POINT
PRO-POLE	(7) WHITE	.012"	CONTINUOUS		POLES IN PROFILE
PRO-SAG-DIST	(7) WHITE	.012"	TDASH2		DISTRIBUTION CONDUCTOR SAG
PRO-SAG-NEUT	(7) WHITE	.012"	TDASH		NEUTRAL DISTRIBUTION SAG
PRO-SAG-STATIC	(3) GREEN	.0071"	CONTINUOUS		STATIC OR FIBER OPTIC LINE SAG
PRO-SAG-TRANS	(5) BLUE	.012"	CONTINUOUS		TRANSMISSION CONDUCTOR SAG
PRO-STATION	(7) WHITE	.012"	CONTINUOUS		POLE STATION LINE
PRO-VERT_INSUL	(7) WHITE	.012"	CONTINUOUS		POLE TOP INSULATOR LOCATION
PRO-XING	(1) WHITE	.012"	CONTINUOUS		WIRE CROSSINGS IN PROFILE
REV	(1) RED	.022"	CONTINUOUS		REVISION NOTE & REVISION CLOUD
TEXT	(7) WHITE	.012"	CONTINUOUS		TEXT
TEXT-LRG	(7) WHITE	.012"	CONTINUOUS		LARGE TEXT
TEXT-SM	(7) WHITE	.0071"	CONTINUOUS		SMALL TEXT
VPORT	8	.012"	CONTINUOUS	THIS LAYER IS SET NOT TO PLOT	VIEW PORTS
VPORT BOUNDARY	253	.012"	TDASH	THIS LAYER IS SET NOT TO PLOT	SHOWS PSPACE VPORT BOUNDARY IN MSPACE
XREF	(7) WHITE	.012"	CONTINUOUS		EXTERNAL REFERENCE DRAWINGS

5. Scale and Drawing Size

a. For urban areas, utilize a scale of 1"=200' horizontal, 1"=20' vertical. For rural areas, utilize a scale of 1"=400' horizontal, 1"=40' vertical.

b. Draw plans and profiles full-size in model space and scale via viewport in paper space. Omit any excess entities in model space that are not being viewed in paper space.

c. Lock the viewport after it has been scaled and positioned correctly.

d. Use only the standard dimension styles that come in the CORPD-TRAN.dwt template file. See Table 2 for a list of standard dimension styles for plan and profile drawings. For example, when using a scale of 1"=400' horizontal, use dimension style “400.”

e. Set Ltscale at <0.25>, PSLtscale at <1>, and Plinegen at <1>.

f. Save files in paper space zoomed to border extents with the zero layer active.

Table 2—Text and Dimension Styles

			DIMENSION	TEXT					
DRAWING	HORIZONTAL	SCALE		0.09375		0.125		SAMPLE	
ENVIRONMENT	SCALE	FACTOR	STYLE	STYLE	HEIGHT	STYLE	HEIGHT	TEXT-LRG	TEXT-SM
PAPER SPACE	1"=1"	1	1	T1S	0.09375	T1L	0.125	TEXT-123	TEXT-123
MODEL SPACE	1"=50'	50	50	T50S	4.6875	T50L	6.25	OTHER SETTINGS PSLTSCALE = "1" LTSCALE = .25 PLINEGEN = "1"	
MODEL SPACE	1"=100'	100	100	T100S	9.375	T100L	12.50		
MODEL SPACE	1"=200'	200	200	T200S	18.75	T200L	25		
MODEL SPACE	1"=400'	400	400	T400S	37.5	T400L	50		
MODEL SPACE	1"=600'	600	600	T600S	56.25	T600L	75		

6. Text Style

a. Use only the standard text styles that come in the CORPD-TRAN.dwt template file. See Table 2 for a list of standard text styles for plan and profile drawings. For example, when using a scale of 1"=400' horizontal, use text style T400L for large or T400S for small text.

b. When plotted to scale, large text shall be ⅛-inch and small text shall be $^{3}/_{32}$-inch.

7. Blocks and Tables

7.1. Standard Abbreviation Block

Locate the standard abbreviation block along the bottom of the border and to the right of the structure and conductor tables in paper space. Do not explode this block.

7.2. Structure Table

a. Locate the structure table in the lower left hand corner of the border in paper space.

b. List all the structure types used on the sheet being viewed, plus any other associated drawings such as framing, foundation, load tree, criteria, and/or manufacturer drawings.

c. The structure table may be exploded if necessary to expand the number of lines, but the attributed text within the tables shall not be exploded.

7.3. Conductor Table

a. Locate the conductor table along the bottom of the border and to the right of the structure table in paper space.

b. Fill in the conductor information as shown on the sample plan and profile drawing.

c. The conductor table may be exploded if necessary to expand the number of lines, but the attributed text within the tables shall not be exploded.

BLOCK	BLOCK NAME	LAYER
CONDUCTOR TABLE	CHART-C	CREATED IN LAYER "0"

CONDUCTOR INFORMATION									
		DISPLAYED				DESIGN			
SECTION	CONDUCTOR TYPE	TEMP. °F	WEIGHT (lb/ft)	FINAL TENSION	ICE (in)	RULING SPAN	MWT (lbs)	NESC LOADING	FINAL SAG CHART NO.

BLOCK	BLOCK NAME	LAYER
STRUCTURE TABLE	CHART-S	CREATED IN LAYER "0"

STRUCTURE INFORMATION				
STRUCTURE TYPE	FRAMING DRAWING NO.	STEEL STRUCTURE DRAWINGS		
		FOUNDATION	OTHER	WORK ORDER

BLOCK	BLOCK NAME	LAYER
STANDARD ABBREVIATIONS	STANDARD ABBREVIATIONS	CREATED IN LAYER "0"

STANDARD ABBREVIATIONS

SG – SIDE GUY(S)
SPG – SPAN GUY(S)
HG – HEAD GUY(S)
BG – BACK GUY(S)
LD – HORIZONTAL GUY LEAD(S) (MEASURED FROM SURVEY CENTERLINE TO ANCHOR ROD EYE)
SI – STRUT INSULATOR
☐ – FIBER SPLICE POINT
A – ANCHOR(S)
(24D) – 24" DISK
(30D) – 30" DISK
(SA) – SCREW ANCHOR
(RA) – ROCK ANCHOR
CL – CLASS OF POLE
ø – PHASE
L,C,R – LEFT, CENTER, RIGHT
⊥ – DAMPER: DOGBONE
–^^– – DAMPER: SPIRAL VIBRATION

Figure 1—Standard Conductor Table, Structure Table, and Abbreviation Block

8. Profile Structure Text

The text above the structure shall include the following information, in the order shown:

a. Structure height

b. Type

c. Class (for wood structures) or steel (for steel structures); (see Examples 1 and 2 below)

d. Switch number (switch structures only)

e. Cross braces

f. Number of guys. List guying as number of guys to number of anchors, plus direction (for example, “3BG-2A 45' 65' LD” for three back guys going backwards on station to two anchors; “3HG” means three head guys)

g. Number of anchors

h. Anchor type

i. Guy lead distance (see example 1 below.) List lead length after anchors. The lead is the horizontal distance from pole base to anchor eye.

j. Structure or foundation depth (steel structures only); (see examples 2 and 3 below)

k. Foundation type and diameter (see example 3 below)

l. Name of tap line, if applicable (see example 3 below)

Example 1—Wood Pole with Guying

75'-75' TG420 CL-2
X-BRACE
4SG-2A(24D),45', 50'LD

Example 2—Steel Pole with Direct Embed

80' TG201 STEEL
DIRECT EMBEDMENT 10'-0"

Example 3—Steel Structure with Caisson on a Tap Line

85' TS600 STEEL SW#3L162
CAISSON: DEPTH=26'-6",DIA=6'-6"
TAP TO VALLEY SUBSTATION

9. Phasing

a. Represent phasing using phasing diagrams (i.e., structure stick figures) showing how the structure is configured. Note phasing at the conductor attachment points.

b. Show the new phasing diagram in profile view whenever there is a framing type change or transposition.

c. Place the structure number and directional coordinates under the phasing diagram. Show the direction of the structure looking ahead according to stationing.

d. Indicate how phasing was determined as a note on new drawings or in the revision block for revised drawings. For satellite phasing, note the reference used (e.g., Portland hub, Salt Lake City hub). For phasing determined visually, note the source (e.g., line patrolman, transmission engineer, or operations from sub to sub).

10. Required Elements for Plan & Profile Drawings

See the company's sample plan and profile drawing for examples of the following required elements.

10.1. Plan View Required Elements

a. Adjacent transmission lines and taps labeled with line name, voltage, and drawing number.

b. Topographical features such as bodies of water, ditches, wetlands, rock outcroppings, wooded areas, highways, main roads, local roads, dirt roads, buildings, fences, pipelines, other utilities (above- or underground), railroad tracks, orchards, other power lines, trees, curb and gutter, driveways, sidewalks, and vegetation.

c. Crossings such as highways, roads, wire crossings, pipelines, and railroad tracks shown with labels.

d. County and state lines, shown with labels.

e. Section line labels. Label section corners and center of sections with the appropriate blocks. Label text must be oriented to correspond with the north arrow (such that the text is right-side up when the drawing is oriented with north arrow pointing upwards).

f. Section and quarter-section lines with labeled section corners. Where available, include 40 acre lines.

g. Section corner ties. The transmission line should be tied to a section corner or quarter-section corner at least twice per sheet, preferably at angle structures. Label ties with the bearing and distance.

h. Coordinates at every angle structure. On drawings with no angle structure shown, a minimum of two coordinates shall be tied on the sheet at two tangent structures.

i. Coordinates in UTM feet, NAD 83, within the proper zone, 10, 11, 12, or 13.

j. Angle structure labels. All angle structures are to be labeled showing the structure number, station, and deflection angle ahead to the nearest second, with the coordinates, for example:
#50 138+00 PI=39°44'13"RT. N: 151878525 E: 889886.

k. Label at least every fifth structure.

l. Substation labeled with large text. Only show the perimeter fence, substation rack (deadend structure), span going into the substation, and attachment point at the substation rack.

m. Down guys shown in the direction that the structure is guyed, with the number of anchors visually represented. (Use the guying layer and correct anchor dimension style.)

n. Span guys and stub poles (shown with the guy leads).

o. Transmission right-of-way (ROW) lines with labeled width.

p. Survey bearing next to the centerline placed in each bearing section between angle points.

q. Section, township, and range lines labeled when crossed. If a township and range line isn't shown through the viewport in paper space, the township and range label shall be placed parallel to the north arrow.

r. North arrow.

10.2. Profile View Required Elements

a. Section of line labeled with a letter corresponding to the conductor table. Each section shall be labeled whenever there is a change in the conductor info. Changes in conductor info include wire type, ruling span, and maximum working tension.

b. Structure numbers for every structure listed beneath the pole. Structures are numbered sequentially with a number symbol (e.g., #145) or structure over mile (e.g., 14/12).

c. Major station gridlines labeled horizontally every 1000 feet for 400-scale drawings or every 500 feet for 200-scale drawings.

d. Major elevation gridlines labeled every 100 feet for 400-scale drawings or every 50 feet for 200-scale drawings.

e. Ground elevation lines shown as surveyed along the centerline of the main line route. If necessary, right and left side shots should be shown and labeled as "R" or "L."

f. Profile grid using a standard grid block which shall never be exploded. For most profiles, the "profile1" block is appropriate. In cases where the profile doesn't accurately correspond to the "profile1" block, the "profile3" block may be substituted. The "profile2" block is used for full-page profiles.

g. Crossings above or below the ground line noted under the ground elevation line. Crossing may include any obstacle with horizontal or vertical clearance restrictions, such as wires, roads, railroad tracks, water ways, signs, trees, buildings, pipelines, underground utilities, etc.

h. Conductor sags drawn using information from the conductor table.

i. Direction of structure stationing and numbers, increasing as they move from left to right across the sheet.

j. Station tic marks placed perpendicular to and on the bottom of the grid line.

k. Structure stations labeled vertically above tic marks (include station equations as necessary).

l. Deflection angle text (rounded to the nearest minute) shown at the bottom of the profile grid next to the structure station.

m. Mile markers placed at the bottom of the profile gridline every mile using the standard mile marker block. Mile markers shall run in the same direction as the structure numbers and stationing.

n. Poles drawn to full height, taking into account the standard embedment depth of ten percent of pole height plus an additional two feet. For example, an 80-foot pole will measure 70 feet from the ground line to the pole top.

o. Wire attachments for transmission, distribution, neutral, and communication using the "PRO-ARM" layer to draw a short line perpendicular to the structure line at each attachment point. This layer is visible but will not plot.

p. Span length (rounded to nearest foot) listed below the bottom conductor between structures horizontally.

q. "Fiber Splice" block placed at OPGW AND ADSS fiber deadend splice locations on the pole in the profile view.

r. "VERT-INS-TIP" block placed where a conductor attachment is above the pole top because it is attached to a vertical post insulator.

s. "DAMPER-SPIRAL" or "DAMPER-DOGBONE" blocks placed as appropriate.

10.3. Paper Space

The only objects that belong in paper space include the structure table, conductor table, standard abbreviation block, and CORPD-TRAN border.

11. Handbook Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to Daniel Newcomer, transmission engineering, (503) 813-6791. This handbook document shall be used and duplicated only in support of company projects.

9B.2—Substation Drafting Standards

1. Scope

This section of the company's engineering handbook provides substation discipline-specific drafting and design standards, including details on electrical and protection & control drawings.

For an overview of general company drafting standards, see Engineering Handbook Volume 9A, *Computer-Aided Design*.

2. General

Standard drawings and blocks have been developed for use in substation drafting. They are referred to here. However, the actual standard drawings reside within Document Manager and the AutoCAD blocks reside within the ...\AutoCad Support\ directory.

Tabbed files are not used in electrical drawings.

3. General Drafting Practices

The following are general drafting practices standard to the company. When creating documents for company substation engineering, adhere to the standards set forth by the engineering and asset management department.

3.1. Title Blocks

Title blocks of existing drawings shall be converted to the current title block. This is not necessary if the drawing is being voided, or being used only for reference in the design package. Older drawings shall not be voided and superseded with a new drawing just to bypass the process of converting the title block.

The command TBS, or the BAD audit tool, will convert nearly all older title blocks with minor cleanup. The older revision history is deleted and is not transferred to the new title block. If it is deemed necessary to keep the most recent revision, then the REVSWAP command can be used to convert the old nomenclature into the new revision block.

Any floating text over the old title block shall be removed or entered into the new title block.

3.1.1. Title Block Nomenclature

If the following information is missing, it shall not be corrected or filled in with current project nomenclature:

- WO/ER#
- Date
- Signatures

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If the following information is missing or incorrect it shall be corrected. Refer to engineering document Policy 104, *Indexing of Discipline and Document Type*, for correct disciplines and document types:

- Discipline name (for example, “SUBSTATION” is not a valid discipline name)
- Document type
- Substation name for example, if the voltage is included in the substation name, “DIXONVILLE 230KV SUBSTATION,” the voltage shall be removed. Keep in mind that DIXONVILLE 500 (without the KV) is a valid facility name and 500 is not to be removed. If the facility is DIXONVILLE 500 and the 500 is missing it will need to be added. The plant locality for DIXONVILLE 500 is 068163.
- Scale, which shall read, “NONE,” “AS NOTED,” or be entered with a valid scale

3.1.2. Correct Date Format

- JANUARY 03, 1997 shall be 01/03/1997
- 1-3-97 shall be 01/03/1997
- 1/3/1997 shall be 01/03/1997

3.1.3. Sheet Numbering

Sheet numbering shall be corrected as follows:

1. Sheet 1 shall read, “1 OF (total sheets)”
2. 2 OF 10 shall read, “2”
3. 2 OF * shall read, “2”

3.1.4. Plant Locality Number

The plant locality number, shown shall be 6 digits. If the plant locality number is missing or incorrect, it shall be filled in or corrected. If the plant locality number is only 5 digits, place a zero (0) at the beginning of the plant locality number.

3.2. Drawing Numbers

Drawing numbers are assigned, and establish a relationship between each drawing within a drawing series. Drawing numbers are unique identifiers, managed within the Document Manager system. Any addition, removal or modification must be approved by the company’s document control department. For more information on this process, see Volume 9A.2, section 7, *Drawing Numbers*.

3.2.1. Adding New Drawing Numbers

If a new drawing number is needed, email drawing@PacifiCorp.com to reserve drawing numbers for your project.

3.2.2. Adding Drawings to a Series

If new drawings are to be added to an existing number series, sheet 1 of that series is checked out so that the total number of drawings in the title block can be modified to reflect the new drawing series total. Adding new sheets to the end of the drawing series may be the only modification to sheet 1, and in this case, sheet 1 will be included in the design package and “rev'ed up” with a revision cloud around the new total number of sheets.

3.2.3. Legacy Drawing Numbers in Drawings

Use the FIND command to replace any old drawing name formats that reference legacy drawing names, for example: PD-, PA-, PC-, PB-, UD-, UE-, UC-, as the prefix of the drawing number. If any such names are found, they shall be deleted, leaving only the 5-digit number.

Find-and-replace will also do a global legacy number clean-up. Enter the prefix “PA-” in the find field and select “Replace All”; do this for all prefixes mentioned above. If the drawings are in .tif format, remove the prefix using “raster design.”

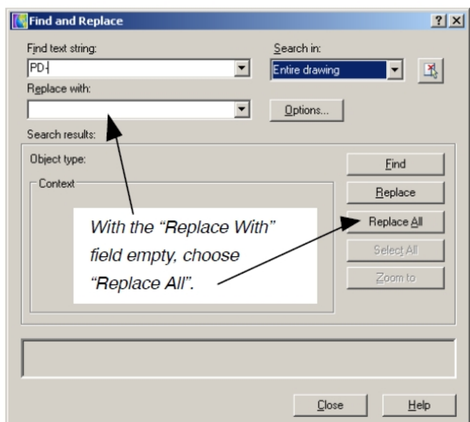

Figure 1—Find-and-Replace to Remove Legacy Prefixes (Example)

3.2.4. Splitting Drawings

New drawing sheets shall not be created from an existing sheet within a drawing series by splitting the drawing and naming it with an “A” behind the drawing number (for example, 12345A09A , or 123456.009A).

If a drawing must be split, perform either of the following:

1. Move forward all drawing content of the sheets following the sheet being split. This is described in the process for creating a key sheet. If this process is problematic, call AutoCAD technical support at (503) 331-4392 for assistance.
2. Move the two sheets to the end of the series making them both Rev 0 drawings. The drawing number that is being split or moved will be rev'ed up and left black as a place-

holder for future use. See Engineering Handbook Volume 9A.4, section 3.7 for information on voiding drawings.

3.3. Drawing Notes

Parentheses should not be used when a reference to a note is associated with a leader. When the reference is within a sentence or without a leader, parentheses should be used. See Figure 2 below. The text should read “NOTE 1” rather than “SEE NOTE 1.”

Strings of text that refer to a certain note shall be consistent in all the company drawings.

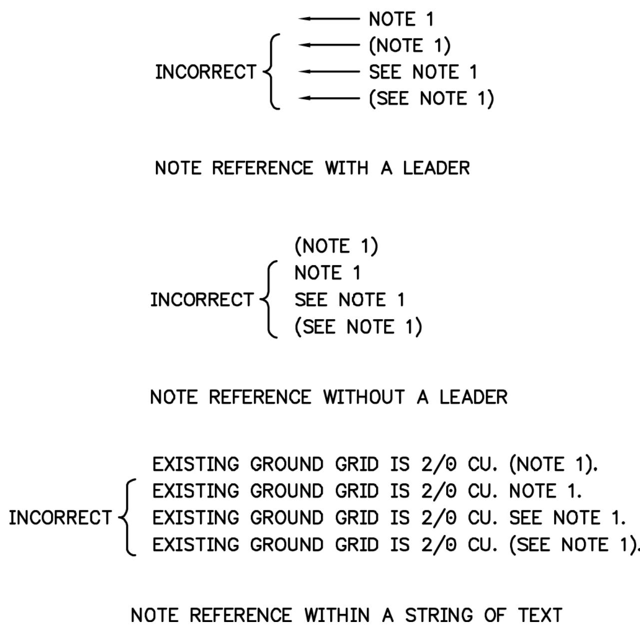

Figure 2—Text String Formatting For Notes

3.4. Dimensions

Use the appropriate DIM style for the scale of the viewport from the standard palette. Do not modify, create, or stick-build dimensions. Always use real associative dimensions and QLEADERS taken from the standard palette. Follow these guidelines:

1. Place dimensions on the DIM layer color green.
2. Leaders shall be placed on the same layer with which they are associated, not the DIM layer. Typically this is the text layer.
3. Linear dimensions should be offset when arrows are forced out, to keep arrowheads from overlapping (see Figure 4).
4. DIM text shall be above the dimension line or off to the side, and centered, when the arrows are forced out.
5. DIM nodes shall be snapped to the entity being dimensioned such that the DIM gap is displayed and not overlaying the object.
6. When dimensioning to a circle, the DIM nodes shall be snapped to the quadrant (not to the center).
7. Dimensions originating from a line type (such as a center line or property line), shall have extension lines pulled back to the arrowhead so that the line type is not compromised.
8. Floating text placed outside the dimension shall be avoided. Enter additional text within the dimension by entering “ED” at the command line. To place text beneath the dimension line, enter a backward slash and an uppercase “X” behind the dimension value. The “ \X ” will force the additional text below the dimension line.

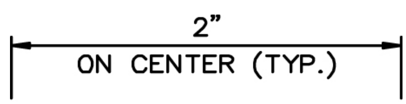

Figure 3—Forcing Text Below the Dimension Line (Example)

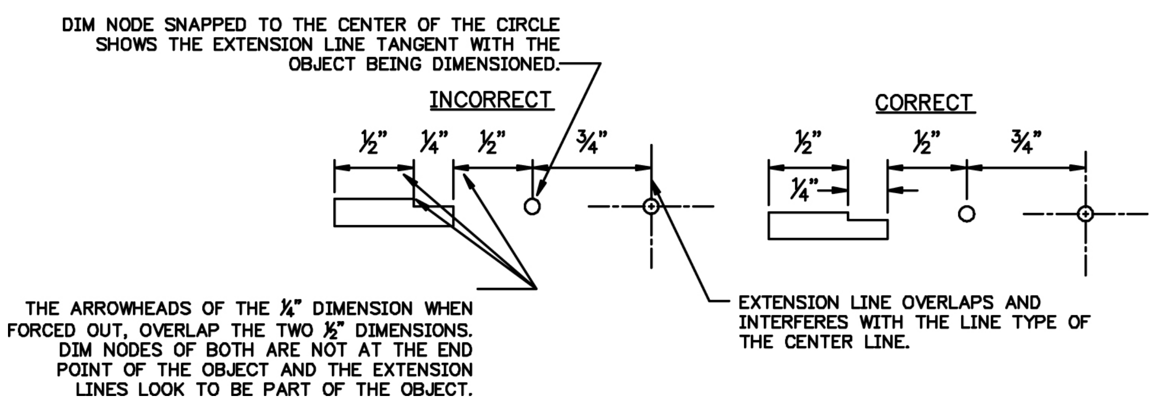

Figure 4—Overlapping in Linear Dimensioning

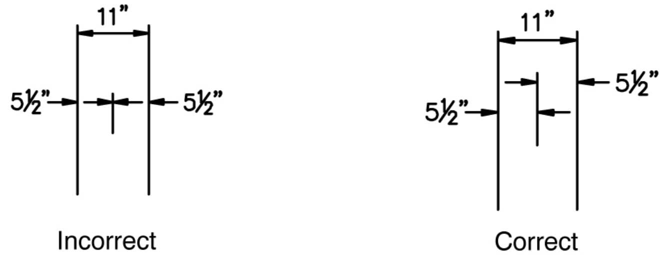

Figure 5—Electrical Dimensioning

3.5. Hatch

Place a hatch object within a closed PLINE using the hatch-outline layer to create the hatch boundary. The boundary is to be retained (not deleted) so the hatch remains associated. Be sure that the insertion points of all hatches are within the closed boundary, not at a point outside. Ensure this by selecting the hatch to see where the grip is located.

Never explode hatch. If time permits, replace a poorly-placed hatch that does not comply with the criteria described above.

3.6. Key Sheets

When a key sheet is added to an existing drawing series, as in a one-line, general plan or grounding plan, the original sheet 1 becomes the key sheet. The document type stays as the same. The text "Key Sheet" is placed on the fourth line (attribute #6) of the title block. The title block retains its original information and is rev'ed up. All title blocks of the subsequent sheet files stay in place. Only the drawing content is transferred to the other sheets (and rev'ed up) with the revision block describing the modification. Revision blocks and information are not moved to other sheets with the drawing content. However, the new revision shall note that the sheets were moved forward due to the addition of a key sheet. Alternately, a note may be placed to indicate this. See " Title Blocks" on page 1

The last sheet shall be a new sheet with all the new nomenclature in the title block and will be a rev-zero drawing, even if the drawing content came from an existing drawing. Sheet 1 will have the total number of drawings adjusted to reflect the new sheet total, with a cloud around the new number. The revision block shall describe the modification.

Note: Matchlines should be used on all key sheets except for one-lines in which the key sheet line type and text should be used. For more on placing matchlines, see " Matchlines" on the facing page, Matchlines.

3.7. Layers

This section provides general instruction regarding drawing layers. See " Layers" on page 27 for layers specific to electrical, and protection & control drawings.

Legacy title blocks and reference drawing blocks were built using a layer called "BDR." If present, this layer shall be converted to layer zero using the BAD audit routine.

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Do not use the Layer Translator to convert the BDR layer. This will force the colors back to bylayer causing the title block and the PacifiCorp logo to lose their forced colors.

3.8. Matchlines

Use the dynamic MATCHLINES block, which contains different views for the different uses. This block is found on the standard palette on the paperspace tab.

1. Stretch the matchline out past the area of entities that terminate at the matchline by an inch or so. The text can be stretched along the line for desired placement.
2. Remove all entities beyond the matchline by trimming, or clipping with XCLIP.

3.9. Tab / Tabbed Files

Tabbed files shall not be used in the company's electrical or protection & control drawings.

3.10. Watermarks

Drawings undergoing review during the design phase shall be labeled by selecting the appropriate view of the provided "issue stamp" block, or by a watermark in PDF files. This process is only used when the drawings are going to an external entity for bid purposes, or for preliminary review.

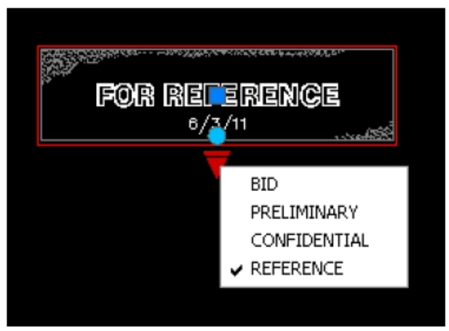

Figure 6—Watermark Setup Options

Drawings issued for construction shall not use this block or be watermarked. Construction drawings must have final approval signatures, with an attached transmittal for construction.

4. Demolition/Green Line Drawings

Demolition drawings are not retained or uploaded into Document Manager. For construction purposes, the AutoCAD file is "saved-as" with the word "DEMO" placed in front of the file name with a dash, and also in the title blocks as follows:

Example: DEMO-123456.001.dwg title block reads, "DEMO-123456.001." The original drawing number of 123456.001 is retained, and the existing content is replaced with the new design with a revision cloud and revision block describing the new work.

When there is a need to include "Green Line" drawings with a construction package, observe the following procedure:

1. The drawing is copied out of Document Manager in its original form, and is kept separate from the other construction drawings in a "reference drawings" folder. It is important that changes are not made to the drawing being used for the green line.
2. The drawing is printed full size (22″ × 34″), and the portions to be removed are marked with a green pencil or highlighter taking care not to obstruct the text. When all parts to be removed have been marked, the drawing should be scanned in color and a copy retained with the project documents for reference.
3. The green line is included with the construction package that is issued to the field; however there is no need to reproduce it for all the packages.

5. Manufacturers' Drawings

5.1. Placement and Scale

Manufacturers' drawings are to be placed in modelspace and shown through a viewport. The viewport is not zoomed to extents, but scaled so that the text is at or near the height of 3/32″.

5.2. OLE Objects

Some manufacturers' files may come with OLE Objects. These objects shall be embedded rather than linked.

5.3. Color Modification

Generally, manufacturers' drawings are not modified unless any layer or entity uses the colors cyan, red, #30, #140, or #230. Those colors have an undesirable bleed and shall be changed to a color that plots lighter. Additionally, line weights need to set to bylayer.

5.4. Manufacturer's Title Block

Place a minimum margin of 1″ between the manufacturer's title block and PacifiCorp's title block.

5.5. Trachte Manufacturer Tab Files (Converting Drawings that Use Tabs or an XREF'ed Title Block)

Files from manufacturers' drawings with attachments will not be accepted, and shall not be entered into Document Manager.

5.5.1. Handling Tab Files

1. Bind the XREF'ed manufacturer's title block to the tab file (do not XREF this).
2. Separate tabs into individual drawing files, i.e., 123456.001, .002, and so on. (There can be approximately 25 to 35 tabs to a file.)

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3. In the new sheet files, bring all that is in modelspace to paperspace by typing CHSPACE in each of the viewports. This allows the process in step 7 to take place without bringing nested layers that are frozen to paperspace.

5.5.2. Handling Layers

In the layer manager, change all layers that use cyan to white and change any entity forced to cyan back to bylayer.

In each of the viewports, layers are frozen within certain blocks so that certain entities do not appear when plotting. In modelspace, use the BURST command and select all the entities by making a window or crossing around them.

Note: This process only affects blocks with nested layers or layers which are frozen in the viewports (not text or dimensions).

As the final step, PURGE all.

5.5.3. Handling the Viewports

1. in files viewing the same entities through two different viewports:
   a. Enlarge one of the viewports.
   b. Enter into floating modelspace.
   c. Make a copy of the entities being shown in another viewport.
   d. Bring that copy to paperspace.
   e. Delete that viewport.
   f. Move the copied entities to the desired location in paperspace.
   g. Enter the viewport of the other showing the same entities, and bring them to paperspace.
   h. Delete that viewport.
2. Once all valid contents are in paperspace, delete all the viewports, go to modelspace and delete all that is left behind.
3. In paperspace, create a single viewport with an appropriate scale and transfer all the manufacturers' entities through it into modelspace. Lock the viewport and "purge all."

5.6. Switchgear Drawings

Of the files provided, nearly half are true manufacturers' files; the rest come from the company's standard drawing files. The true manufacturers' files should already have the document type "Manufacturer's Drawing" in the 3rd line of the title block.

The company files already meet the substation discipline's 3rd line drafting standard. Do not replace what is already in the 3rd line of the title block with another 3rd line doc type. Do not change the document type to read "Manufacturer's Drawing," and do not change the layout name for these files.

5.6.1. Logo

Leave the manufacturer's logo in all the drawings.

5.6.2. Numbering the Drawings

Number the switchgear drawings with the following criteria:

1. Manufacturer's drawings shall share the same 6-digit drawing number, with the suffix of .001, .002, .003, etc.
2. Potential schematics and current schematics shall have a different 6-digit drawing number, either the same number as the existing relative schematic of the substation (if it exists), or a newly-assigned number.
3. The one-line drawings shall also have another 6-digit drawing number, combined together under one 6-digit number with the suffix of .001, .002, .003, etc, or added to the substation's existing one-line drawing series.

The same process applies to key sheet drawings (see " Key Sheets" on page 6, Key Sheets).

5.6.3. Layers

Two layers are provided and used by the manufacturer when connecting to company drawings. The layers are:

1. OEM-PPP-DIM
2. OEM-PPP-WIRING

These layers are used only by the switchgear manufacturer, and are to be left in the drawings as they are. They are not to be converted to layer zero or the text layer, or dim layer.

6. Text

All text is to plot at a height 3/32″. Single line text (DTEXT) is preferred for single strings of text. Multiline text (MTEXT) is preferred for strings of text, such as notes, that require multiple lines of text.

When placing DTEXT, justification shall be set either left, right, or centered with a plotting height of 3/32″.

MTEXT justification shall be appropriate to the placement of the text in relation to the design with which it is associated. For example, TL, TC, or TR shall be used with leaders and notes.

6.1. Headings

A block called SUB TITLE is used beneath larger details, in plan drawings, and plan and elevations drawings, and is placed on layer zero. This block is placed beneath each detail in the same modelspace or paperspace environment where the detail is located. Protection & control drawings do not use this block.

Another block called MULTILINE SUBTITLE is used where multiple lines of text need to be used for both top and bottom attributes.

In legends, notes, tables, and other areas where the desired height is 1/8”, text is placed on the text layer (not the text-hvy layer, which has been removed from production).

6.2. Layers

Text shall be placed on the text layer, color yellow from the standard palette. Other acceptable layers for text are as follows:

1. FUTURE
2. DIM, if the text is associated with the dimension, but it is preferred that the text be entered inside the dimension. See " Dimensions" on page 5, Dimensions.
3. REV (if associated with the revision cloud, which is removed during the next revision)
4. KEY-SHEET-LINE-TEXT with a text height of 1/8″ for the associated text

6.3. MTEXT Editor

In the MTEXT editor, if the fraction is stacked horizontally, right mouse over the stacked fraction to obtain the menu as shown below, and select “Stack Properties.” If the menu is hidden, first type ATTIPE, set it to 1, then return to the MTEXT editor and proceed.

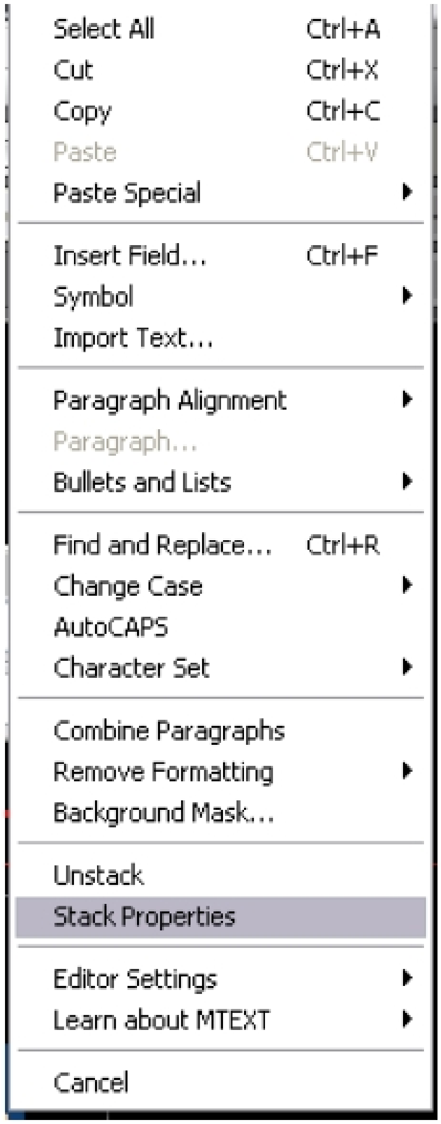


Figure 7—Selecting Stack Properties

Set the appearance to “Fraction, Diagonal,” then select “AutoStack,” and check the boxes as shown below in "AutoStack Properties."

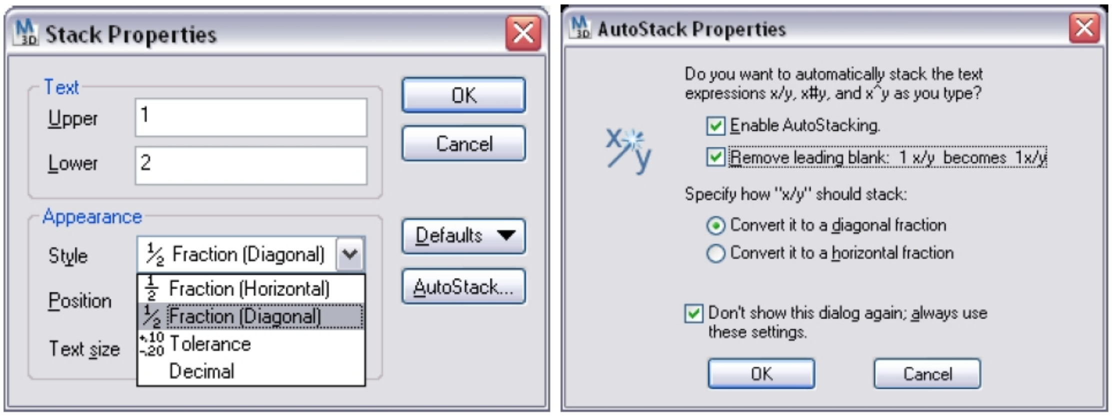


Figure 8—Fractional Diagonal Appearance and Set AutoStack Properties

7. Notes

The offset and separation between notes and legends and from the title block should be visually consistent within the drawing and other drawings within a set. The separation shown below is a guide since the arrangement of the notes is sometimes dictated by the layout of the drawing. For example, notes across the bottom or along the right side but read from the right as with legacy wiring diagrams.

The stacking order always places construction notes on top and places the reference drawings always on the bottom. Please note that colons (:) are not used as a suffix to the titles, i.e., NOTES rather than NOTES:

1. The "Construction Notes" block is used for these notes and is placed on REV layer to be removed during the next revision.
2. If the reference drawing block is not used, it shall be deleted. If it is deleted, the other notes will be moved toward the bottom near the title block.

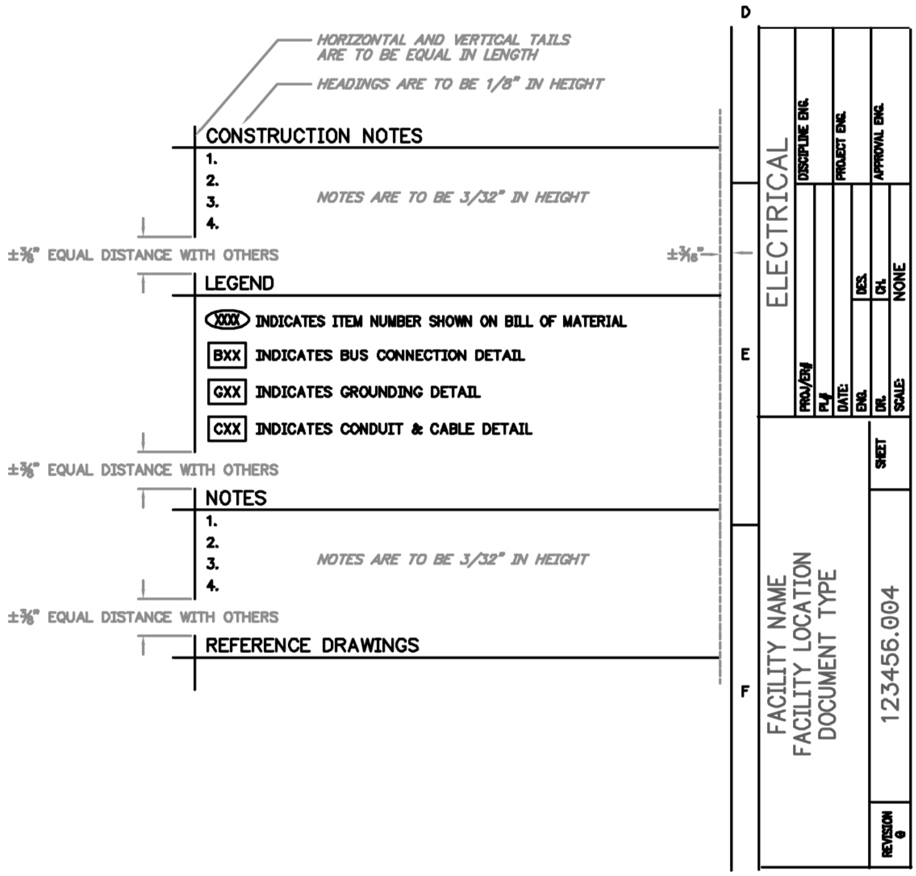


Figure 9—Note Stacking Order/Offset

8. Page Setup

The page setup shall be set to the D-Size-KIP7000 setup found in the CORP-D template file.

Note: For in-house drafters, perform page setup by entering PSETUP at the command line. When done editing the files, set the current layer to layer 0, ZOOM EXTENTS, save and exit. “Purge” all at the time of review, and again at the end of the project.

9. Standard Drawing Files

If drawings are taken and ’saved-as’ from a company standard file, leave the layout name unchanged so the original source drawing file is identifiable. This will help to troubleshoot a standard file that may need to have CAD or design corrections made to it.

The layout name need not be the same as the CAD file. Make the layout and CAD names the same only when the file is saved from another substation in which the layout name has already been named to match that file name.

Thaw the rev layer, delete all the revision clouds, and then purge the rev layer.

10. Electrical Blocks

10.1. Major Equipment Blocks

Major equipment is created on layer 0. Major equipment typically comes with too much detail and should be reduced in size by deleting any unnecessary entities. All small and close knit entities within the interior of these blocks that may cause ink to merge when plotting should be forced to color 9. With these types of blocks, the exterior perimeter of the major equipment is to remain as a color bylayer.

Layers such as center or hidden may be used within a block, while the majority of the block is constructed on layer 0. The completed block is placed on the correct layer.

10.2. Wipeout

The use of WIPEOUT is preferred rather than exploding and trimming blocks that lay in front of or above other entities. WIPEOUT is only to be used when needed, and only within a block. It is undesirable to have a wipeout floating in the field of the drawing and outside of a block.

10.3. Editing a Block in Block Editor

Use the wipeout layer found on the “physical layers” tab on the standard palette and follow these steps for editing a block in block editor:

1. Using the WIPEOUT command, a closed PLINE is traced around the outer portion of the desired view of the block using the wipeout layer. For arcs and circles, a crudely placed PLINE with minimal pick points along the curve is preferred. Picking points tightly traced around curves or circles as shown below is not necessary.

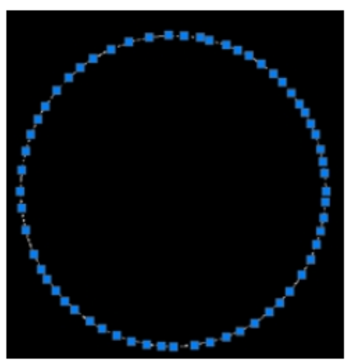


Figure 10—Incorrectly-Traced PLINE

2. Close the PLINE and temporarily turn off the wipeout layer. Under the edit menu, copy all entities in the view by using the COPY WITH BASE POINT command. Use the coordinate of 0,0.

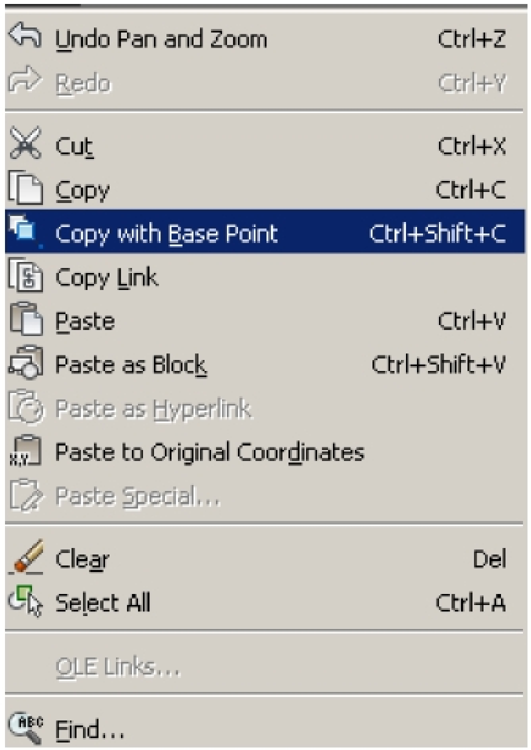


Figure 11—Use the COPY WITH BASE POINT Command

3. "Erase Previous," and then paste the copied entities at 0,0. Do not use the option "Paste as Block."
4. Turn on the wipeout layer.
5. Exit the block editor, and ensure that the wipeout you have placed is working correctly by inserting it over, or in front of, other blocks or entities.
6. Make sure that the wipeout layer is set to plot, otherwise it will not display correctly.
7. "Erase Previous," then paste what was copied with base point at a coordinate of 0,0. This will place the wipeout beneath the entities of the block and establish a permanent draw order. AutoCAD will "assume" that the wipeout was drawn first.

This process ensures that the display order is correct and that the wipeout is beneath the block entities.

11. Images

Place .tif images on a layer called IMAGE, color "7," with a continuous line type. The image, when attached, shall match the AutoCAD file name. Only one image attachment per CAD file is permitted.

The following procedures are standard for the placement of images in company drawings:

1. Insert .tif images in modelspace.
2. Deselect the "Specify On-Screen," "Scale," and "Insertion Point" boxes within the image dialog box. Turn on image transparency and turn off image frame.
3. Use the ZOOM EXTENTS command and scale the image by reference so that the objects are at a one-to-one scale.
4. If there are dimensions, scale them by reference to one of the longer whole number dimensions.
5. If images are wiring drawings, scale them so the text and symbols match PacifiCorp's CAD standards for symbols and text heights.
6. If the image has scalable entities such as plan and elevations, the viewport is given a standard scale, and that scale shall be entered in the title block.
7. If images are wiring, the viewport shall be 1:1, and the scale entered into the title block shall read, "NONE."
8. If the drawing requires a scale bar or north arrow, place them in paperspace.
9. Ensure that the image is not hard-pathed. If it is, clear it using the FX command.
10. The image will often come attached to existing drawings with a generic file name. That name shall be corrected to match the CAD file.

11.1. Image Modifications

- Images shall be cleaned of any of the following that may show up when plotting:

    a. speckles and smudges
    b. construction and text lines
    c. previous revision numbers and clouds
    d. creases from folded paper picked up by a scan

- Images are not to be modified using XCLIP, floating wipeouts, or shown through polygonal viewports, in lieu of removing portions of the image. When the image is significantly reduced in size by removing entities, the image frame should be cropped using Raster Design's "Crop by Rectangular Region."

11.2. Legacy Drawing Numbers in Images

If reference drawing numbers and names are found in the field of a .tif image, enter the numbers and names into the reference drawing block and edit them from the image. Place this block in paperspace on layer 0 in the lower right-hand corner of the drawing. (Do not explode, burst, or modify this block). All legacy drawing numbers shall be edited out of the image.

12. Hybrid Drawings

The objective with hybrid files is to eventually replace the entire image with AutoCAD entities. When the image has been reduced to 50% or more with design modifications, the extra effort of redrafting the image in CAD should be done, and the image detached.

If editing a file with an image already attached, ensure that the attachment conforms to the above procedures, even if it's not part of the project scope.

If the image is not yet attached to a CAD file and the file name is generic, obtain a correct file name (document name) from Document Manager or through the company's document control department. Do not rename it to the file name taken from the name in the scanned title block. The name in the title block is nearly always incorrect and does not conform to the company's 5-digit legacy or current 6-digit drawing naming conventions.

13. Electrical Discipline Drawings

13.1. General Plan

A layer named "region" is used for areas that need to be shown at a larger scale and placed on separate sheets. For example, if there are multiple conduits on the plan that are too clustered to call out details, a closed polygon is placed around the entities on the region layer to denote the new sheet area. Next to the polygon in a standard string of text is placed the sheet number as shown.

This layer is only used on the general plan, conduit plan, and the grounding plan and does not replace the matchline layer nor does it replace the key-sheet-line-text layer primarily used on one-line drawings.

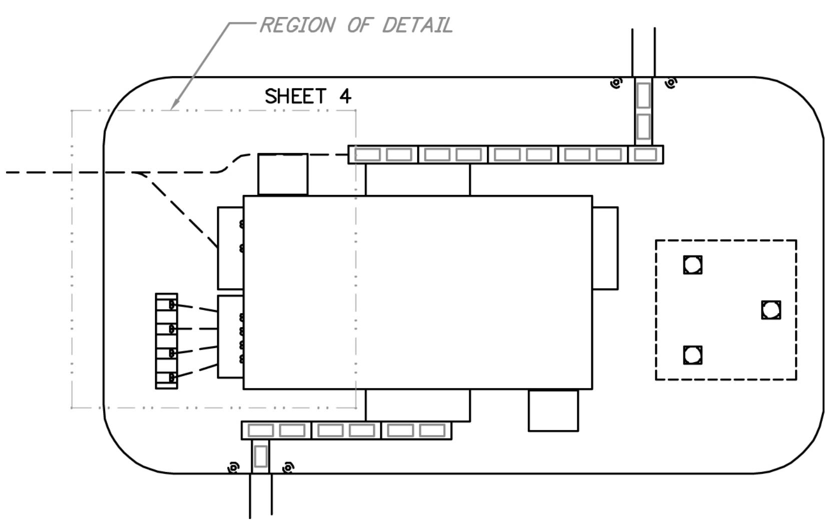


Figure 12—Region of Detail

The "ANIMAL-ENHANCEMENT" layer, color 10 (shown in Figure 13, in red) with DASHDOT2 line type is used to delineate the areas where animal protection is required on bus connection details.

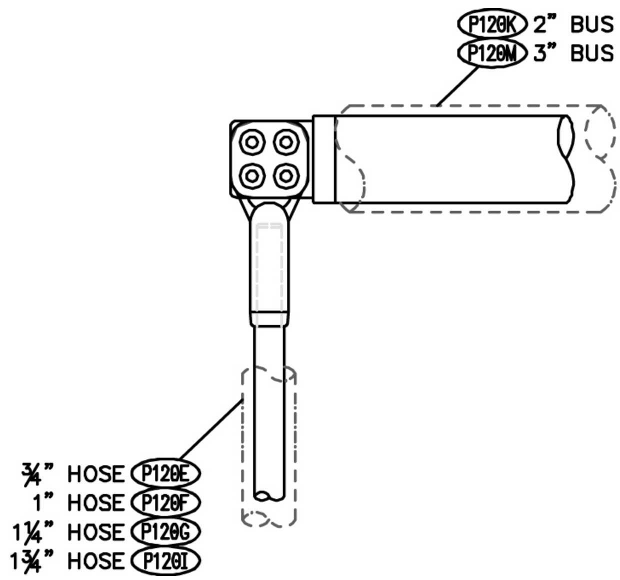


Figure 13—Animal Protection

The DETAIL-FRAME layer color 4 (cyan) with a continuous line type is used as the outer frame to enclose a group of similar details. The inner frames within used to separate the details are placed on layer zero. Figure 14, below, shows an area prepared for one detail.

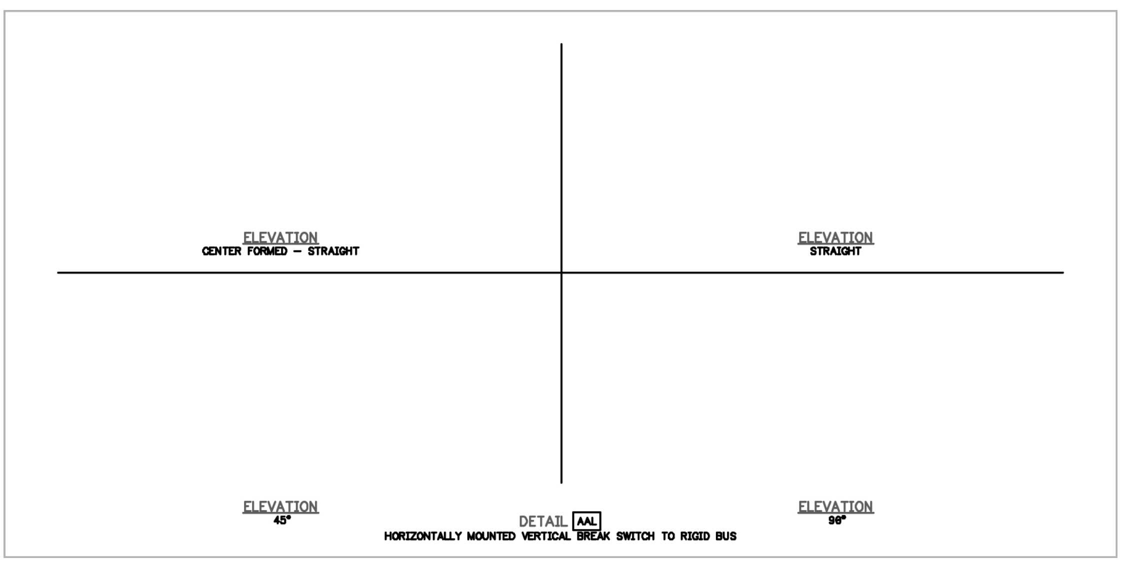


Figure 14—An Area Prepared for One Detail

This series of drawings shall have two XREFs attached, the XB and the XE. The XE will share the same 5- or 6-digit file name as the general plan drawing series.

Below are examples of the general plan in large substations where the document type is the same in all sheets.

13.1.1. Property & Transmission Layout Sheet

The first sheet is considered "Property & Transmission Layout." The 4th line of the title block (tag 6) shall read, "Property & Transmission Layout," and is shown at a smaller scale showing the overall site plan, i.e., 1″ = 80′-0″.

The first sheet shall have the XB and the XE attached.

13.1.2. Future Development or Ultimate Plan Sheets

The second sheet is considered "Future Development," or "Ultimate Plan." The 4th line of the title block (tag 6) shall read, "Future Development."

The XREF attachments shall be *.UXB and *.UXE, showing the yard as it may look in the future. All equipment shall be on proper layers, not on the future layer. The whole file is considered future.

13.1.3. Sheets Showing the Project Area of the Yard

The 3rd sheet, and others if needed, shall show the project area of the yard (the first general plan used for construction purposes. This sheet and subsequent sheets shall have the XB and the XE attached.

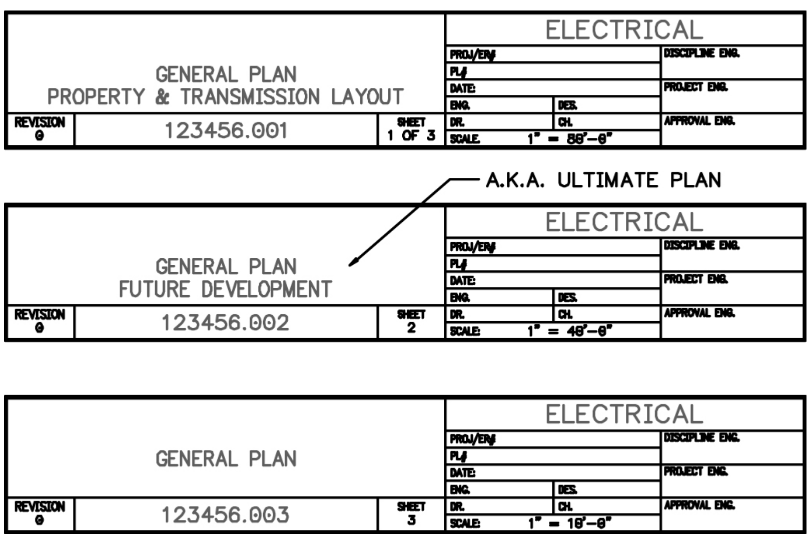


Figure 15—Fourth Line for General Plan by Page

13.2. Plan & Elevations Drawings

Plan & elevations drawings are comprised of the XB and the XE XREFs, and are inserted at 0,0 with zero rotation. All plan & elevation drawings shall have a plan above the elevation, shown through one viewport (not two). The XB and XE are XCLIP'ed to display only the necessary plan view, and if need be, the view is twisted in modelspace. The XREFs are XCLIP'ed so the elevation can be placed close to, and below, the XCLIP'ed plan.

The elevation is built directly below the XCLIP'ed plan. When necessary, to build an elevation of the side or top view of the plan, twist the view using the ROT command (rather than the physically-rotating the XREF). The view within the viewport is also twisted, scaled, and locked. Multiple floating polygonal viewports (one for the plan and one for the elevation) are not used in lieu of clipping the XREFs.

13.2.1. Line Leaders

Ovals or circles used for item numbers shall have the line leader originating from the center. Rectangular detail call-outs shall have the line leader originate from the corners of the rectangle. Both are placed on layer zero and shown on the elevation view, or plan view when necessary.

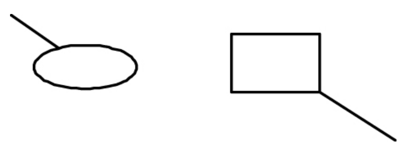


Figure 16—Proper Call-Out Formatting for Item Numbers

13.2.2. Cable, Strain Bus and Grounding Wires

All cable, strain bus, and grounding wires shall be drawn on appropriate layers using PLINES, with the width set to the actual cable size of the cable.

13.2.3. Labeling Breakers, Switches, and Vts on Plans & Elevations

All labels for breakers, switches, and VTs are shown on the "elevation view" rather than the plan view of plans & elevations drawings and are labeled with their respective numbers. The equipment numbers and voltage can be found on the one-line and should be centered below the dimension as shown in Figure 17. An exception would be when there are multiple pieces of equipment at one location. The equipment number shall be shown next to the equipment, also shown in Figure 17.

ROCKY MOUNTAIN POWER PACIFIC POWER

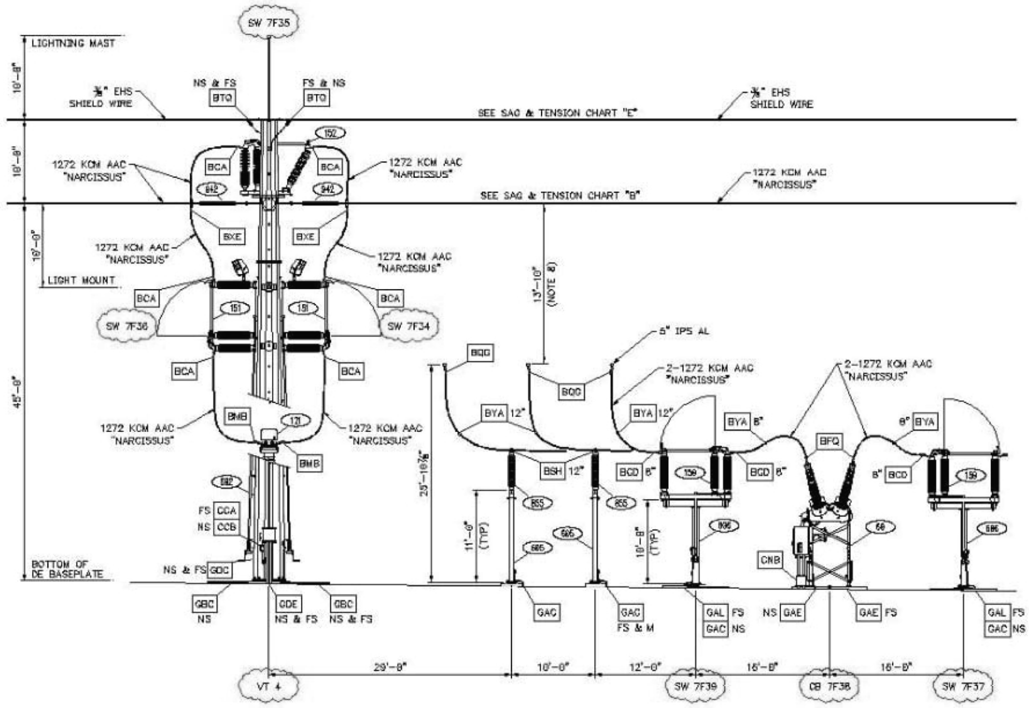


Figure 17—Labeling Breakers, Switches, and VTs

13.2.4. Matchlines and Brackets

Certain design situations, at the direction of the staff engineer, may allow the use of either matchlines or brackets. Separate matchlines shall be used (rather than brackets) on both the plan and the elevation drawings, where the facilities continue on another sheet. Brackets and text are used to reference the destination of transmission lines outside the substation.

Matchlines are not to be placed through equipment showing half on one sheet and half on the second sheet.

13.2.5. Dimensions and Text

Dimensions and text are added last with the appropriate DIM style for the scale of the viewport. If dimensions and text are added before the view is twisted, they will likely be upside-down, or read from the wrong direction.

Place dimensions and text by either dimensioning through the locked viewport or in modelspace. If the view is twisted through the viewport, then twist the view in modelspace to match the viewport.

13.3.Conduit & Cable Plan

The conduit & cable plan shall have the XB and XC Xref'd into the sheet file. Conduit & cable details are not part of the same drawing number series as the conduit plan. They will have their own drawing number starting at sheet one (.001).

The baselines of attached XREFs are to be frozen and replaced with the floating BASELINE CROPPED block with the dynamic ends pulled outside the fence.

The attributed circle block used to label the conduits on the conduit plan is called CND_NUMBER and is located on the conduit plan tab within the conduit palette. The block to be used, Figure 18, left, is smaller in size than the CABLENU block, Figure 18, right, used for panel layout and wiring drawings.

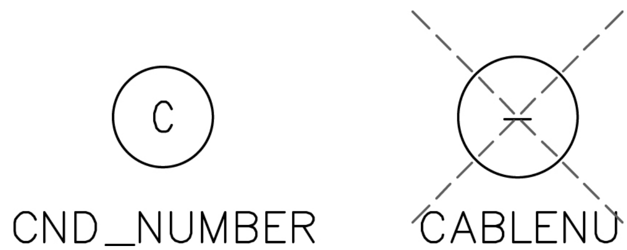


Figure 18—CND_Number and CABLENU

13.4. Grounding Plan

The grounding plan shall have the XB and XG XREF'ed into it to show the grounding mats, foundations, fence, gates, and cable trench. All other unnecessary layers of the XB shall be frozen.

The baselines of the attached XREFs are to be frozen and replaced with the floating "Baseline Cropped" block with the dynamic ends pulled outside the fence.

Grounding details are not part of the same drawing number series as the plan. They shall have their own drawing number, starting at sheet one (.001).

13.5. Lighting Plan

Lighting plans are comprised of the XB and a block named "FLOOD LT-PLAN" placed in areas of the yard, showing the direction of the light. The block does not reflect the type of light, but is a symbol of the light. The actual style of the light is shown in the XE file where it is XREF'ed in the plan view in various sheet files.

13.6. North Arrows and Scale Bars

1. North arrows are placed in the upper right-hand corner of the drawing in paperspace. If an existing drawing has the north arrow placed elsewhere, it should be relocated.
2. Scale bars shall be placed in the lower right-hand corner of the drawing and shall match the scale of the viewport.

3. Both the north arrow and scale bar are placed in the following drawings:

General Plan

Conduit & Cable Plan

Grounding Plan

Plan & Elevation

Lighting Plan

13.7. Vicinity Maps

Use the vicinity map template found on the standard palette to create a new map. Use match properties and the blocks found in this template.

When completing a new vicinity map, the finished map should be made into a block called, “(SUBSTATION NAME) VICINITY MAP,” so the forced entities are within the block, rather than loose in the file, and are not recognized or corrected by the audit routine.

13.8. Avian & Animal Enhancements

The AVIAN & ANIMAL ENHANCEMENTS document class is used to document and detail provisions for substation bird and animal protection (see company SV construction standards). "Avian & Animal Enhancements" drawings are under the electrical discipline. They should be given the last number in the drawing series.

The “Avian & Animal Enhancements” drawings use two drawing numbers, the first number is for PLANS & ELEVATIONS, which shall be listed on the fourth line of the title block.

After elevations, on the next drawing number, show the bus connection details, named "BUS CONNECTION DETAILS" as the fourth line.

In the plans & elevations drawings, display dimensions and phasing and remove all the other information that is normally shown. When necessary, matchlines or brackets should be used to show continuation on subsequent sheets. See " Matchlines and Brackets" on page 22, *Matchlines and Brackets*.

The legend should reference the avian & animal enhancement details, and should list which sheets contain details pertaining to the current construction. The notes should list information pertinent to the current construction. If necessary, the scale of the drawings may be increased to show more detail, however only to the point which the drawing will allow. The barriers and covers should all be shown in the ELEVATIONS and should be placed on the animal-enhancement layer. The details shown should be called out with the DETAIL-ID WITH QUANTITY block.

In the Details drawings, all the details pertaining to the current construction should be shown. The barriers and covers in these details will be placed on the animal-enhancement layer. List the items used to make the details with item callouts, which correspond to the Bill of Materials and which are listed following the same method as other details. The avian & animal enhancement details will have an “A--” detail designation as shown in Figure 19.

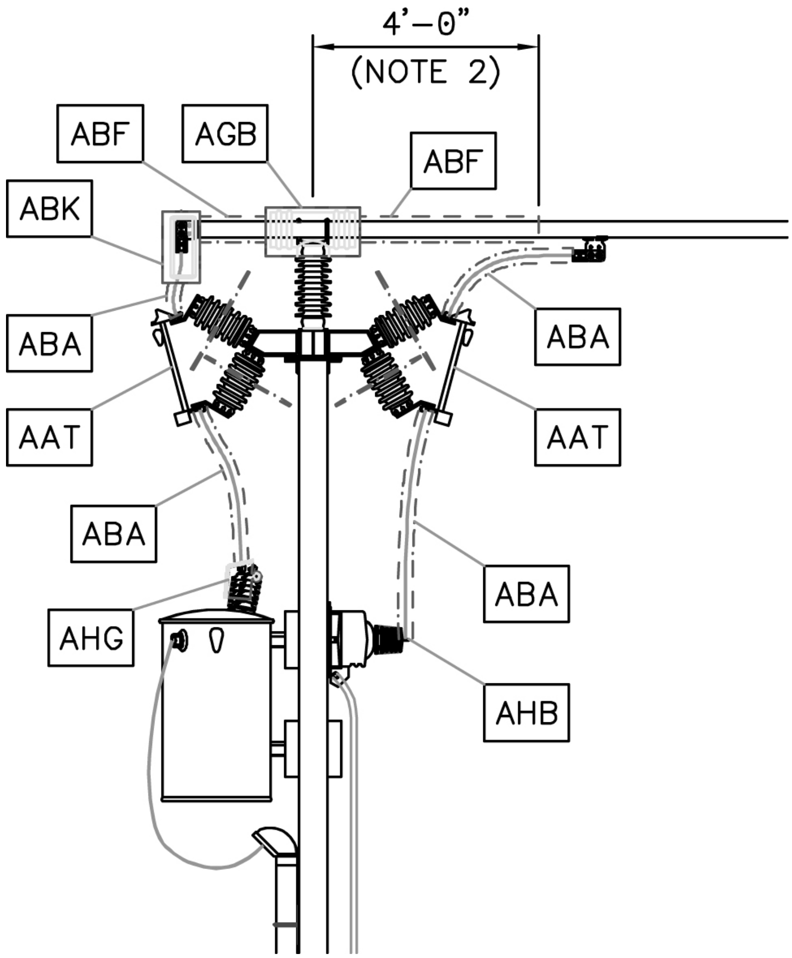
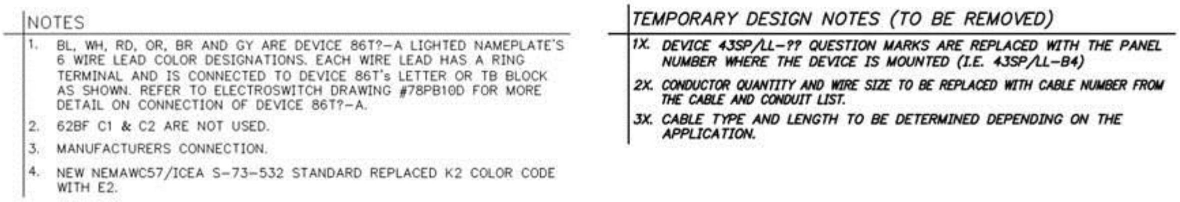


Figure 19—Animal Enhancement Details

14. Protection & Control Drawings

All wiring and schematic entities shall be placed in paperspace. There is an exception: when a .tif image is attached, all CAD entities except the notes, legends, tables and the title block are placed in modelspace with the image.

Standard drawings will come with design notes placed on a non-standard layer. The design notes are to be removed when the standard becomes a project. The design notes will be of a different color and will be italicized to distinguish them from the notes that remain in the drawing.


NOTES

1. BL, WH, RD, OR, BR AND GY ARE DEVICE 86T?–A LIGHTED NAMEPLATE'S 6 WIRE LEAD COLOR DESIGNATIONS. EACH WIRE LEAD HAS A RING TERMINAL AND IS CONNECTED TO DEVICE 86T's LETTER OR TB BLOCK AS SHOWN. REFER TO ELECTROSWITCH DRAWING #78PB10D FOR MORE DETAIL ON CONNECTION OF DEVICE 86T?–A.
2. 62BF C1 & C2 ARE NOT USED.
3. MANUFACTURERS CONNECTION.
4. NEW NEMAWC57/ICEA S–73–532 STANDARD REPLACED K2 COLOR CODE WITH E2.

TEMPORARY DESIGN NOTES (TO BE REMOVED)

1X. DEVICE 43SP/LL–?? QUESTION MARKS ARE REPLACED WITH THE PANEL NUMBER WHERE THE DEVICE IS MOUNTED (I.E. 43SP/LL–B4)

2X. CONDUCTOR QUANTITY AND WIRE SIZE TO BE REPLACED WITH CABLE NUMBER FROM THE CABLE AND CONDUIT LIST.

3X. CABLE TYPE AND LENGTH TO BE DETERMINED DEPENDING ON THE APPLICATION.

Figure 20—Standard Drawing Design Notes

14.1. Panel Layout & Wiring Drawings

1. As of this publication, on all new panel layout & wiring drawings, the panel will be shown on sheet 1 and the panel wiring will be shown on sheet 2 of the drawing series.
2. In legacy drawings, the panel within layout & wiring drawings is drawn 1:1 in modelspace and shown through a viewport with the wiring in paperspace.
3. The viewport is typically 1-1/2″=1′-0″ or 1:8, with a dimension scale of 8. Two DIM styles of 8 are created (one showing feet and inches and one showing only inches). The DIM style for a panel layout & wiring file is "8-IN," which shows only inches. Modifying DIM styles to achieve the look of inches is not permitted.
4. Panel layout & wiring drawings typically display a nameplate list with the lengths and widths specified. The details of the nameplate legacy drawings will sometimes show dimensions, which should be removed to avoid discrepancies.
5. All text headings for equipment in panel layout & wiring drawings are to be 1/8″ in height as shown with "AB" in Figure 21.
6. All viewports shall be locked to avoid accidental changes.

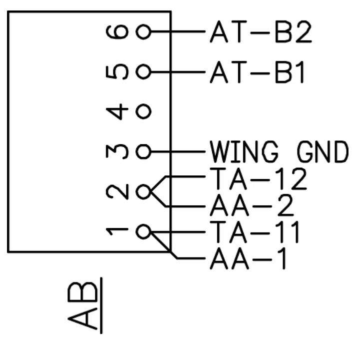


Figure 21—Text Headings

14.2. Schematic Drawings

All text headings above the equipment outlined with the dashed layer shall be 3/32″ in height as shown with "11A" in Figure 22.

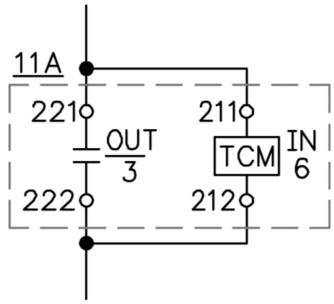


Figure 22—Schematic Drawings

14.3. Layers

All layers are taken from the wiring layers tab on the standard palette.

14.3.1. Yard Termination Cabinet Layer

Five template layers are included in our standard files for the yard termination cabinet. Layers YTC, NO_YTC, WVRT, NO_WVRT, and MCG are found in our standard files and are design options which lay over the top of each other.

1. Determine which of the five layers are used in your design.
2. Incorporate the layer (or entities of that layer) into the standard layer.
3. Place text on the text layer.
4. The remaining entities on the unused layers are purged.

   For example, if the no-YTC layer is used, then entities on the YTC and MCG layers are deleted and purged. The YTC and MCG layers are also deleted and purged.

   NOTE: If lines from the no-YTC layer are used rather than the terminal blocks from the YTC layer, the three lines between the two terminal blocks should be one continuous line and not comprised of three line segments. Achieve this by deleting two of the lines and extending one.

5. In the end, all five template layers are purged from the drawing after incorporating the elements into standard layers.

14.3.2. Bus Layer

The bus is drawn on the bus layer using a PLINE with a width of .03. Three-phase one line blocks associated with the bus are placed on the bus layer.

14.3.3. Logic

Logic is placed on layer zero.

14.3.4. Non-standard Key Sheet Layers

Non-standard layers shown in Figure 23, below are solely used by the standards group referring to other standard drawings. These layers are found in the standard one line diagram key sheet drawings. A note within (shown below) to the drafter/designer gives direction to remove and purge the layers and then delete the note and the table when the standard drawing becomes a project drawing.

NOTE TO DRAFTER/DESIGNER:
THE NON-STANDARD KEY SHEET LAYERS USED WITHIN THIS DRAWING ARE FOR REFERENCE ONLY. PLEASE REMOVE AND PURGE THESE LAYERS, THIS NOTE, AND THE REFERENCE TABLE WHEN THE FILE BECOMES PROJECT SPECIFIC.

LAYER NAME	DRAWING TITLE
PC 230 A	LINE COMPENSATION, LINE REACTOR AND SINGLE POLE TRIP, EHV TRANSMISSION
PC 235 A	SINGLE POLE TRIP & W/O LINE COMPENSATION, EHV TRANSMISSION
PC 240 A	THREE POLE TRIP, EHV TRANSMISSION
PC 245 A	CURRENT DIFFERENTIAL, EHV TRANSMISSION
PE 150 A	EHV POWER XFMR, BREAKER AND A HALF/RING BUS CONNECTION
PE 153 A	EHV POWER XFMR, SECONDARY CONNECTED TO PHASE ANGLE XFMR
PE 160 A	EHV PHASE SHIFTING (ANGLE) TRANSFORMERS
PE 330 A	??KV, EHV BUS DIFFERENTIAL
PE 530 A	EHV SHUNT CAPACITORS
PE 630 A	EHV SHUNT REACTOR

Figure 23—Non-standard Key Sheet Layers

14.4. Text

Text within protection & control drawings shall be the standard width of 1. Text styles S1 through S8 should not be used unless they are necessary due to limited space.

The DTEXT shall be justified appropriately to the left, right, or center (ML, MR, or MC).

MTEXT justification shall be appropriate to the placement of the text in relation to the design with which it is associated, typically TL, TC, or TR.

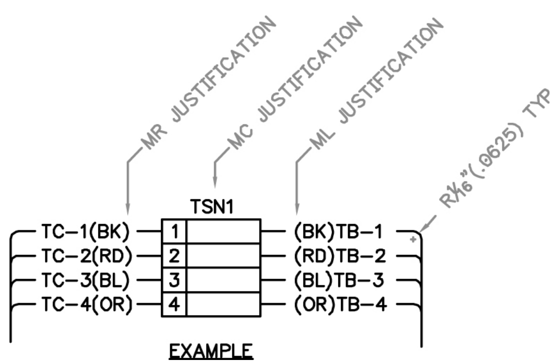


Figure 24—Justification, Left, Right, or Centered

ROCKY MOUNTAIN POWER PACIFIC POWER

14.5. OLE Objects

OLE objects within CAD files shall not be used. Some manufacturers' files may come with OLE objects, and these objects shall be embedded rather than linked.

14.6. Single Line Entities and Snap

Wiring is drawn using single line entities (rather than PLINES), with the radius for turning wire direction set to .0625 (1/16″).

If SNAP is used for placing wiring, blocks, and text, the SNAP should be set to a minimum value of .03125″ (1/32″), or multiples thereof.

14.7. Wiring Blocks

Wiring or protection and control blocks are created on layer 0 with attributes and text forced to color 7. No other layers are used within these blocks.

These blocks are to be inserted on layer 0 with the exception of one-line bus blocks, which are inserted on the BUS or FUTURE layers. In this scenario, the attributes or text will remain white while the other block entities will be the color of the layers.

Certain dynamic blocks used in current schematics and one line diagrams which have horizontal and vertical views may need to be physically rotated 90 degrees while using the flip actions to achieve the desired view of the attributes. The desired view is that the attributes are to be vertical and read from the right. For example, the horizontal view may be selected, and then rotated 90 degrees to a vertical position. The flip actions are then used to orient the attributes vertically. This is only to be done if the view cannot be achieved with a 0 rotation while using the flip actions. None of these blocks shall be modified, exploded or burst to achieve this. Please note that this is not for one line key sheet as the attributes are read horizontally, but may be necessary for one line drawings that follow the key sheet and for current schematics.

14.8. Wire Color Codes

Wire color codes are placed within parentheses and entered in the same text string as the terminal designation. See Figure 25 for the current color table, and Figure 26 for the proper text placement of wire color and terminal designation. The current color code block is found on the standard palette on the paperspace tab, i.e., W1 is shown as (BK).

WIRE/COLOR CODE CONVERSION CHART

COND NO.	K1 (C4)	K1 (C12)	K2
W1	FIELD TO		BLACK (BK)
W2	SPECIFY		RED (RD)
W3	SEQUENCE		BLUE (BL)
W4			ORANGE (OR)
W5			YELLOW (YL)
W6		FIELD TO	BROWN (BR)
W7		SPECIFY	RED/BLACK (RD/BK)
W8		SEQUENCE	BLUE/BLACK (BL/BK)
W9			ORANGE/BLACK (OR/BK)
W10			YELLOW/BLACK YL/BK)
W11			BROWN/BLACK (BR/BK
W12			BLACK/RED (BK/RD)

Figure 25—Current Wire Color Table

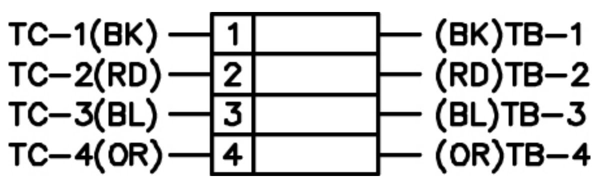


Figure 26—Proper Text Placement of Wire Color and Terminal Designation

This color code format within a single string of text is to be used in all modifications and on all text strings in rev zero drawings. The wire color is to be within parentheses and placed closest to the terminal block, as shown.

15. XREF Documents

XREFs are externally referenced files. For general XREF procedures, refer to Handbook Volume 9A.5, section 6, *External Reference Drawings*. The following XREF procedures are specific to substation drawings.

15.1. XREF File Naming Conventions

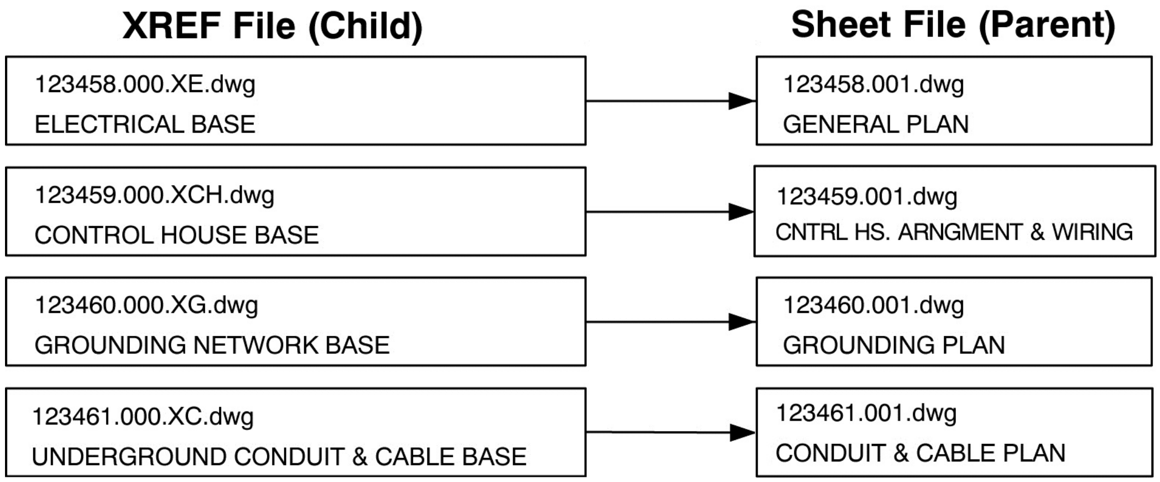


Figure 27—XREF File Name Translation

New XREF files tied to legacy file names can be created with an appropriate sheet file name. For example, if an XE does not exist, and one is created, the file name of the XE would take on the 5-digit file name of the existing general plan, i.e., 12345A01 = 12345A00.XE. (This new XE would not take on the current 6-digit file naming convention, for example 123456.000.XE.)

If XREFs do not exist for existing substations and a project begins to develop an electrical base plan, those modifications will become the new XE XREF. For example, if a new bay of equipment is added, then that will become the XE and effort should be made to incorporate the existing electrical entities into the XE by placing them in the new XREF file.

16. Excel Files

Standard Excel template files are located in the forms directory within the ...\AutoCad Support\ directory.

When modifying existing Excel files, update the old PacifiCorp logo (with the three blue diamonds) with the new logo found in the forms directory. The new logo has a taller height. The only file types that do not accommodate the new logo are legacy conduit & cable lists.

PACIFICORP

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

Figure 28—Old PacifiCorp Logo **Figure 29—New PacifiCorp Logo**

To accommodate the new logo, the two bottom row heights shall be changed from 23 to 33 as shown below. Do this for the entire length of two rows, then paste and center the new logo.

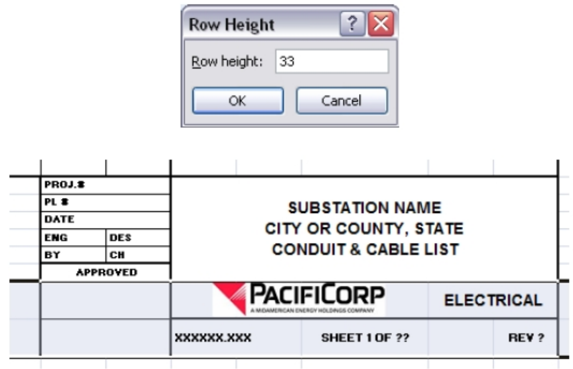


Figure 30—Adjusting Row Height to Accommodate Current Logo Height

All modifications are shown with the cell highlighted with light green. Highlighting of previous modifications is removed.

Tabbed Excel files area to be numbered through page setup starting with the second tab. Shown below in Figure 31 are examples of a file using two tabs with the page number starting with 2.

16.1. Cable List

This file was previously named conduit & cable list. Its only reference to conduit will be the conduit number. The cable list will be accompanied by a separate AutoCAD file called “Conduit Schedule,” which will list the remaining conduit information and have reference to the cable number from the cable list. New rev 0 cable lists will use the cable list template located in the ...\AutoCad Support\FORMS\ directory. The cable list will have reference to the conduit number taken from the conduit schedule and placed in the appropriate "In Conduits(s)" column.

1. When an existing conduit & cable list is checked out for modification, the new conduit information is placed within:

   a. An existing conduit schedule, if one exists

   b. If one does not exist, then an AutoCAD conduit schedule template file is used, and is assigned a drawing number. The drawing number will always be the last number in a new or existing conduit plan drawing series. This template file is located in the ...\AutoCAD Support\Templates\Substation\ directory.

2. The legacy conduit & cable list will be modified as follows:

   a. The header of the legacy conduit & cable list will be corrected to read “Cable List.”

   b. The PacifiCorp logo, if need be, is replaced with the new logo.

   c. The conduit number for new work shown in the conduit schedule will be placed in the remarks column in the cable list.

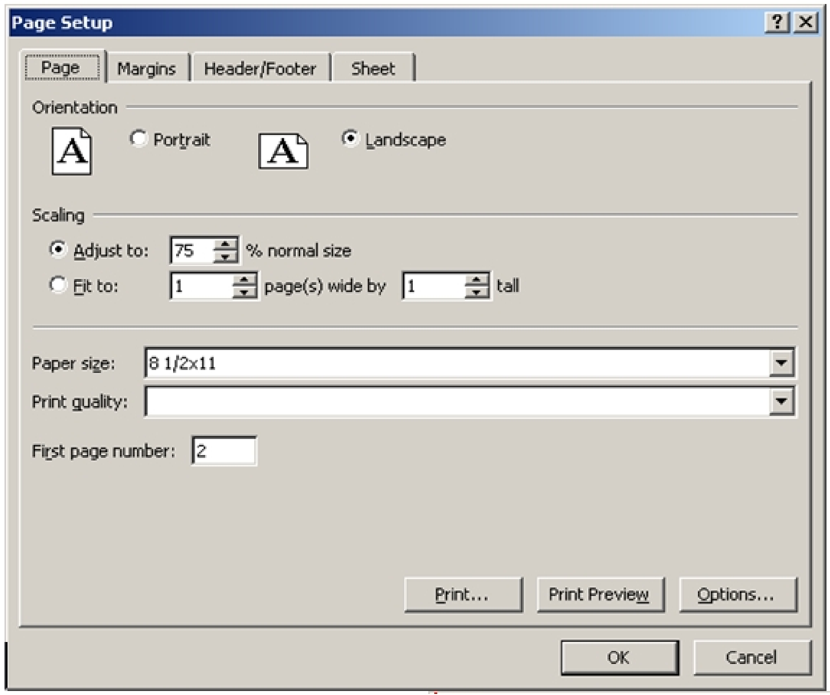


Figure 31—Multiple File Tabs Using Two Tabs

Template files are set up with the first page number filled in, and once the numbers of pages in each tab are determined, these may need to be adjusted. The total number of pages is entered in the footer and the title block of the first tab.

In the footer of each tab, the [Page] is automatically taken from what is entered in the first page number field shown in Figure 31, and the number of sheets is entered manually, as is the revision number.

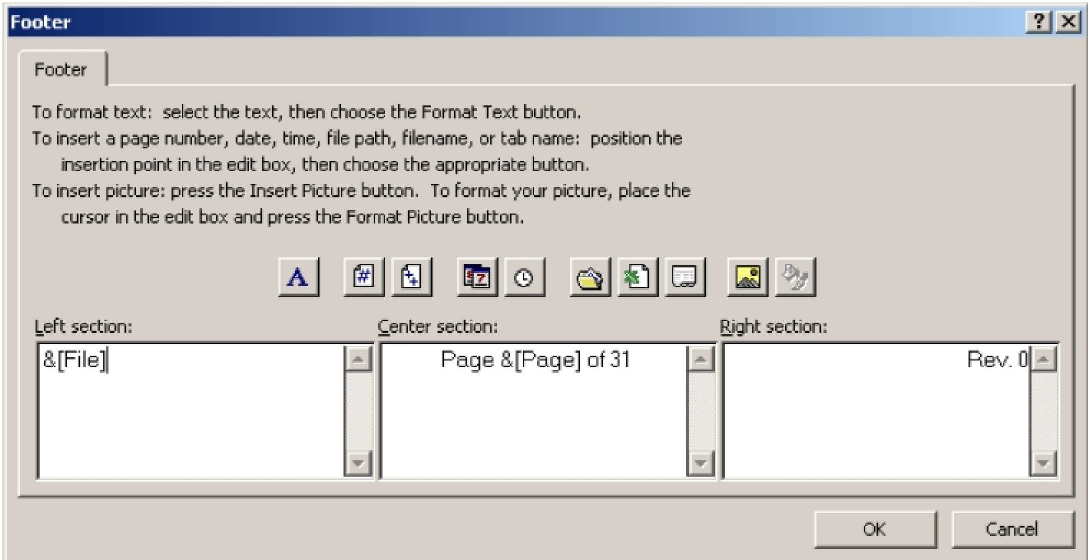


Figure 32—Footer Formatting

17. Handbook Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to substation engineering. This handbook document shall be used and duplicated only in support of company projects.

9B.3—Civil Drafting Standards

1. Scope

This section of the company's Engineering Handbook provides civil discipline-specific drafting and design standards. For an overview of general company drafting standards, see Engineering Handbook Volume 9A, *Computer-Aided Design*. Also see company Engineering Documentation Policy 206, *Civil Drawing Expectations for Consultants*.

2. General Drafting Practices

The following general drafting practices are standard for civil drawings. Adhering to these procedures ensures conformity to standards set forth by civil engineering.

1. All plan views shall be drawn to scale, and details shall be drawn to scale whenever possible. If a detail cannot be drawn to scale the subtitle shall indicate that no scale is used (see Section 3.3).
2. QC audits shall be run as early as possible to support correct practices in CAD standards. These audits include, but are not limited to:
   a. Using the PacifiCorp AutoCAD templates when creating a drawing.
   b. Creating and developing a drawing per the narratives and intended use of the PacifiCorp templates.
   c. Verify that all objects are put on the appropriate layers and that they are by layer.
   d. A CAD standards check (found in the tools pull-down menu in the CORP-C3D.dws template file)
   e. The FX command (never on grading plans or topographic surveys).
   f. A purge of finalized drawings or projects
   g. A BAD audit tool self-audit (prior to the issuing of the package).
3. Leaders shall be MLEADERS (unexploded) in all new drawings, and shall be placed on appropriate text layers. If leaders are added to old drawings they shall match the leader type of that existing drawing.
4. When ARC leaders are used, they shall be placed by using the ppg.lsp for modelspace and pp1.lsp for paperspace. The correct DIM style for the scale of the viewport must be current prior to using the ppg.lsp for leaders in modelspace. If the viewport scale changes, then the leaders shall be redrawn such that the arrowhead is properly scaled.
5. Texts associated with dimensions shall be placed within the dimension via the text editor and not floating outside near the dimension.
6. Notes in drawings with more than one string of text shall be either MTEXT or MLEADER without the leaders, and shall be placed on an appropriate text layer.

2.1. Tabbed Drawings

A tabbed drawing file name shall have the suffix ".000" which indicates the file has multiple sheets. Tabbed drawings shall have the layout tab named to match the sheet number, i.e., .001, .002, & .003.

TIF files added to a tabbed file shall have the same name as the drawing, i.e., 123456.000.tif. If there are multiple .tif files, the .tifs can be merged together within the image frame of one file by using "raster design." Refer to PacifiCorp Engineering Handbook 9A, Section 7.1, *Hybrid Drawings* for merging multiple images.

Multiple paperspace layouts within one file are only to be used with certain civil, structural, and foundation drawings. Although this is a useful tool for multiple sheets within a single drawing number, the company still documents, manages, revises and issues each sheet individually; therefore, the following requirements apply to the files stored in PacifiCorp's Document Manager for Power Delivery. As stated in 9A.2, Section 7, *Drawing Numbers*, multi-page documents shall have the suffix 000 (or A00 if the drawing is derived from a legacy file name).

- Multi-layout drawings are only to be used within a single drawing number. For example, file number 123456.000.dwg should only contain layouts labeled with the sheet number (e.g., .001, .002, .003, etc.).
- Each layout within a drawing shall be rendered to its own individual PDF file for indexing, viewing, and plotting in DM. PDFs shall only be rendered for the layout tab that was modified. PDFs shall accompany the drawing file when returned to document control to be renditioned to the in-house data management system, P8.
- Multiple layout drawings shall not exceed a 10 MB file size. Multiple layout drawings are only acceptable for civil, structural, and foundation drawings.
- When creating a new layout tab within a drawing, utilize the LAYOUT FORM TEMPLATE feature from the layouts toolbar, or from the insert pull-down: layouts>layout form template.
- The existing template files are located at AutoCAD Support\Templates.
- Follow the standard procedure pertaining to modelspace/paperspace drawing files as described in 9A.5, Section 4.

3. Drawing Components

3.1. Contours

All major contours shall be labeled with text on their associated CONTOUR layer. While minor contours are typically unlabeled, labeling may be preferable when a major contour is not present, or where labeling adds clarity to the plan. Existing and proposed contours shall be on separate layers per the CORP-3D template in order to distinguish between them, and shall be created with CORP-3D using the appropriate styles preset in the template.

3.2. DIM Styles and Text

The civil department uses specific dimension layers with a prefix of “C-” taken from the civil palette or from the CORP-3D template. Civil DIM style units shall be either “architectural” or “decimal.” Grading and survey plans use the “decimal” annotative DIM style (except for details, which can use an “architectural” DIM style) while all other drawings use the “architectural” DIM style. All existing civil drawings maintain their dimension styles, while the latest DIM styles can be used for new dimensions as follows:

1. Texts added to dimensions shall be entered via the text editor. Certain lines of text shall be placed beneath the dimension line by entering “\X” (CAPS must be on) between the dimension value and the string of text.

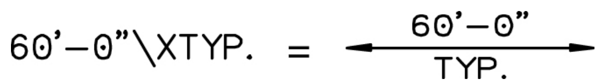


Figure 1—Placing Text Below Dimension Line (Example)

2. Dimensions may have the dimension value overwritten to represent X & Y values for various lengths, widths, or heights, as denoted in charts such as in the concrete and reinforcing charts.
3. Dimensions shall be set such that the arrowheads do not overlap as shown in Figure 2.

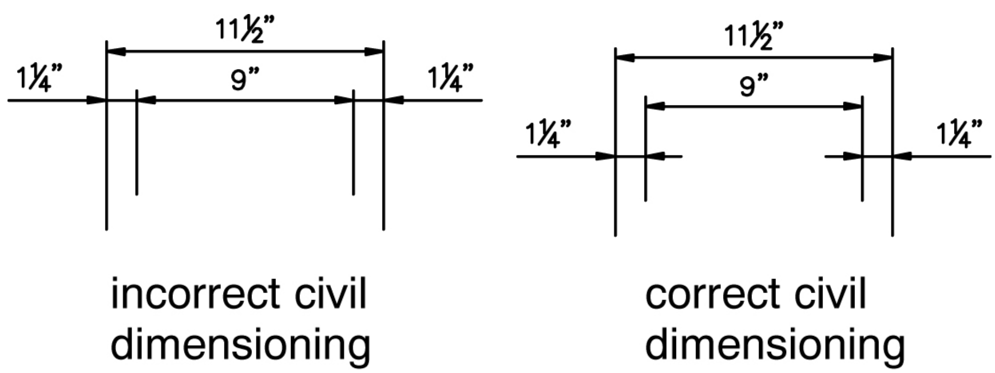


Figure 2—Civil Dimensioning

3.3. Drawing Scale

Drawing scales entered in the title blocks for decimal-unit drawings, shall be written: 1″ = 20′ rather than 1″ = 20′-0″. There shall be no spaces between the = sign and the -0″ shall not be used.

Scales of multiple viewports shall be noted using the SUB TITLE block. Place this beneath each detail in the model or paperspace environment where the detail is located. “AS NOTED” shall then be entered in the scale on the title block.

Details that don't have a scale (when shared on the same drawing as other details that have a scale) shall be noted using the same SUB TITLE block, with "NTS" entered in place of a scale.

If all the details on the drawing have no scale, do not enter scale information beneath each detail. Only the title block shall note that the drawing scale is "NONE." If all details have common scales, the scale shall only be noted in the title block and not beneath each detail.

Acceptable scale notations within the title block shall be:

1. "AS NOTED"
2. "NONE"
3. Or a valid scale using the appropriate ACSI codes found in the Volume 9A.

Acceptable scale notations within the title block shall not be:

1. "AS SHOWN"
2. "NTS"
3. "N.T.S."

3.4. Drawing Units

Drawing units shall be "architectural" for all drawings except the grading plan and surveys that shall have drawing units set as follows:

1. INSERTION SCALE = "feet"
2. LENGTH TYPE = "decimal"
3. LENGTH PRECISION = "0.0000"
4. ANGLE TYPE = "surveyor's units"
5. ANGLE PRECISION = "N 0d00'00" E"

NOTE: When set in surveyor's units, the ANGLE TYPE displays in deg/min/sec. and also lists the bearing of a line. Angles will still display in deg/min/sec.

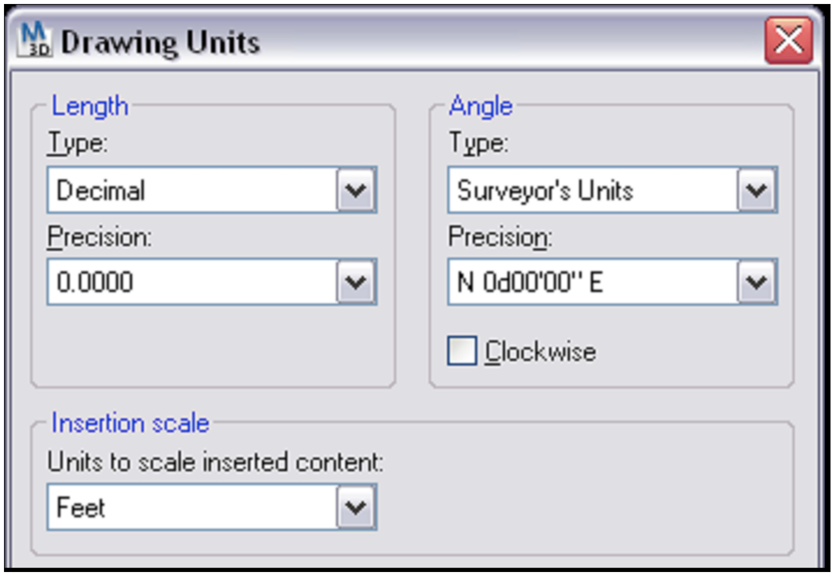


Figure 3—Drawing Units for Grading Plans and Survey Plans

3.5. HATCH Layers

Only HATCH layers taken from the civil palette, the CORP-C3D template file (having ‘HTCH’ OR ‘PATT’ within the layer name) shall be used. These layers shall not be modified, nor shall new layers be created.

3.6. Paperspace / Modelspace for Civil Design

To begin a new drawing, select the most appropriate template from ...\AutoCAD support\templates\ directory, containing most of the required layers, text styles, and base dimension styles. These procedures shall be followed to utilize paperspace / modelspace:

1. Create all drawing content at 1:1 scale in modelspace.
2. Create viewports in paperspace (floating viewports) as needed to view the contents of modelspace. Place the viewports on the DEFPOINTS layer.
3. Set the PSLTSCALE variable to 1 and the LTSCALE to 0.25 such that the line types will look identical in all viewports. The CORP-C3D template already has these variables set.
4. General notes, title block, legends, and bills of material, shall be created in paperspace. The CORP-C3D template also contains procedure notes to assist the user, to outline the company’s plan creation and delivery requirements, and to explain the intended use of the template. When using the proper template drawings, the company border already resides in paperspace. If a border does not exist, insert the appropriate border block as described in Engineering Handbook. 9A.2, *Borders*.
5. Plan views in paperspace shall be oriented to coordinate with the General Plan in order to avoid confusion throughout the project. When creating a new drawing where the

orientation of the plan view has not been previously established, the north arrow shall comply with national drafting standards and the north arrow shall point upward toward the northern quadrants.

6. Viewports shall be locked so that the scale and scope of the viewports do not change.
7. Create all details at 1:1 in modelspace. However, if the detail's scale differs from the primary drawing scale, use the following procedures:
   a. Show the detail in paperspace through its own viewport with the appropriate scale. Use the SUB TITLE block (found on the standard palette) to place the scale beneath it.
   b. See Section 3.3 if multiple details with the same scale are shown on a sheet and there are no other details on the sheet with a different scale.
   c. See Section 3.3 if multiple details with different scales are shown on a sheet.
8. Blocks, hatches, MLEADERS, MTEXTS and dimensions shall be annotative in the modelspace of grading plans and set to the scale of each viewport that those items will be viewed.

3.7. Scale Bars

Scale bars for civil drawings shall be taken from the civil palette or the CORP-C3D template. Scale bars shall only be used for plan views. They shall match the scale of the viewport and the title block.

3.8. XB (External Reference) Base Outline

The XB shall be XREF'ed into all plan sheets, for example: in the grading plan, fence plan, foundation plan, and cable trench plan.

The naming of the XB file shall follow the same 5- or 6-digit prefix used for the foundation plan with a suffix of .000.XB, or the legacy name followed by A00.XB, or S00.XB.

In the "units dialog" box, set "length type" to "architectural" and the "insertion scale" to "inches."

NOTE: With the exception of the grading and survey drawings, all other drawings that have the XB inserted shall have the units set to "architectural" and the insertion scale set to "inches."

If XREFs do not exist for existing substations and a project begins to develop a base plan, those modifications will become the new XB XREF. For example the foundations will become the XB and effort will be made to extract existing entities that belong to the XB such as:

- Foundations
- Fence
- Property lines
- Roads

These XREFs will follow the criteria in 9A.5, Section 6.2, *Building the XREF File*, which includes baselines (if the location is known). The insertion point will be at 0,0 and at the intersection of baseline.

3.9. Demolition Drawings

The drawing to be demolished shall be copied or "saved-as" with the word "DEMO" placed in front of the existing file name to prevent overwriting the original drawing file, e.g., DEMO-123456.001.dwg. Likewise, the drawing name in the title block shall have the word "DEMO" placed as a prefix, e.g., DEMO-123456.001.

When plotting demo drawings, the paper plot shall be stamped "FOR REFERENCE" in the lower right-hand corner of the drawing, as space allows.

The original drawing 123456.001 shall show the proposed design changes and shall be revved up. Drawings shall never be revved backwards to revision zero.

If an entire substation is being replaced or demolished, every drawing or document associated with the substation shall be voided. Within the void stamp block, "SUBSTATION REMOVED" (attribute tag #3) shall be entered, followed by the year. See 9A.4, Section 3.7.1 and 3.7.2 on voiding CAD and image files.

The title block in XB files shall be the Foundation discipline, and have the fourth line (attribute tag #6) read “BASE DRAWING,” and the third line (attribute tag #5) read “XREF.”

The components that primarily make up the XB are:

1. Baselines
2. Fences
3. Gates
4. Roads
5. Property lines
6. Foundations
7. Cable trench
8. Grounding mats

The XB file will not contain:

1. Text
2. Dimensions
3. or any above or below ground electrical facilities

Baselines shall run through the site placed in a north/south and east/west direction and shall avoid crossing foundations. The end of the baselines shall terminate 3′ inside the fenced yard where monuments shall be set as control points.

Design changes while creating an XB in a new substation may require that the placement of the baseline be adjusted during design or in creating the as-built. Baselines cannot be moved on existing substations or XB files after these processes because all drawings that reference the XB file will be affected. The intersection of the baselines in the XB shall always remain at 0,0.

4. Fence Plan and Fence Plan Detail Drawing

Fence plans and details are derived from the standard SR001 and SR002 template drawings. Fence plans and details differ from grading plans (which uses decimal units, decimal scale bars or decimal dimension styles). Unnecessary details from these templates shall be deleted when creating these drawings.

An overall plan of the fence is included, detailing the fence and gate locations measured from the base lines. The plan base (XB) shall be XREF'ed and attached at 0,0 with a scale of 1 (not with a scale of 12 or .08333).

The substation's sign placement shall be covered in the material and fabrication notes on the first sheet.

EXAMPLE: Rather than physically placing all the signs every 65′ along the fence, place one at a fence corner for pictorial representation while referring additional placements in the note. Turn off all foundations in the XREF.

5. Foundation Drawing

5.1. Creating New Foundation Drawings

To ensure the preservation of construction notes and history (rather than merging them to the new drawing), existing foundation drawings shall be retained, and not voided. Notes shall be placed in both the existing and the new drawing that refer to each other. Check out the legacy drawing, REV it up, and place notes that read as follows:

On the legacy drawing: "REFER TO DRAWING #123456.001, REV (#), DATE(MM/DD/YY) FOR ADDITIONAL FOUNDATION DESIGN."

On the new drawing: "REFER TO DRAWING #12345A01, REV (#), DATE (MM/DD/YY) FOR PAST FOUNDATION DESIGN."

5.2. Foundation Key Designators

Foundation key designators are typically letters, but may in some cases be alpha-numeric. These designators follow a process similar to that used in structural drawings. They do not, however, inherit any part of the drawing number.

Whenever possible, the HEX block designator shall be placed outside the fenced yard between the foundation centerline and the dimensions. The HEX block shall be taken from the civil palette, and shall be aligned at an equal distance from the fence.

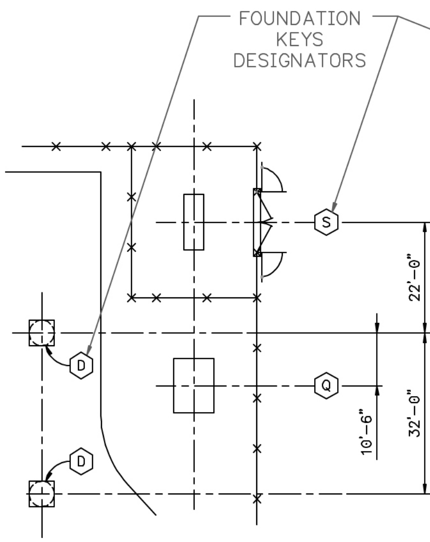
NOTE: For foundations within the yard where the designators cannot be placed outside the fence, place designators near the foundation with an arced leader. For consistency, arced leaders shall be similar in size and curvature. MLEADERS may also be used.

The foundation detail key shall be placed in paperspace in the upper right-hand corner against the title block border. The key block shall be taken from the AutoCAD civil palette, on the "Notes & Tables" tab.

FOUNDATION DETAIL KEY

KEY	DESCRIPTION	FOUNDATION DWG NO.	STRUCTURE DWG NO.	TOC ELEVATION
A	138KV 40'–0" DEADEND, TYPE 1	146007.003	146020	5022.00
A1	138KV 40'–0" DEADEND, TYPE 1, MIDDLE	146007.003	146020	5022.00
B	138KV 40'–0" DEADEND, TYPE 2	146007.003	146021	5022.00
B1	138KV 40'–0" DEADEND, TYPE 2, MIDDLE	146007.003	146021	5022.00
C	138KV 45'–0" DEADEND, TYPE 3	146007.003	146022	5021.80
D	138KV 40'–0" DEADEND, TYPE 4	146007.003	146023	5021.80
E	138KV 3PH CCVT STRUCTURE	146007.001	146024	5022.00*
F	138KV 3PH SURGE ARRESTER STR.	146007.001	146025	5022.00*
G	138KV LOW BUS STRUCTURE	146007.001	146026	5022.00*
H	138KV LOW SWITCH STRUCTURE	146007.001	146027	5022.00*
J	138KV HIGH BUS STRUCTURE	146007.001	146028	5022.00
K	138KV HIGH SWITCH STRUCTURE	146007.001	146029	5022.00*
L	CONTROL HOUSE	146008	–	5022.25
M	138KV SSVT FOUNDATION	146007.002	146033	5021.70
N	138KV CIRCUIT BREAKER FOUNDATION	146010.001	–	5022.00*
P	138KV CT/VT METERING STRUCTURE	146007.001	146031	5021.80
Q	EMERGENCY GENERATOR	146009.001	–	5021.70
R	TRANSFER SWITCH STRUCTURE	146034	146034	5021.70
S	PROPANE TANK	146011	–	5021.55
T	PANEL SUPPORT STRUCTURE	146036	146036	5021.70

* EXCEPT AS NOTED ON PLAN



SAMPLE SUBSTATION SALT LAKE COUNTY, UTAH FOUNDATION PLAN		
REVISION 0	144164.001	SHEET 1 OF 3

Figure 4—Placement of Foundation Key Designators

5.3. XREFs in Foundation Drawings

The XB base file shall be the only XREF attached to the foundation plan. It shall always be inserted at 0,0,0, on the XREF layer. The XB shall never be rotated.

6. Topographic Survey Drawing

6.1. Creating Drawings for the Company (For Surveyors)

All surveyors shall use the CORP-C3D template and shall download survey data into the CORP-C3D template. All points and line work in the CORP-C3D template shall be on the template layers; no other layers shall be created without company approval.

The existing grade (EG) surface shall be created in the Prospector, and shall be intact when the CAD file is delivered to civil engineering. The CORP-C3D template includes notes to assist the surveyor, to outline the company's plan creation and delivery requirements, and to explain the intended use of the template. The surveyor shall provide all of the information that is required by the Survey Scope of Work.

6.1.1. General Requirements

Entities shall be drawn at 1:1 scale and oriented to true north, so that the drawing coordinates for any point will match the final record survey coordinates. Text height shall be 3/32″ in paperspace, except for titles.

Surfaces, contours, profiles, etc., shall be developed in the Civil 3D Prospector using the company styles.

NOTE: If created with an earlier version of AutoCAD, contours can be polylines with elevations, on approved PacifiCorp layers.

6.1.2. Layering Conventions

All company layering conventions shall be used. Points, line work, breaklines, surfaces, profiles, symbols, text, dimensions, etc., shall be on their intended and designated layers (point descriptor code-dependent).

NOTE: If AutoCAD Civil 3D is not used, company layering conventions, noted above, is still required. If an earlier version of AutoCAD is used by the surveyor, contact the company to have the template saved for that version.

6.1.3. Borders and Title Blocks

The company border shall not be modified or exploded upon insertion. All shape files, text files, symbols, etc. shall be provided by the company. No external vendor specific shape files (*.shp or *.shx) shall be used. Surveyor's logos may be inserted into the drawing as a block near the title block.

The surveyor title block may be provided in paperspace, inside the rectangular boundary provided. The company border and title block shall be removed so as not to compromise the intended scale of the survey when the surveyor's .tif drawing is re-inserted into the PacifiCorp border by the company.

6.1.4. Surveyor Drawing Package Requirements

The civil software and version shall be clearly documented, i.e., "AutoCAD Civil 3D Release 2014." The following elements shall be included in the drawing package for submission to the company:

1. Captured point data used to create the final TIN or surface
2. The existing grade (EG) surface model, if created in Civil 3D within the company template, with the grading model information intact
3. The text (.txt) point file

4. All objects used to build the existing surface (such as 3D polylines, breaklines, points, etc.)
5. All contour information (polylines with elevations) generated by AutoCAD
6. An exported XML file of the points and EG surface
7. All the information required by the Survey Scope of Work.

See Section 8 of this document for more details on the CORP-C3D template.

6.1.5. Surveyor Notes Instructions

1. Use the coordinate system required by the Survey Scope of Work, i.e., UTM NAD 83 Datum.
2. The coordinates shown on the survey shall be the ground coordinates.
3. Specify the grid-to-ground scale factor in a note.
4. Specify the control point that was used as a base point when converting from grid-to-ground coordinates. Use a base point near or central to the point group.
5. A coordinate system shall be specified in the 'Units and Zone' tab in the drawing settings. The drawing settings can be found in Toolspace \ Settings \ right-click on the drawing name \ edit drawing settings.
6. A grid scale factor must be specified in the transformation tab. The grid scale factor can also be found or specified in the drawing settings.
7. The reference point must be specified in the drawing settings in the transformation tab.
8. The depth (or invert) elevation must be shown in the point description.

While working with the CORP-C3D template, the surveyor shall observe the following procedure:

1. Place survey data in modelspace using the required coordinates.
2. Delete the PacifiCorp title block in paperspace.
3. Fit the final survey inside the rectangle that remains inside the company's title block, including the surveyor's own title block, stamp, and company information.
4. After receiving it from the surveyor, the company will insert the final survey .tif image, including the surveyor's title block, inside the PacifiCorp title block.
5. The survey plan will be used as the record survey when completed. The CAD file shall be returned to the company (with all company conventions intact), with a PDF copy bearing the surveyor's stamp.

6.1.6. Submission to the Company

A company AutoCAD template shall be supplied to the surveyor, and shall be returned to the company with the conventions intact. These conventions include company styles, layering system, linetypes, dimension styles, text styles, blocks, etc. Other conventions shall not be accepted without pre-approval.

Surveyors shall furnish on a CD (or via email) a drawing file that can be used in AutoCAD Civil 3D, version 2014. An alternate version of AutoCAD Civil 3D may be used to create the existing surface model if pre-approved by a company representative.

The final deliverable shall include the following:

1. A stamped topographic survey drawing in AutoCAD and a PDF
2. All associated AutoCAD files and directory folders
3. Survey coordinate data in text (.txt) file format (point, north, east, elevation, description), and an .xml file that contains the survey data
4. Descriptor code legend, and a hard copy of all supporting information including field notes, and sketches
5. Any digital photography in ".jpg" file format with an accompanying photo log.

Digital data shall be delivered and included with any and all hard copy information.

6.2. Creating Drawings (From Surveyor's Files)

To create a topographical drawing from a surveyor's file, the file is saved with a company drawing number. Entities in modelspace shall remain in their original coordinates. These steps shall then be followed:

1. Create a new LAYOUT tab and move it to the front, as the first tab.
2. Insert the PacifiCorp border.
3. Convert the PDF file received from the surveyor to a .tif.
4. Assign the .tif the same drawing number as the new topographic survey drawing (e.g., 123456.000.tif).
5. Insert the .tif into modelspace.
6. On the leading layout tab, create a viewport and place the .tif (which is in modelspace) within the PacifiCorp border.

NOTE: The surveyor's title block should fit inside the viewport at the right scale. If the .tif does not fit in the viewport at its original scale, have the surveyor revise their survey plan so that it will fit. The scale of the survey shall not be altered.

7. Place the proper signatures in the PacifiCorp title block.

NOTE: These signers will be responsible only for the PacifiCorp title block, not for the content of the drawing.

ROCKY MOUNTAIN POWER PACIFIC POWER

Upon successful completion of these steps, the drawing shall have an image of the signed original survey shown within a PacifiCorp title block (the image being in modelspace and the title block being in paperspace) along with the actual survey entities in modelspace (not shown through the paperspace viewport).

7. Grading Plan Drawings

The primary software for developing grading drawings is Civil 3D. The provided template, in tabbed format, shall be used. The file name shall end with ".000" (i.e., 123456.000). No XT XREF shall be used on new projects and all sheets shall be cut from the tabbed file. An XT XREF may be used when revising an old grading plan that has an XT XREF, when a new survey is not available, and when creating a new surface containing the XT topography is impractical relative to the scope of work

The template—which includes a workflow used as an aid to develop of the grading plan—includes pre-developed "styles" with the required layers, line types, dimensions, profiles, notes, and details. Internal roads and yard surfacing shall be detailed and dimensioned using these styles and layers.

8. Company AutoCAD CORP-C3D Template

The company has created an AutoCAD CORP-C3D template to assist in the creation of proper grading plans. The template is intended to have all of the tools necessary to develop a set of grading plans.

Though all users have preferred methods of working in AutoCAD, the final grading plans that are delivered to the company must comply with company standards. Notes in the template file outline the company's preferred procedures, conventions and requirements, and help to explain what the company expects from the user.

The CORP-C3D template was created to:

- Establish grading CAD standards
- Enforce the grading CAD standards
- Produce quality and consistent grading plans
- Establish efficient procedures for creating grading plans
- Easily exchange grading plans between the company and consultants
- Simplify the management of electronic files
- Effectively convert survey CAD files to grading plans

The company's goal is to make the template as user-friendly as possible. The company's civil design group welcomes comments and suggestions that may improve the efficiency and quality of the template.

8.1. CORP-C3D Template Instructions

Users of the template are expected to be familiar with company standards. They are also expected to be proficient with AutoCAD, and to know how to use layers, annotative objects, MLEADERs, viewports, Toolspace Prospector, and Toolspace settings and styles. Though the company has issued formal standards and criteria, consultants are expected to resolve general AutoCAD questions and issues on their own.

While developing the grading plan the CAD operator / template user shall follow this procedure:

1. Use “Match Properties” to update entities to the company standards.
2. When viewports are assigned a certain scale, annotative texts, hatches, blocks and dimensions from modelspace won’t appear through the viewport unless they have been enabled to appear. To enable them, right-click on the annotative objects within modelspace and enable them to appear at the desired scales within “Properties.”
3. Place viewports on the DEFPOINTS layer.
4. The PSLTSCALE = 1.
5. The LTSCALE = 0.25.
6. Text height = 0.09375″ (all text shall appear to be the same height, with title scales being 0.125″).
7. Layer assignments:

All paperspace text shall be on the “TEXT” layer

   a. All modelspace text should be on the “C-ANNO-TXT” layer (or “C-ANNO-TXT1,” “C-ANNO-TXT2,” or “C-ANNO-TXT-BOLD.”)
   b. Blocks shall be on their respective layers.
   c. Tables shall be on the ”C-ANNO-TABL” layer.
   d. Keynotes shall be on the “C-ANNO-KEYN” layer.
   e. Survey points shall be on the “C-TINN-PTS-V” layer.
   f. FG points shall be on the “C-TINN-PTS” or the “C-ANNO-IDEN” layer.
   g. Symbols shall be annotative, and on their respective annotative layer, or the “C-ANNO-SYMB” layer.

8. All dimensions shall be annotative and placed on the “C-ANNO-DIM” layer. They may also be placed on an alternate DIM layer (i.e., “C-ANNO-DIM1”) if necessary. A DIM style named ‘annotative’ was created in the CORP-C3D template and shall be used by the user. If adding an annotative dimension in modelspace the paperspace scale needs to be the current scale in the lower right corner, or an annotative scale can be added in properties. Another approach is to add a dimension through the viewport where it needs to be seen because the dimension will automatically be drawn to the annotative scale of the viewport.
9. All leaders with text shall be created with MLEADER (annotate/leaders/multileader) and shall not be exploded. An MLEADER style named ‘annotative’ was created in the CORP-C3D template and shall be used by the user. If adding an MLEADER in

modelspace the paperspace scale needs to be the current scale in the lower right corner, or an annotative scale needs to be added in properties. Another approach is to add an MLEADER through the viewport where it needs to be seen because the MEADER will automatically be drawn to the annotative scale of the viewport.

10. All hatches shall be on their respective layers, and shall appear at the same scale in all views, including the profiles, sections and details. Since they are annotative, they shall appear at the same scale in all views. The paperspace scale is noted beside each hatch in the legend. The hatch shall be annotative when created, and the various scales can be assigned to the hatch. While creating a hatch in modelspace set the drawing scale (in the lower right corner) to the scale that the viewport will be in paperspace, and within 'Hatch Creation' set the paperspace hatch scale in 'Properties' and select Annotative' in 'Options'. For example, the yard finish rock hatch pattern scale will be 0.50 in 'Properties'. If the hatch pattern needs to be seen in a viewport with a different scale than the hatch was created with simply add that annotative scale within properties. If a hatch is created in paperspace the scale will be 1″=1´.

11. Delete all items from the grading plan that are not applicable (such as line types in the legend, notes, etc.).

12. The PacifiCorp blocks can be taken from the civil palette or from the template file and placed on their respective layers. Since they are annotative, confirm they are assigned the appropriate scales to appear in the desired viewports.

13. Before drawing any objects, ensure that the appropriate layer is current.

14. To avoid importing erroneous layers, ensure that all objects are on an appropriate layer before copying/pasting them into the grading plan.

15. Profiles are to be created using the “PacifiCorp PV-5 VERT” or “PacifiCorp PV-10 VERT” profile view styles. Profiles shall follow the same conventions used in the profile examples located in modelspace.

8.2. Existing Grade (EG) Creation

If the EG surface needs to be created because it has not been provided by the surveyor, the designer shall create the EG surface in the grading plan with the data provided by the surveyor. A designer building the EG surface shall take the following steps:

1. Save the CORP-C3D Template as the project grading plan by naming it the assigned sheet number.

2. Communicate with the surveyor to assure that the grading plan is using the same coordinate system as the survey, and then set the coordinate system within the cad file to the appropriate coordinate system. This can be done as follows: *Toolspace*, *Settings*, right click on the drawing title, *Edit Drawing Settings*… .Then set the appropriate coordinate system in the Units and Zone tab. The surveyor should also provide information about the scale factor needed to obtain the ground coordinates and the point that was used as the

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base point. See the Survey Scope of Work to verify the specific requirements for the project.

3. Import the XML file provided by the surveyor, or if an XML file is not provided import the points from the surveyor's point file into modelspace. Make sure that the current layer is set to 'C-TINN-PTS-EG or V'. The points can be made into a "Point Group," excluding any points that are above or below the existing grade. The survey points can be renumbered if necessary to avoid conflicts with the finished grade (FG) point numbers. Make sure that the appropriate coordinate system is set within the before importing an XML file (see 8.3.3.2).
4. Copy/paste the objects from the surveyor's CAD file if the template was not used by the surveyor, making sure that the objects are on the PacifiCorp layers prior to copying them. The objects used for creating the EG surface are 3D polylines, boundaries, and drawing objects. Since contour lines do not show what is happening between the contours, 3D contour lines may only be used in conjunction with points and breakline. Contours may only be used if no points are available.
5. All objects and points shall be on the coordinate system required by the Survey Scope of Work.
6. If an XML file is not provided by the surveyor, build the EG surface from the data and objects provided by the surveyor.
7. Compare the EG contours with the surveyor's contours. If they don't match, troubleshoot until they do.
8. Convert the PDF file that was provided by the surveyor to a .tif.
9. Assign the .tif the same drawing number as the new topographic survey drawing (e.g. 123456.000.tif).
10. Insert the .tif into modelspace.
11. Create a viewport in paperspace inside of the company border and assign it the correct scale.
12. The survey, including the surveyor's border and title block, shall fit to scale inside the viewport.

8.3. Grading Plan Creation

Once the EG surface is built from the survey data, the paperspace tabs in the template shall be used to create the necessary sheets within the grading plan. Delete any unused tabs. After the grading plan is created, objects from the CORP-C3D template can be copied into the grading plan. Viewports can be copied from the template, as long as the objects in modelspace are in their appropriate locations.

Read the procedure notes to become familiar with the intended use of the template. After becoming familiar with the procedure notes, the notes may be erased, and all items from the template that are not applicable to the project may be deleted. The user shall use all company styles, layers, blocks, hatches, linetypes, dimension styles, text style, tables, borders, specifications, contractor notes, and construction notes. If the user needs something that is not provided in the template (such as a style or a hatch or a block), something else may be used, if approved by the company. Items created or supplied by the user must reside on a PacifiCorp layer.

The user shall purge the drawing when the grading plan is completed. The final CAD file must be audited against the company standard template and returned to the company when it is complete. The company will not accept any CAD files that do not pass the audit.

8.3.1. Grading Plan Revisions

If a grading plan is created for an existing substation, and the substation has a previously-developed grading plan, consider how to work with the coexisting grading plans. The existing grading plan can by kept by revising it and adding the new information as a revision, or the existing grading plan can be voided and superseded with the new grading plan. Confirm that no other sheets are left behind when voiding a grading plan. Only an entire series can be voided.

Any revisions, voiding, or superseding must be properly processed, documented and checked back in. Alternately, use notes to cross reference two or more coexisting grading plans when voiding or superseding an existing plan is not preferred or practical. If a new plan is created, the old plan shall be checked out and a reference note added. It shall be upgraded to the next revision number and checked back in.

Drawings under review shall be revision “0A” with a “Preliminary” stamp. After the drawing is complete, checked, and ready to be checked in, it shall become revision “0.” If the drawing is created for bidding purposes, it shall have a “For bid purposes” stamp.

If any revisions are made to the drawing after it has been issued for bid, it shall be upgraded to the next revision number and reissued to retain a record of any changes and subsequent change orders issued by the contractor during the construction phase.

8.3.2. Grading Plan Vicinity Maps

The vicinity map should be at a large scale (such as 1″ = 1000′) that will represent a bird’s eye view of the area. An example of the vicinity map is shown on the template. The finished map shall then be made into a block to skirt past the audit routine. See company Engineering Handbook 9A, Section 16, *Vicinity Maps*.

8.3.3. Recommended Workflow for Grading Plans

1. **Setting layer and scale:** Make sure that the current layer is set to the right layer before drawing objects, importing points, and X-referencing drawings or images. The “Annotation Scale” in the lower tray must also be set to the appropriate scale when creating profiles, dimensions, MLEADERS, hatches, tables, points, etc. If objects are copied/pasted from other CAD files, the objects being copied shall be on a PacifiCorp layer before pasting them into the grading plan (unwanted layers may come with pas-

ted objects). Imported blocks from the palette should automatically be placed on the right layer.

2. **Importing survey data:** Before importing survey data assure that the grading plan is using the same coordinate system as the survey, and then set the coordinate system within the cad file to the appropriate coordinate system. This can be done as follows: *Toolspace*, *Settings*, right click on the drawing title, *Edit Drawing Settings*…. Then set the appropriate coordinate system in the "Units and Zone" tab. The surveyor should also provide information about the scale factor needed to obtain the ground coordinates and the point that was used as the base point. See the Survey Scope of Work to verify the specific requirements for the project.

Import the XML file provided by the surveyor, or if an XML file is not provided import the points from the surveyor's point file into modelspace. Make sure that the current layer is set to 'C-TINN-PTS-EG or V'. If data is not imported using Civil 3D (points from a file), the survey data file can be XREF'd after converting the AECC points to blocks (home: points: convert land desktop or AutoCAD points to blocks, then explode to blocks) then bound and exploded. This procedure will create XREF layers that will need to be changed. Units in both files shall be set to feet; coordinates and elevations shall correspond to the survey. Data may also be copied/pasted from the survey CAD file, provided that the objects are on the proper layers before copying and the coordinates, and that elevations correspond to the survey. If survey data is placed on the PacifiCorp template, it can be used as the grading plan, but it must first be verified that objects are correct and on the right layers.

3. **Viewports:** After the survey data is imported, stretch the viewport in paperspace as needed to fit the sheet. Allow enough room around the viewport for the notes, the legend, and other necessary information in paperspace. Locate the survey through the viewport by using zoom-extents, and zoom to the survey. Pick an appropriate scale for the viewport to fit the project area by picking the viewport border and by using the scale menu in the lower tray. Once the appropriate scale is selected, lock the viewport.

4. **XB file:** Visit the XB to verify that the baselines and fence lines have been drawn correctly and placed on the right layers. Make sure that the design is current. The baselines should terminate 3′ inside the fence lines. The intersection of the baselines shall be at 0,0.

5. **XREF the XB:** While in the grading plan modelspace, XREF the XB file (make the XREF layer current), place it in the proper location, and rotate as needed. While XREFing the XB, make sure that the "Path Type" is set to "No Path." The XB shall be kept in the grading plan, and the objects in the XB shall be used to represent those objects in the grading plan. Keep the XB attached as an XREF. Foundations and cable trenches drawn in the XB shall be frozen inside the grading plans. Be aware that changes made in the XB will impact the grading plan.

6. **Existing grade (EG) surface:** Before the proposed surface can be created, an existing grade (EG) surface must be created (see #2). Use the information from the

survey to create the EG surface, and compare the resulting contours with the survey contours to ensure that it is correct.

7. **Finished grade (FG) surface:** Design the proposed substation based on the XB. The fence line can be offset 5′ out; the offset lines may be used as the edge of the yard rock. These lines are also used as the edge of the substation and the top of the slope to the surrounding area. If the slope rises beyond the edges of the substation, a ditch is needed to manage the stormwater runoff. This means that the outer edge of the substation (5′ minimum outside of the fence line) will always slope down, either to the existing grade or to the bottom of a new ditch. If a new ditch is added, it will always slope up from the bottom of the ditch to the existing grade. The slopes outside of the substation edge shall have a 2:1 maximum slope. The ditch should be deep enough to adequately manage the stormwater runoff. Slopes that are steeper than 2:1 shall be pre-approved by a company representative. Raising or lowering the substation finish grade elevation may be necessary in order to balance the cut and fill volumes.
8. **Substation slopes:** The finished grades inside the substation shall slope about 1% to drain the surface runoff. They shall slope in the direction that the native grade slopes when possible. All sheet-flows should be a maximum of 300′ long, after which the runoff should be intercepted by a stormwater collection system such as an underdrain, catch basin, trench drain or ditch, and diverted to a strategic discharge location.

In an expansion project, matching the proposed grades with the existing substation grades shall be considered. Also consider the grades in the area of foundations and new substation equipment. The proposed grades will slope for drainage. Since the tops of foundations remain constant, some foundations may reveal more than others. For example, some footings may reveal 6″, while others may reveal more or less. It may be more practical to slope the surface in a different direction.

9. **Stormwater runoff:** All runoff should simulate historic runoff patterns and should discharge to locations that will compensate for the impact of the development. Since the construction will disrupt the natural flow of the runoff, it is necessary to release the storm water in a way that models pre-developed conditions. Also consider treatment, detention/retention, how to deal with concentrated flows where there used to be sheet flows, how to release the runoff at historic rates, and how to prevent post-construction erosion. All storm water runoff shall be managed according to local governing requirements.
10. **Excavation:** While designing the grades for the substation, it is important to minimize the amount of excavation. Review the geotechnical report for the depth of top soil removal and to see if the native soils can be used as backfill. The cut and fill volumes shall be balanced if possible, but this will depend on the existing terrain. If the native soils cannot be used as fill, minimize the amount of imported fill. It is more economical to export excavated native soil then to import structural fill.
11. **Building an FG surface:** 3D polylines may be used to define the outer edges and grade changes of the substation, ditches, ponds and access roads. Draw the 3D

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polylines wherever grade breaks are needed, and then stretch the 3D polylines in the Z direction to establish the desired elevations. The 3D polylines (and breaklines) should go on the “C−TINN−BKLN” layer. Alternately, feature lines may be used instead of 3D polylines. This method of creating an FG surface is a suggestion and alternate methods may be used.

After the 3D polylines are drawn, the proposed FG surface can be created. The 3D polylines are converted to Feature Lines and an FG site can be created with the Grading Creation Tools. The outer 3D polylines that represent the edges of the substation (sloping down to the existing grade) and the new ditch bottom (sloping up to the existing grade) are the outer limits of the FG surface. It is often easier to draw a continuous 3D polyline along the outer limits of the FG surface to minimize the number of Feature Lines used to ‘daylight” to the existing surface. After creating an FG Site and Grading Group the outer Feature Lines are used to ‘daylight’ to the existing surface and the inner Feature Lines are used to create ‘infills’

If a 2D polyline boundary is drawn around the outer limits of the surface to control the contour lines, it should go on the “C-TINN-BNDY” layer.

As stated earlier, raising or lowering the substation finish grade elevation may be necessary in order to balance the cut and fill volumes. There is a way to do this in AutoCAD Civil 3D, and the CORP-C3D template has some notes in modelspace to explain how it is done.

After the FG surface is created add enough contour labels to the 5′ contours to adequately show the elevations in the area. If the contours are far apart, or if clarity is needed, add contour labels at 1′ intervals.

12. **EG mask:** After creating the FG surface, the new contours will be shown and the quantities can be determined. The EG contours that are behind the FG surface can be masked by creating a polyline around the edge of the FG surface and using it for the mask. The Limits of Construction closed polyline (on the C-CTRL-LOCN layer) that was created by the user when building the FG surface (by using the ‘daylight’ polyline found on the C-TOPO-FEAT and C-TOPO-GRADE layers) can be used to create the mask polyline. The mask polyline should be on the “C-TOPO-MASK” layer, and it can be turned off.

13. **Profiles:** Profiles and sections shall be provided to help illustrate the grading and material sections. A sample of the profiles can be found in the CORP-C3D template. The new substation shall have a minimum of two profiles that are perpendicular to each other, showing the full extent of the yard. Alignment polylines are drawn where the profiles or sections are intended to be, and the alignments are created from the polylines. All access roads should have a profile along the centerline alignment that shows the grades and vertical curves that can be tied to the horizontal alignment of the road. All ditches, trenches, utility structures and ponds shall have a section or detail to clarify the intent of the design.

14. **FG points:** When creating surface points on the grading plan to define the coordinates and elevations of each controlling feature, put them on the "C-ANNO-IDEN" layer, and in a strategic pattern that is easy to follow. The points shall also have a description that is easy to understand. See sample grading plans to see how points are positioned, defined and described. A point table shall be generated in modelspace from the inserted FG points and put on the "C-ANNO-TABL" layer. A viewport in paperspace shall appear on the grading plan to show the point table. The profile sheet is provided on the CORP-C3D template, and the viewport will show the profile if placed in the proper place in modelspace.

15. **Quantity tables:** The active quantity table is located in modelspace where it can be populated. An explanation of table use and quantity entry is provided with the table. The table is viewed through a viewport on sheet 2 of the CORP-C3D template and is locked.

16. **Blocks and symbols:** All symbols, such as scale bars, north arrows, section arrows, subtitles, and breaklines, should be taken from the palette whenever possible. A block (also on the palette) with all the layers can be brought onto the drawing to reinstall the Civil 3D layers.

17. **Hatches, texts, blocks and dimensions:** Hatches, texts, blocks and dimensions in modelspace should be annotative, so that they will be the proper size in the desired paperspace viewports. The objects must be set in modelspace to appear in those paperspace viewports. The "Annotation Scale" in the lower tray must be set to the appropriate scale when creating these objects, or they can be set in the 'Properties' tab, and they shall be on the appropriate PacifiCorp layer as defined in the CORP-C3D template.

8.4. Civil3D Data-Shortcuts

Civil3D data-shortcuts are very small XML files which provide complete reference copies of objects that can be inserted into one or more drawings. Data shortcuts are not used in the company; all data references shall be promoted in Civil 3D cad files prior to delivering to PacifiCorp.

9. Pre-Construction CAD QAQC Submittals

Pre-construction CAD QAQC submittals are used for quality checks only, and none of these documents are input into the company's DM. Make a copy of the working project, promote all data-shortcuts, and send the company complete stand-alone files for these submittals. Please note that pre-construction CAD QAQC submittals will not be archived or stored on company servers, nor will they be returned to the originating consultant.

10. Initial Issued-for-Construction Submittals and Subsequent Submittals

To submit initial issued-for-construction packages, and subsequent submittals, please include the following:

- One or more DVDs with a .zip file containing the complete directory structure of the working Civil 3D project. Include all production and reference drawings and the working directory. Also include any additional files and materials required for the complete archival of the project at the time of its submittal to the company. The .zip file will be entered into the company's electronic document management system (DM), and referenced in each individual project drawing's metadata.
- A spreadsheet clearly listing all submitted company project drawings (also to be included in the project ZIP file).
- A complete set of production drawings in PDF format suitable for input into the company's DM.
- A complete set of production AutoCAD drawings with all data shortcuts promoted. These promoted drawing files will be entered into the company DM. A notation will be placed in each records comment (version) field indicating that it was created with Civil 3D. Reference the name of the archived Civil 3D project .zip file.

11. SPCC Drawings

Spill Prevention Control & Countermeasure (SPCC) drawings shall be created using the same method as foundation drawings, using a Corp-D title block and with the following criteria:

1. Notes and legends shall follow the standard format using horizontal and vertical lines with the text string above the horizontal line. Text height shall be 1/8″ and the body of the notes shall be 3/32″.
2. North arrows shall be placed in the upper right-hand corner of the drawing.
3. The scale bar shall be placed in the lower right-hand corner.
4. The drawing units shall be set to "architectural."

12. Structural Drawings

Structural drawings are tabbed files created from the standard file in DM, or from a previous project. When blocks are modified, all sheets will be updated. Structural drawings follow the standard sheet layout where sheet one shows the front elevation, side elevation and plan. Subsequent sheets include the mark numbers and their details.

Design shall be done in modelspace, drawn 1:1 and shown through viewports in paperspace with a valid scale. Text justification for DTEXT shall be middle left and middle right. Text justification for MTEXT and MLEADERS shall be top left and top right. When lining up the multiple details in paperspace, the details are to be lined up horizontally and vertically.

13. Sheet Contents

Sheet one shall include the bill of material, material and fabrication notes, general design notes, legend and reference blocks. These are all taken from the civil palette.

Subsequent sheets shall include the mark numbers, which reflect the last three digits of the drawing number (as shown in Figure 5).

	A	B	C	D	E	F
1	BILL OF MATERIAL (1 STRUCTURE)					
2	NO. REQ'D	MARK	DESCRIPTION	REMARKS	UNIT WT.	TOTAL WT.
3	2	164-1	COLUMN ASSEMBLY	SEE DETAIL	276.3	553
4	1	164-2	BEAM ASSEMBLY	SEE DETAIL	675.0	675
5	2	164-3	END PLATES	SEE DETAIL	3.5	7
6						
7						
8	2	–	⅝"DIA.x1¼" BOLT		0.311	1
9	9	–	⅝"DIA.x2¼" BOLT W/HEX NUTS		0.390	4
10	11	–	⅝"DIA. FLAT HARDENED WASHERS		0.036	0
11				ESTIMATED WEIGHT		1239
12				PLUS 5% FOR GALV.		62
13				TOTAL EST. WEIGHT		1301

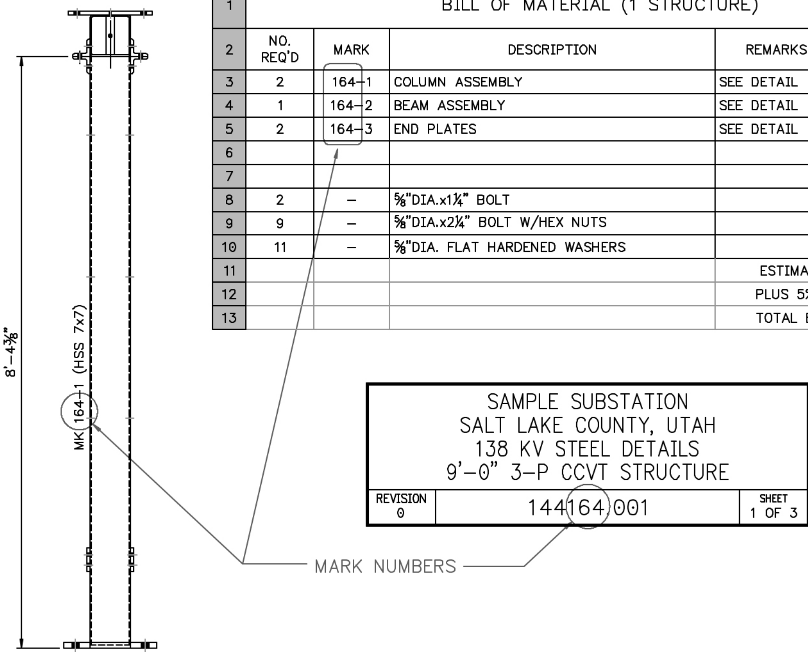

Figure 5—Sheet Numbering and Mark Numbers

13.1. Layering

Steel blocks in these drawings shall reside on the steel layer (with the exception of center, hidden and dashed lines, which shall be on their respective layers). Line work inside the block shall be on layer zero.

13.2. Blocks

When using the WELD-SYM block from the palette: set the appropriate DIM style current, pull the block in from the palette, then update the leaders with the “DIM update” command. This will give the leaders the proper arrow size.

XCLIP’ing is used with blocks. It is permissible in structural drawings only. When a column or beam is stretched, ensure the details that use the column or beam as a block are not adversely affected.

EXAMPLE: If the item is stretched out of the limits of the XCLIP frame, detail will be lost. Some steel entities may be dynamic and can be stretched by highlighting the object and using the arrow to stretch.

13.3. Base Plate Holes

Base plate holes shall match the anchor bolt size. For example, if the bolt diameter is less than 1″ then the base plate hole shall be "bolt dia. + 1/8″," however, if the bolt diameter is greater than, or equal to 1″, then it shall be "bolt dia. + 1/4″."

13.4. Dimensioning

Below is the typical style of dimensioning where an overall dimension, a center dimension, and dimensions from the center, are used for dimensioning details. Dimensions shall be shown at the top and left side of the details. Text shall be shown on the right and on the bottom. Use single line text on the TEXT layer using "%%U" for the line placement as shown for the section.

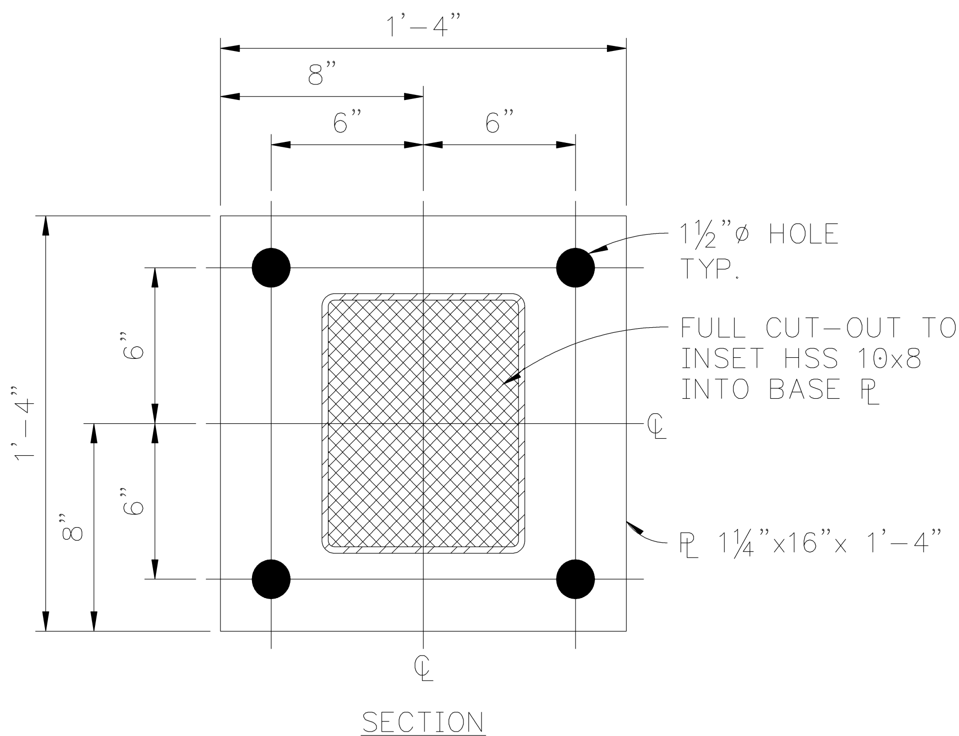

Figure 6—Typical Dimensioning (Example)

14. Handbook Document Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to civil engineering. This document shall be used and duplicated only in support of company projects.

9B.4—Communications Drafting Standards

1 Scope

This section of PacifiCorp's Engineering Handbook provides communications discipline-specific drafting and design standards. For an overview of general PacifiCorp drafting standards, see Engineering Handbook volume 9A, *AutoCAD—General Standards*

Communications drawings vary from the standards discussed in volume 9A. *Block Usage and Development* drawings have their own standard format (discussed in section 3). Drafters without access to PacifiCorp servers should contact their EPC contact or the communications drafting department admin at commdraft@pacificorp.com to request access.

2 General Document Standards

The following are general drafting practices standard to communications drawings. Following these practices when creating documents ensures conformity to standards set forth by communications engineering.

1. If more than half of a raster image requires revision, the entire file shall be redrawn in AutoCAD.
2. Drawings scaled at 1:1 shall have no viewport. All entities shall be placed in paper space. Each drawing shall have only one layout tab named "Layout1." If more layout tabs are included in an existing drawing, they shall be deleted.
3. With drawings found to be out-of-scale, it is not reasonable to re-draw the drawing. Putting NONE in the scale area of the title block is acceptable.
4. When needed, the communications department does allow the overwriting of dimension text.
5. Drawings with a CII−CRITICAL INFRASTRUCTURE INFORMATION stamp shall be on the 0 layer. There should be no new rev 0 drawings with the CII−CRITIICAL INFRASTRUCTURE INFORMATION stamp unless specifically approved by PacifiCorp's transport and SCADA engineering departments.
6. Revision clouds, text, leaders, and dimensions shall be placed in the same space as the rest of the drawing (paper space or model space).
7. SNAP shall be turned off, except in block & level drawings.

2.1 Layer Control

1. Use only the standard layers that come in the CorpD−Comm.dwt template file.
2. All colors, line types, and line weights shall be set to BY LAYER for all lines, objects, blocks, and text.

3. All all non-standard blocks, text styles, dimension styles, layers, and line types shall be purged.

2.2 Text and Dimensioning

Text and dimensions that are incorrect shall be corrected and formatted as follows:

1. Text shall be set to the Simplex1 font type “standard.” Use only the text style that comes in the CorpD−Comm.dwt template file.
2. Use the S1, S2, S3, S4 thru S8 styles to narrow text.
3. The width factor shall always be set to 1.00.
4. Lowercase text shall not be used. (Exceptions: industry standard units and names, i.e., dBm, MHz, kHz, DMXplore.)
5. Use only the dimension styles in the CoprD−Comm.dwt template file.

NOTE: Manufacturers’ logos on equipment elevations are allowed exceptions.

2.2.1 Text Height

1. Text height shall be properly justified and 1/8” (.125) in height.
2. Headings shall be 3/16” (.1875) in height.
3. Headings that are free-floating shall be underlined and placed on the TEXT HVY layer. If the heading is part of a table, place headings on the text layer and do not underline them.

The following entities have varying text size and exceptions are allowed. These are:

1. equipment elevation views
2. 66 block diagrams
3. tables in drawings (where the size of the table takes up nearly the whole drawing, and the text size is smaller than 1/8”)
4. DS1 diagrams
5. existing attributed blocks with established text heights

Additionally,

6. Manufacturer’s logos and card elevation views: text inside these should be left as-is, however, any text and leaders describing the equipment or card should be standardized.
7. If the drafter encounters any other drawing in which the information and/or the integrity of drawing would be compromised by changing the text size, it should be left as found.

2.3 Drawing Size

Print size for communications drawings shall be set to 11 × 17 inches for all drawings except for block & level. Block & level drawings shall be set to 8.5 × 11 inches. The following settings shall also be set:

1. LTscale = 0.25
2. PSLTscale = 1
3. Plinegen = 1

Drawings shall be saved set to paper space, zoomed to border extents, with the 0 layer active.

2.4 Communications Title Block

Communications title blocks are different from any other discipline. Attributes in this block that are missing or incorrect shall be corrected as follows:

Tag 1 **Discipline:** If COMMUNICATIONS is not in this tag, and if the red lines do not direct changing this to COMMUNICATIONS, then do not work on this drawing; contact communications document control.

Tag 1A **Facility Name & Type:** If the site is a COMM SITE, this field shall be spelled out with two words.

Tag 2 **Document Type:** Proper document type naming shall be taken verbatim (without exception) from the list found in Pacificorp Engineering Policy *104 – Indexing of Discipline and Document Type.* (http://idoc.pacificorp.us/policies_and_procedures/eamp/dadc/fpp.html).

NOTE: Where dashes are used on the 3rd line (Document Type), a space is placed before and after the dash. For example: "EQUIPMENT ELEVATIONS - A1."

Tag 12 **PL Number (or Plant Locality Number):** Use the official PL# if available. These can be found in a pull-down menu on the border tab of the BAD CAD audit.

NOTE: Some sites do not have a PL#, or their drawings deal with an overall view of large scale, multi-state systems. PL#s are not required.

3 Block & Level Drawings

Block & level drawings have unique standards which should be followed during creation and/or modification.

1. All block & level drawings shall have no viewports with all entities set in paper space.
2. Each drawing shall have only one layout tab which shall be named Layout1. If there are more layout tabs, they shall be deleted.
3. The rev numbers in the title block and the revision block shall match. There shall be only one revision block per drawing. Revision blocks shall not be stacked.
4. Text shall be set to the Simplex1 font type "standard."

5. Use S1, S2, S3, S4 thru S8 styles to narrow text. An exception used in microwave blocks is: VERT.
6. Text height shall be properly justified and 1/16” (.0625) in height. Allowable exceptions to this include existing attributed blocks with established text heights (text inside these should be left as-is). If the drafter encounters a drawing in which the information and/or the integrity may be compromised by changing the text size, it shall be left as found. Contact communications engineering at commdraft@pacificorp.com with questions.
7. To identify text for the location of equipment and /or antennas, use the “B&L–FAC–BRKT” block.
8. Lowercase text shall not be used. (Exceptions: industry standard units and names, i.e., dBm, MHz, kHz, DMXplore.)
9. SNAP shall be set to 1/32” and shall be used for all items.

The following attribute tags 1–17 and 24, if missing or incorrect, shall be filled out as follows:

Tag 1 **Discipline:** (Typical: COMMUNICATIONS)

Tag 2 **Circuit Number:** (Typical: two numbers, three letters, and four numbers)

Tag 3 **Facility Type:** (Typical: CIRCUIT DIAGRAM).

Tag 5 **Document Type:** (Typical: BLOCK & LEVEL)

Tag 6 **Drawing Title:** (All CAPS)

Tag 7 **Drawing Number:** In filenames of older drawings, “C” designates an East-side location while an “E” designates a West-side location (for example, 99999C01 = East-side).

Tag 8 **Sheet Number:** Sheet 1 shall read “1 OF (total sheets).” Following sheets shall read numerically i.e., “2”.

Note: When adding sheets, “1 OF (total sheets)” shall be clouded and the sheet shall be “revved” up.

Tag 9 **Revision Number**

Tag 10 **Drawing Scale:** (Typical: NONE)

Tag 11 **Project/ER Number**

Tag 12 **Drawing Date:** (i.e. 01/01/01, not 1/1/2001, or 1/1/01)

Tag 13 **Engineer’s Initials**

Tag 14 **Designer’s Initials**

Tag 15 **Drafter’s Initials**

Tag 16 **Checker’s Initials**

Tag 17 **Approver’s First Initial and Full Last Name**

Tag 24 **CAD File Number**

4 Handbook Issuing Department

The Engineering and Asset Management Documentation department of PacifiCorp published this document. Questions regarding editing, revision history and document output may be directed to the lead editor at (503) 813−5293. Technical questions and comments regarding the content of this document may be directed to Drazen Galic, Transport & SCADA Engineering, (503) 813−6910.

This material specification shall be used and duplicated only in support of PacifiCorp projects. This document is considered a valid publication when the signature blocks below have been signed by the current revision's author and manager.

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Engineering Documentation

9B.10—Thermal Generation Drafting Standards

1. Scope

This section of the company's Engineering Handbook provides thermal generation discipline-specific drafting and design standards. The requirements elaborated in this document apply to the thermal generation group only and should not be considered applicable to other company groups. This handbook document must be used in conjunction with Engineering Handbook Volume 9A, *AutoCAD—General Standards*. These two documents together form the computer-aided drafting standards for thermal generation. This document applies to all work, whether it is prepared internally or externally.

2. General

While the AutoCAD standards are contained in this document, procedural information, and other files used for creating and managing AutoCAD drawings are available from document control personnel.

2.1. Acceptable AutoCAD Format

- All AutoCAD files must be provided in the current, company-accepted format.
- Final AutoCAD hybrid or XREF'd drawings must be compatible with the current Electronic Document Management System (EDMS).
- Final documents must not be provided in a newer version of AutoCAD than the edition being used by the company.

3. Borders

All borders will have a border revision date near the lower left corner just inside the border line. Each AutoCAD drafter/designer, whether internal or contracted, is responsible for ensuring that the most current version of the company border or template is used.

3.1. Border Insertion Point

All border insertion points are located at coordinates 0,0 in the paper space environment. This places the lower left corner of each border at coordinates 0.5,0.5.

3.2. Border and Paper Size

The borders shown in 9A, Table 1 have been developed for use on all company drawings. All borders approved for thermal generation are named as described below:

1. The CORP-D-GEN border is the preferred border, but the CORP B-GEN, CORP-E-GEN, and CORP-A-GEN may be used to meet specific plant needs.
2. *The CORP-B2-GEN border must be used for Dave Johnston Plant "B" sized drawings*. **This border shall not be used for any other plants or locations.**

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3.3. Drawing Numbers

3.3.1. Assignment

Company document control shall use the following procedures when assigning new drawing numbers:

When to assign new numbers

New drawing numbers shall be assigned when the need arises for new drawings to be created at new or existing company facilities. For contract jobs, the document control and design/drafting personnel responsible for the plant site will issue a list of drawing numbers for each project.

How to use new numbers

Once the user has determined how many new numbers are needed, he or she shall contact company plant site document control personnel. The user will be given new numbers based on current plant numbering procedures for the specified location.

Legacy numbering

Legacy drawings created with numbers not associated with the plant numbering system may retain the legacy drawing number. At the discretion of facility drafting support, these numbers may be changed to meet the plant standard numbering system.

If the numbers are changed to meet the plant numbering system, the legacy numbers must be entered in the vendor assigned number fields for the drawing title block and in the EDMS. All other associated drawing numbers in this legacy series must be changed in the same way.

If necessary, new drawings may be added to an existing legacy drawing number series.

Generic numbering convention

When plant site numbers are not available, a generic numbering convention may be assigned by company document control personnel or plant site document control personnel. This will be structured as shown in Figure 1, and must appear in the drawing title block and the drawing file name. *<u>The generic numbering convention will only be used when there are no plant specific numbering requirements.</u>* See Table 1 for examples of drawing/document numbers for various types of files.

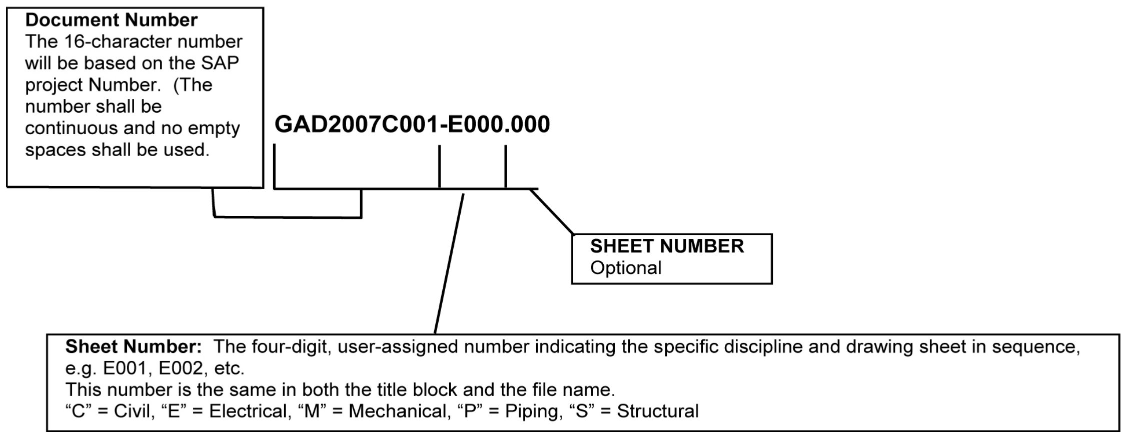

Figure 1—Drawing Number Diagram

Table 1—Drawing Number Example

Description		File Name	Title Block
Single sheet stand-alone drawing:			
		GAD2007C001-E001.dwg	GAD2007C001-E001
Drawing with multiple sheets:			
	Sheet 1	GAD2007C001-E001.dwg	GAD2007C001-E001
	Sheet 2	GAD2007C001-E002.dwg	GAD2007C001-E002
	Sheet 3	GAD2007C001-E003.dwg	GAD2007C001-E003
or			
	Sheet 1	GAD2007C001-E001_001.dwg	GAD2007C001-E001.001
Raster image file for # GAD2007C001-E001.DWG GAD2007C001-E001.tif			

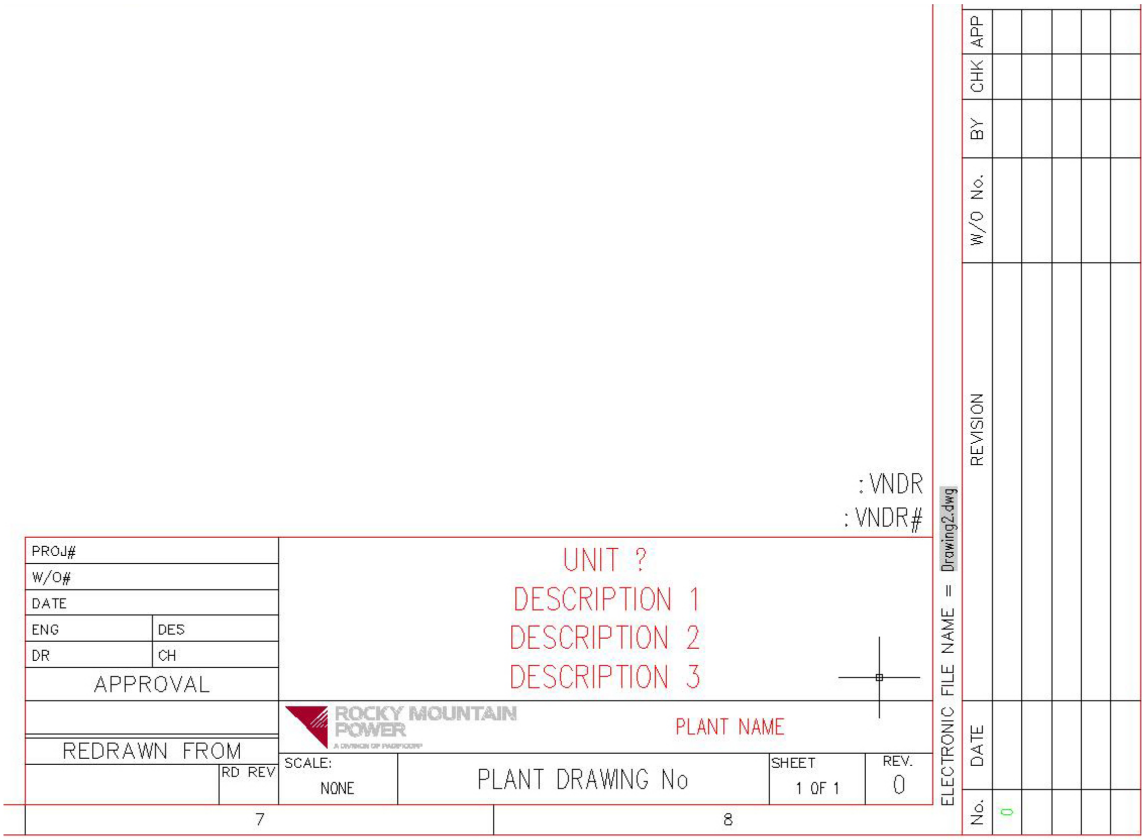

Figure 2—Title Block

3.4. Title Block

The title block is provided as part of the border, and has been assigned attributes for use with EDMS. The attributed borders have been designed to be inserted into a new or existing drawing and are required on all company AutoCAD files. They are not to be exploded or modified in any way. Modifying attribute types and styles is not acceptable. For example, modifying the drawing number attribute to a field is not acceptable. The following guidelines apply to creating content for the title blocks:

1. When entering information into the attributed fields, leading or trailing spaces are not allowed.
2. Generic, generalized title information is not acceptable. Drawing type and descriptions must be specific enough to be searched in the current EDMS.

3. The following are examples for the attribute tag TITLE_LINE_2 with the prompt of DRAWING TYPE:

   Example 1: Title information for a current structural steel drawing might say, "STRUCTURAL STEEL." An appropriate and acceptable description might include, "STRUCTURAL STEEL PLAN AT ELEVATION 2150', " or "STRUCTURAL STEEL DETAIL "A" AT COLUMN 3 TURBINE DECK."

   Example 2: Title information for a current instrumentation diagram might say, "INSTRUMENT DIAGRAM." An appropriate and acceptable descriptions might include, "TURBINE SUPERVISORY INSTRUMENT DIAGRAM LOOP 151 4-20mA."

4. All electrical one-line and three-line diagrams must be indicated as such in the title information.
5. All drawings used as a reference, attachment or XREF must be listed in the drawing information.

3.5. Converting Legacy Title Blocks to New Title Blocks

All legacy drawings being modified shall have the title blocks updated to the most current version. The D-style title block is preferred. Where necessary, and under the direction of the local facility drafting support personnel, alternate company standard title blocks may be acceptable. Similar nomenclature in existing title blocks is transferred to the new title block. Missing fields or incorrect nomenclature shall be corrected.

It is not necessary to transfer the legacy revision information when converting the title blocks. The drawing is rev'd up to the next number with a description of the current modifications.

4. Font and Text Style

4.1. General

Text on new company drawings shall use the *simplex.shx* font as it is supplied by Autodesk as part of the off-the-shelf AutoCAD package.

If, for any reason, the *simplex.shx* font cannot be used, <u>the only fonts that may be substituted are the AutoCAD off-the-shelf fonts</u>. No custom font libraries shall be used; Windows-based fonts common in other software is discouraged.

The T&D PacifiCorp owned *simplex1.shx* font mentioned in Standard 9A is not allowed.

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4.2. Use of Text Symbols and Fraction Codes

The *simplex.shx* font contains all standard keyboard characters and many other special characters. Special characters in most cases can be created using single-line text (DTEXT). If a special character is not part of the *simplex.shx* character set, another AutoCAD packaged off the shelf font may be used. Multiline text, (MTEXT), can be used to stack numbers, fractions or other text.

4.2.1. Special Characters

Table 2, gives %% and international code (Unicode) entries for some commonly used symbols that are a part of the simplex font library. Some of these characters are not available by using "%%" but are available through Unicode. These start out as \u+ for the code value.

Table 2—Codes for Special Characters

Symbol	Code	Symbol	Code	Symbol	Code
° (deg)	%%d or \u+00b0	±	%%p or \u+00b1	⌀ (diameter)	%%c
⅊ (plate or property line)	\u+214a	℄ centerline	\u+2104	Ω (omega)	\u+2126
µ (micro)	\u+00b5	underscore	%%u	∠ (angle)	\u+2220
Δ (delta)	\u+0394	(subscript 2)	\u+2082	(squared)	\u+00b2
ɸ (electrical phase)	\u+0278				

4.2.2. Fractions

Use MTEXT to create stacked fractions and text other than those created and used within the standard dimension styles.

5. Drawing Revision

5.1. Dynamic Revision Blocks and Triangles

When it is not possible to properly cloud revised imagery, the dynamic revision block should be used. Where drawing space is insufficient, a revision triangle may be placed at the revision location. Caution must be used with these triangles as they can be confused with other legitimate symbology.

Triangles, clouds, and dynamic revision blocks from previous revisions must be removed.

All revision clouds, dynamic revision blocks, and revision triangles must be placed on the rev layer in the appropriate space.

Revisions in model space must have clouds, dynamic blocks, or triangles in model space. Revisions in paper space must have clouds, dynamic blocks, or triangles in paper space.

6. Drawing Practices

6.1. Drawing Practices—Electricals

All new electrically-oriented company drawings must be done in a consistent manner that separates each class to its own style of drawing. (Pure single-class drawings are required.) Combination drawings are unacceptable. For example, a combination of a schematic and connection or wiring diagram in a new drawing is unacceptable.

Some practices to abide by but not limited to, include:

- Single-line diagrams shall only contain single-line imagery.
- Three-line diagrams shall only contain three-line imagery.
- Schematic diagrams shall only contain schematic imagery.
- Connection diagrams shall only contain connection imagery.
- Layout diagrams shall only contain layout imagery.

6.2. Cable and Conduit Schedules

If local plant drafting support has specific requirements, they must be followed including the use of their local template file, otherwise cable and conduit schedules must be provided in an Excel spreadsheet format.

6.3. Circuit Schedules

If local plant drafting support has specific requirements, they must be followed including the use of their local template file, otherwise circuit schedules must be provided in an Excel spreadsheet format.

6.4. Panel Schedules

If local plant drafting support has specific requirements, they must be followed including the use of their local template file, otherwise panel schedules must be provided in an Excel spreadsheet format.

6.5. Drawing Scale

All drawings should be made in real-world dimensions 1:1, (1 to 1) and shall be in the U.S. customary measurement system. For tables see Handbook 9A, Section.5, *Drawing Practices*.

6.6. Layers

Layer sets are provided with the standard border templates and should be used accordingly. Additional layers are available through the standards pallet or upon request. If the necessary layers are not available, others can be created based on the standard layer naming convention and with approval of the appropriate drafting support personnel.

6.7. Model Space

Model space layouts shall be used in all company drawings in the following manner:

1. All drawing geometry shall be drawn in the model space (tab) with the lower left corner at or near coordinate 0,0 unless accurate placement is requires for state plain or world coordinates systems.
2. Place the border, notes, and legends in paper space.
3. Draw all objects at 1:1 or full scale within the model space environment.
4. Set units to inches; set the types to fractional with 1/256 precision; set the angle to decimal.

6.8. Paper Space Drawings

Paper space must be used for all drawings, and must adhere to the following parameters:

1. Set units as described above in model space.
2. Insert all borders in paper space at coordinates 0,0.
3. Place general notes and legends in paper space in the available area above the drawing title block.
4. The paper space layout (tab) must be renamed from the AutoCAD default. (Example: 36x24 D) The AutoCAD default (TAB) name is not acceptable.
5. Configure the page setup at the scale of 1:1, with the plot area set to “EXTENTS” and “Center the Plot” selected.
6. Multiple paper space layout (tabs) are NOT to be used within any single drawing file.
7. Delete all paper space layout (tabs) other than the first one.

6.9. External Referencing

External referencing is encouraged throughout the design process because it reduces drafting effort in collaboration among users and across disciplines. (See the XREF documentation located in Handbook 9A, Section 5, *Drawing Practices*) The use of the XREF base drawings is not limited to the examples and directions shown in 9A, but embedded XREFs must be avoided.

Local plant drafting support may, at their discretion, require that all XREF documents be bound to the parent drawing using the XBIND command. Contractors will consult with plant designers/drafters for plant-specific requirements when working with drawings containing externally referenced files.

6.10. Voiding and Superseding

The following is the standard procedure for voiding and superseding CAD and image files. The void stamp is a block provided as part of the standard CAD pallet. This block and its attributes must be used as described below.

6.10.1. Voiding CAD Files

Drawings being voided shall have the void stamp placed near the lower right-hand area of the drawing with the attributes completely filled in. If the drawing is being superseded by another drawing, the drawing number(s) shall be referenced in the void stamp. The drawing that supersedes the voided drawing shall have a string of text placed above the title block stating, for example, “THIS DRAWING SUPERSEDES DRAWING 123456.001, REV 3, DATE 6/11/03.” The revision number and revision date shall be that of the latest revision of the voided drawing.

If a drawing is partially superseding another drawing, the superseded note shall state this accordingly: THIS DRAWING PARTIALLY SUPERSEDES DRAWING...

If the drawing is just being voided and not superseded, “N/A” shall be placed in the REMARKS attribute field of the void stamp and the drawing shall not be rev'd up.

If the drawing is being voided, the drawing is updated with the void stamp but is not rev'd up.

6.10.2. Voiding Image Files

To void a stand-alone image file, the file should be temporarily attached to a CAD file as a means of editing and saving the image file through image editing software. In AutoCAD, attach the image, bring in the void stamp, and fill it in. Merge the void stamp into the image file. Save the image file, not the CAD file, and detach it.

7. Block Usage and Development

This section provides guidance on the development of AutoCAD blocks used in company drawings. (See handbook 9A, section 6, *Block Usage and Development*.)

1. All blocks are to be developed on layer “0”, with the color and line type attributes set to bylayer, (unless specific color, line type and layering conventions are wanted for all inserts of the same block). All entities that reside in the block should be drawn using company standards whenever possible.
2. AutoCAD dynamic blocks are powerful; they can limit the amount of time involved in inserting multiple views of the same symbol. One block may provide any one of many possible views for one basic symbol as a selectable option at any time in the editing process. They can also be made to utilize the ability to move, rotate, stretch one or all of the entities within a block.

   While the use of dynamic blocks should be considered, creating the block so that it displays the desired effect can be troublesome. Great care should be taken when creating this type of block. Testing should be done to ensure that the desired effect has been achieved.

7.1. Insertion Point

The insertion point should be on snap, (1/32"), to allow proper alignment with any adjoining components.

8. EDMS Compatibility

8.1. Index

An index must accompany all new and edited drawings provided by anyone outside of the thermal generation group. All indices should have the following attributes:

1. The index must be compatible with Excel in a format that defines each field of information in separate columns. Excel file format or “comma delimited” (CSV) formats are preferred. Use a CSV format if it is unclear which Excel version is needed.
2. The index must contain column headings that clearly describe the information contained in each column.
3. The drawing index must contain the information delineated in the legend of template file, *GenerationThermalDrawingIndexTemplate.xlsx*, located internally in the AutoCAD support directory, J:\Shared Data\AutoCad Support\FORMS\GENERATION.
4. Leading and trailing empty spaces in individual cells are not acceptable.
5. All hybrid-related files returned to the company need to be supplied in a separate folder structure from non-hybrid files. For example, AutoCAD files with .TIFF, XREF'd, and any other attached files all need to be saved to folders different from non-hybrid files.
6. Hybrid files need to be in a separate index, or on a separate tab within an index that is separate from non-hybrid files.

9. Handbook Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history and document output may be directed to engineering publications at eampub@pacificorp.com. Technical questions and comments may be directed to the drafting services group. This handbook document shall be used and duplicated only in support of company projects.

EBU PX-S02 Substation Equipment—Collector Substation Main Power Transformer

1. Scope

This material specification and EBU PX-S02A, Substation Equipment—Collector Substation Main Power Transformer—Specific Requirements, state the requirements for wind or solar generating station collector substation main power transformers, with low voltage rating of 34.5 kV, purchased by the company.

This material specification is being used on a project for the following company:

MidAmerican Energy	☐
PacifiCorp	☐
NV Energy	☐
BHE Renewables	☐
Other: ________________________	☐

See Section 2 in PX-S02A for the type of renewable energy facility associated with the project.

2. References

The following publications shall be used in conjunction with this material specification, and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

2.1. Industry Publications

Referenced industry publications are:

IEEE C57.12.00, *Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*

IEEE C57.12.10, *Standard Requirements for Liquid-Immersed Power Transformers*

IEEE C57.12.70, *Standard Terminal Markings and Connections for Distribution and Power Transformers*

IEEE C57.12.90, *Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers*

IEEE C57.13, *Standard Requirements for Instrument Transformers*

IEEE C57.19.01, *Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings*

IEEE C57.91, *Guide for Loading Mineral-Oil-Immersed Transformers*

IEEE C57.98, *Guide for Transformer Impulse Tests*

IEEE C57.109, *Guide for Liquid-Immersed Transformer Through Fault Current Duration*

IEEE C57.110, *Guide for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors*

IEEE C57.113, *Trial Guide for Partial Discharge Measurement in Liquid Filled Transformers and Shunt Reactors*

IEEE C57.119, *Performing Temperature Rise Tests on Oil-Immersed Power Transformers at Loads Beyond Nameplate Ratings*

IEEE C57.120, *Loss Evaluation Guide for Power Transformers and Reactors*

IEEE C57.123, *Guide for Transformer Loss Measurements*

IEEE C57.127, *Trial Use Guide for the Detection of Acoustic Emissions from Partial Discharges in Oil-Immersed Power Transformers*

IEEE C57.131, *Standard Requirements for Load Tap Changers*

IEEE C57.148, *Standard for Control Cabinets for Power Transformers*

IEEE C57.149, *Guide for the Application and Interpretation of Frequency Response Analysis of Oil-Immersed Transformers*

IEEE C57.150, *Guide for the Transportation of Transformers and Reactors rated 10,000 kVA or Higher*

IEEE 519 *Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*

NEMA C63.2, *Electromagnetic Noise and Field Strength Instrumentation*

NEMA C84.1, *Electric Power Systems and Equipment - Voltage Ratings*

ANSI C2, *National Electrical Safety Code*

NEMA TR1, *Transformers, Regulators, and Reactors*

NFPA 70, *National Electrical Code*

2.2. Company Publications

Applicable company documents include, but shall not necessarily be limited to, those listed below:

Material Specification EBU SI-S04, *Electrical Equipment—Insulating Oil*

Material Specification EBU SI-S02, *Wind, Ice, and Seismic Withstand*

Material Specification EBU SI-S03, *Contaminated-Environment Protection*

Operations Procedure SP-TRF-INST, *Transformer Receiving, Installation and Energizing*

3. General

3.1. Application Information

This material specification and EBU PX-S02A state both the general requirements for collector substation main power transformers and the collector substation main power transformer-specific requirements that vary depending on the installation and intended use.

3.2. Pre-Qualified Accessory Suppliers

The company's pre-qualified suppliers list is included in Appendix A of this document. It is acceptable to submit equivalent alternate equipment for review and pre-qualification by the company. To submit alternate equipment for approval, the supplier shall provide the company with the following information: manufacturer, part number, data sheets, spare part requirements, and experience with the equipment.

The supplier shall also provide the cost to the company for training company field personnel on the use of the proposed alternative equipment. Costs shall include the estimated duration of the training and the rate the trainer will cost per day. The additional costs associated with company employees receiving the training will be evaluated by the company, and will be included in the equivalent total owning cost.

4. Standard Conditions, and Other Service Factors

Transformers operating under standard service conditions shall be in accordance with IEEE Standard C57.12.00.

The following site-specific factors may affect the installation, and are further described in EBU PX-S02A:

- Ambient temperature (EBU PX-S02A, Section 5.1)
- Elevation (EBU PX-S02A, Section 5.2)
- Contaminated environment protection (EBU PX-S02A, Section 5.3)
- Geomagnetic disturbance (EBU PX-S02A, Section 14)
- Wind/solar collector substation main power transformer suitable for step-up operation
- Other unusual service conditions (EBU PX-S02A, Section 5.4)

4.1. Type

Unless specified otherwise in Section 7.3 in EBU PX-S02A, the transformer shall be outdoor, 60-hertz, oil-immersed, with 65° C average winding temperature rise, 80° C hot-spot winding temperature rise, and 65° C top-oil temperature rise, suitable for the collector substation main power transformers (step-up) class of service. The transformer winding type shall be three-winding.

4.2. Seismic Capability

The seismic withstand capability of the transformer shall be in accordance with Material Specification EBU SI-S02.

5. Rating Data

The transformer shall be designed to meet the rating data in IEEE Standard C57.12.00 00 and IEEE C57.12.10. Selections from applicable tables are given in EBU PX-S02A. This section lists additional requirements.

5.1. Kilovolt Ampere (kVA) Ratings

1. Transformers shall be kVA-rated in accordance with IEEE Standard C57.12.10.
2. The complete transformer, including all components and accessories, shall be in accordance with IEEE C57.91.
3. No auxiliary component shall limit the transformer windings and cooling system capacities.
4. The rating limits shall be clearly stated in the bid documents.

5.2. Ratings of Transformer Taps

If specified, the de-energized tap changer shall have the tap ratings listed in EBU PX-S02A, Section 8.1. If specified, the load tap changer shall also have the tap range and capacity listed in EBU PX-S02A, Section 9.1.

5.3. Transformer Bank and Parallel Operation

The following requirements for transformer bank operation shall apply to all de-energized and load tap positions, with impedances on all tap positions in compliance with IEEE tolerances.

If the transformer is single-phase, and if specified in EBU PX-S02A, Section 7.5.1, the transformer shall be suitable for operation in a three-phase bank with the identified similar transformers.

5.4. Polarity or Angular Displacement

If the transformer is single-phase, the polarity shall be subtractive. If the transformer is three-phase, the angular displacement shall be as shown in Figure (x) below.

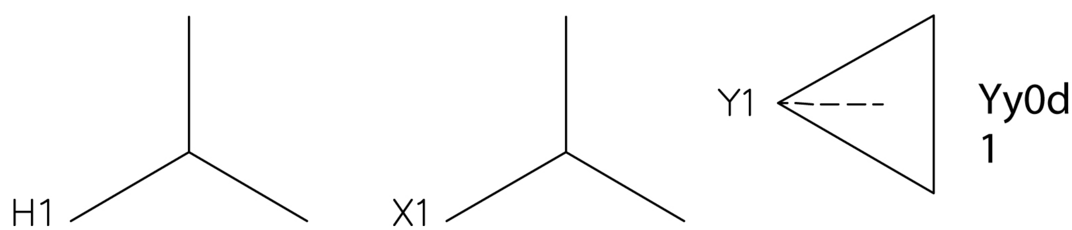

Figure 1—Three-Phase Transformer Angular Displacement

5.5. Losses

The manufacturer shall measure the no-load, load, and auxiliary losses as specified in IEEE Standard C57.12.10.

5.5.1. Loss Penalty

Values of no-load loss and excitation current measured at the nominal rated voltage after impulse tests shall be the values used in determining compliance with the supplier's quoted loss and excitation performance. These values shall not exceed the values measured before impulse tests by more than 7.5%.

IEEE tolerances from the supplier's performance quotation for no-load loss at the nominal rated voltage shall also apply to the excitation current at the nominal rated voltage.

If load tap changing (LTC) equipment is specified, both no-load and total losses quoted in the supplier's proposal shall be the average of respective losses at five LTC positions: (1) neutral (nominal rated voltage), (2) maximum lower, (3) one position above maximum lower, (4) maximum raise, and (5) one position below maximum raise position.

Without prior written approval from an authorized company representative, no supplier shall ship a transformer to the company that exceeds the quoted loss value by 10% or more for no-load losses (NL) or load losses (LL), or by 6% or more for total losses (NL + LL).

6. Construction

6.1. Core Design Requirements

6.1.1. Steel Specification

All cores including main, series, and preventative auto, shall be constructed using low-loss, cold-rolled, grain-oriented, silicon steel. Steel is to be slit to width, annealed, and coated with inorganic insulating material. All slits and cuts must be free of burrs.

6.1.2. Flux Density

With the transformer energized at no-load on any tap position, at 100% voltage, the maximum flux density in any part of the core shall not exceed 1.7 Tesla.

At the maximum forced-cooled rating, the maximum flux density in magnetic shunts shall not exceed 1.2 Tesla.

The transformer shall be designed to meet the following overvoltage requirements, such that the maximum core flux density shall not exceed 1.9 Tesla at any tap position:

1. 115% secondary voltage at no-load
2. 110% secondary voltage with the transformer at maximum rated MVA load condition and at 80% power factor.

The induction level shall be such that the ratio of induction current at 115% and 105% voltages shall not be >3.

6.1.3. Audible Sound Level

The guaranteed sound level for operation at the rated voltage shall be as specified in EBU PX-S02A, Section 7.6.

6.1.4. Core Temperature

The core internal hot-spot temperature shall be limited to a maximum of 125° C, and a maximum core surface temperature of 120° C (at maximum ambient temperature) at:

1. 100% secondary voltage at no load
2. 105% secondary voltage with the transformer at maximum rated MVA load condition and at 80% power factor.

The surface temperature of 120° C is in consideration of both the flux density in the core, and the heating effects of magnetic field leakage. The insulation material between tie bars and the core, and the core frames and core, shall be a high-temperature material (tolerant of 150° C minimum) that coordinates with the surface temperatures in the locations where this insulation is to be applied. A minimum material thickness of 2 mm shall be provided.

6.1.5. Core Construction and Tie Plate Stress

Step-lap core construction is required. All cores must use a mitered-core design.

The edges of the laminations on the core legs shall be protected against rust with a permanent rust-inhibiting coating such as epoxy or varnish; however, the top yoke shall not have epoxy applied to it. The top and bottom yokes shall be continuous, except for building joints. Every core step shall be supported by inserting a non-conductive material between the core step and the base bar that connects the core clamps. The bottom and top of every core step, in every direction, shall be supported from a base bar that connects to the low-voltage and high-voltage core clamps. Every core step shall also be supported at the ends.

Bolting through the core steel is not acceptable except for preventative autotransformers. The design of the bottom core clamps and the tank shall allow inspection of the underside of the bottom yoke after assembly. A design in which the bottom yoke is in a bottom tank trough is not allowed. The axial mechanical support structure for the core and coils, e.g., the tie plates, shall not be stressed more than 65% of the elastic limit of the material of the tie plates during the worst-case conditions of lifting or a short-circuit.

6.1.6. Core and Frame Ground

Each separate core (main, series, reactor and etc.) shall have its own ground bushings. A core separated by sections shall have a separate insulated cable for each core section and be brought up to a location near the top of the tank and be connected together internally. This connection shall be removable, and shall be designed with captive hardware. The connection location shall be easily accessible from a manhole or handhole on the transformer cover and the location shall be clearly identified on the transformer nameplate and marked on the appropriate manhole or handhole cover.

A frame ground bushing shall be provided. When there is more than one (1) frame to clamp separate cores, each frame shall have an insulated cable brought up to a location near the top of the tank and be connected together internally. This connection shall be removable, and shall be designed with captive hardware. The connection location shall be easily accessible from a manhole or handhole on the transformer cover and the location shall be clearly identified on the transformer nameplate and marked on the appropriate manhole or handhole cover.

All core and frame ground bushings shall be separately grounded outside the main tank and rated for 2.5 kV for one (1) minute.

The bushing(s) shall be located on the tank cover or near the top of the tank wall. They shall be labeled to avoid confusion with other bushings, and shall be protected with a removable, machine gasketed groove or o-ring weatherproof metal cover. All ground bushings shall be located in the same area.

All ground bushings shall be separately grounded outside the main tank.

An instruction nameplate shall be furnished and mounted near the core ground bushing(s) specifying that the external bushing terminal must be connected to the tank whenever the transformer is energized.

The transformer shall be shipped with the bushing(s) installed and connections made.

6.1.7. Cooling Ducts

Material used to form cooling ducts in the core shall not be cellulose.

6.2. Winding and Insulation Design Requirements

6.2.1. Conductors

1. All conductor material shall be copper.
2. All conductor paper insulation on CTC (continuously transposed conductor) shall be from an approved paper supplier listed in Appendix A, or an equivalent.
3. At a minimum, the outside two layers of conductor insulation on all strap conductors shall be Dennison paper 22HCC or an equivalent.
4. The insulating paper shall be applied in either single or multiple strands in such a manner that 30% overlaps.
5. All brazed connections in CTC shall be strand-to-strand, i.e., each strand shall be individually brazed and installed.
6. Conductors insulated with Formvar (Vinylec) enamels (or an equivalent type) are not acceptable, except in CTC.
7. The winding hot-spot shall limit the transformer loading (rather than the leads or accessories). The hot-spot of the leads for an individual winding shall not exceed the maximum hot-spot in that winding.
8. All leads shall be clamped with blocks. Ties and tie-wraps shall not be used.

6.2.2. Insulation Structures

1. All pressboard insulation for winding cylinders, barriers, key spacers, etc., shall be from an approved supplier listed in Appendix A, or an approved equivalent.
   The density of all pressboard spacers and barriers shall be 1.15 gm/cc. The minimum density of the pressboard used for formed parts shall be 0.95 gm/cc.

2. All windings and leads shall have insulating paper that is thermally upgraded (suitable for a hot-spot temperature up to 120° C under daily cyclic loading).
3. Each pressure ring, top and bottom, shall be one piece, of uniform thickness. The bottom clamping ring shall be fully supported from below to handle the weight of the windings and the clamping force. The bottom rings shall have a maximum deflection of 2 mm, and the top ring shall have a maximum deflection of 3 mm, with full clamping pressure applied. Coils on core-form designs shall have their full bottom ring circumference sufficiently supported by the frame. There shall be no reduction in the thickness of the top clamping ring in the core window. There shall be no support from the top clamping ring to the top yoke. For units with a top rating of 30 MVA and above with the winding class next to the top ring of 230 kV class or less, tangential grain beech wood top clamping rings shall be used.
4. Winding cooling ducts shall be from an approved supplier listed in Appendix A, or an approved equivalent (with paper on both sides of the blocks).
5. Care shall be taken to prevent chafing of the winding insulation due to contact with the lead support structure, for example, by rounding the lead support structure material.
6. The winding cylinders shall be made from a single piece of high-density material (with one seam) as manufactured by EHV Weidmann. All insulating materials and structures shall be protected from contamination and the effects of humidity during and after fabrication, and after receipt, by storing them in a separate, climate-controlled area.
7. All winding supports and supports in the area of high-voltage field shall have a minimum compression strength parallel-to-grain of 7800 psi (53.8 MN/m^2) and compression strength perpendicular-to-grain of 1400 psi (9.65 MN/m^2).
8. When layer windings are used, each layer shall be designed for “free” buckling, independent of the other layers.

6.2.3. Oil Gap Design

1. The oil gap stress shall be limited to 80% of the degassed curve, as published by Weidmann, for oil gap partial discharge inception.
2. The insulation system shall be designed with a ratio of 2.5 or less between the impulse voltage and the one-minute AC voltage (this is sometimes referred to as the BIL-to-power frequency ratio).
3. The average dielectric stress at any location in the core-and-coil assembly shall not exceed 2.65 kV RMS/mm with the transformer energized at 100% of the rated voltage on the maximum-stress tap position(s). Applicable stresses include, but are not limited, to turn-to-turn, winding-to-winding, winding-to-ground, phase-to-phase, and lead-to-lead. However, if the configuration is similar to a plane-to-plane stress, such as a phase-to-phase stress for a center line entry, then the maximum stress of 3.0 kV RMS/mm may be permitted. The stress shall be calculated accurately using a verifiable computer modeling technique.
4. The supplier shall design the radial cooling ducts with sufficient radial spacer thickness to ensure that cooling and adequate oil flow requirements are met. The supplier

will provide an adequate model of the proposed oil flow design for review during the pre-award and design review meetings. The design will be validated during the factory acceptance testing (including heat run testing).

6.2.4. Coil Design

For a three-phase, core-form transformer with a self-cooled rating of 5000 kVA or above, or a single-phase, core-form transformer with a self-cooled rating of 1500 kVA or above, the winding design shall be circular. For a core-form transformer rated 46 kV and below (high side) with a capacity rating below those specified above, the winding design may be layered and either circular or rectangular.

1. The winding design shall not utilize internal surge protection devices or current limiting reactors. It is recognized that in the special case of the regulating winding located on the HV-side with a relatively high lightning impulse rating (850 kV or higher applied to the terminal that is directly connected to the regulating winding), these devices may be necessary and may be acceptable with written approval of the company; this is to be clearly indicated in the bid documents.
2. The conductor ratio, based on individual uninsulated strands, shall not exceed 6.5 to 1.
3. When a layer winding is used, the radial build shall be a minimum of 3/8-inch (10 mm) for transformers with a self-cooled rating below 75 MVA. For transformers with a self-cooled rating of 75 MVA and above, the radial build shall be a minimum of 7/16-inch (12 mm). Only one conductor in the radial direction is allowed unless the cable used is CTC.
4. All winding crossovers shall be made in between the key spacer columns. If a manufacturer feels there is no way to manufacture the windings without a crossover in between the key spacer column, then this statement, along with an explanation, shall be issued to the company during the bidding stage.
5. All windings subject to inward radial buckling shall be designed to withstand "free" (unsupported) buckling in addition to "forced" (supported) buckling. The control of inward radial forces shall not depend upon bracing to the core. The calculated free buckling and forced buckling stresses shall not exceed 65% of the 0.2% yield stress of the conductor for resin-bonded CTC, and shall not to exceed 35% of the 0.2% yield strength for non-bonded magnet wire. Short-circuit calculations shall be based on 105% of the nominal voltage. Upon completion of the transformer design, the supplier shall furnish to the company the calculated free and forced buckling forces and the withstand values, clearly indicating the factors of safety based on worst-case fault conditions. The short circuit calculations shall take into account the mechanical tolerances (offset) of the windings for worst fault condition. The worst fault condition and fault level currents shall be indicated. The offset used in the calculations shall be per the manufacturer's tolerances, but no less than 6mm.
6. The regulating winding shall be fully distributed.
7. The final coil clamping pressure that shall be applied after vapor phase and prior to tanking shall be equal to or greater than 4N per millimeter squared.

8. The core and coils are to be vapor phase dried and treated prior to being placed in the transformer tank.
9. Multi-start type tap windings shall not be used unless there are at least two turns per tap. Multi-start type tap windings that are located between the core and the LV or common winding with a current summation of 3000 amps or more (current summation is defined as the number of tap groups per layer times the maximum current at the top nameplate rating) shall be designed as two separate windings with opposite current flow. The insulation between the two tap windings shall be oil duct, barrier, and oil duct and the oil ducts shall be of sufficient size for oil flow. LV windings located next to the core shall be designed as two separate windings with opposite current flow when the winding current at the top rating exceeds 3000 amps.
10. All coil spacers shall be keyed using dovetailed “key” spacers to the winding cylinder and to vertical key strips on the outside of the coil (except the outside winding). The sticks are to be captured into the key spacers.

6.2.5. Shell Form Design

Shell form designs are not allowed.

6.2.6. Bolted Connections

All internal, bolted electrical connections shall use two bolts. The only exception is for bolting leads to tap changers where only one bolt connection is provided by the tap changer manufacturer or for bolting leads to terminal boards. Each bolt shall have a compression type washer such as a Belleville washer in addition to the flat washers and double nuts for locking. Split-lock washers shall not be used.

6.2.7. Preventative Autotransformer

Independent, adjustable clamping shall be provided for clamping the windings and for clamping the core legs. The core should be clamped first and then the windings.

The use of a top slab instead of individual top clamping rings and the bottom clamping ring can be omitted if the winding is fully supported at the bottom.

The top and bottom yokes shall be flat.

All the insulation between the top and bottom press beams including the core gap material shall be non-hydroscopic such as fiberglass. Exception: A maximum of 2 mm of high density pressboard may be used if a stack of Belleville washers of sufficient size is provided on each axial clamping rod.

The preventative autotransformer (PA) shall be tested in air prior to assembly to the main unit at 100% maximum step voltage. The phase voltages and phase currents shall be recorded. Full clamping pressure shall be applied to the core legs for the test. In addition, the noise shall be measured on both sides at a distance of three (3) feet from the PA. The loss, phase voltages, phase currents and average noise shall be reported to the customer after completion and shall also be included in the certified test report.

During final factory acceptance tests, the no-load losses shall be tested in the tap position corresponding to the maximum step voltage and also in the adjacent tap position. The measured no-load losses and excitation currents shall be included in the certified test report.

6.3. De-Energized Tap Changers, Switches, and Terminal Boards

6.3.1. Tap Changers and Reconnection Switches

If de-energized voltage taps are specified for the H-winding, X-winding, or both windings of a single-phase transformer, a de-energized tap changer shall be furnished for each specified winding. Each tap changer shall be operated by one external handle.

If de-energized voltage taps are specified for the H-winding, X-winding, or both windings of a three-phase transformer, each tap changer shall be three-phase, or a three-phase internally-ganged assembly, operated by one external handle.

Each tap changer or reconnection switch shall be located under oil, contacts shall be silver-plated to minimize coking, and shall be designed to ensure positive positioning and correct external position indication. Each external operating handle, with its associated position-indication plate, shall be mounted at a height between one and five feet above foundation level, and shall be furnished with provisions for padlocking in any position. An identification nameplate shall be furnished and mounted adjacent to each operating handle.

Two bolt connections are preferred, but at a minimum, the connection shall be a locking type, such as a beveled washer or lock nut.

6.4. Liquid Temperature Indications

An analog liquid temperature indicator gauge as specified in Appendix A shall be supplied on the main tank.

A digital oil temperature indication shall also be supplied for the main tank and LTC compartment (if applicable) using the temperature monitor specified in Section 6.5.1.

6.5. Winding Temperature Indication

A digital winding temperature indication shall be supplied using the temperature monitor specified. The temperature monitor shall simulate the winding hot spot temperature using the oil temperature and current signals from bushing current transformers. The winding hot spot temperatures shall be used to control the cooling equipment.

6.5.1. Temperature Monitor

The temperature monitor supplied shall be as specified in EBU PX-S02A Section 10.7.

The temperature monitor shall be flush-mounted on a panel in the control compartment. The monitor shall be readily visible when the compartment door is open (the monitor shall not be located behind a hinged panel or other concealment).

All temperature monitor input and output terminals, except for terminals connecting to the RTD(s), shall be wired to terminal blocks in the control compartment and connected to the current transformer(s) and cooling equipment.

The monitor's power supply shall be from the company's substation battery.

6.5.2. Resistance Temperature Detectors

Approved resistance temperature detectors (RTD), with associated thermowells, shall be furnished to detect the top-oil temperatures of the transformer's main tank and load tap charger compartment (if applicable).

An additional approved resistance temperature detector (RTD), with a sun shield, shall be furnished to detect the ambient temperature near the transformer. The ambient RTD shall be mounted on the underside of the control compartment in a location that will not conflict with workable access to the compartment bottom drill plate.

Both RTD's shall be 100-ohm platinum, with a compatible connector and shielded cable. The length of the shielded RTD cable may be shortened as necessary, but must connect directly between the RTD and the temperature monitor. It shall not be connected through a terminal block. The oil RTD cable shall be protected in its own rigid steel conduit or flexible, ultraviolet-resistant, waterproof, properly attached UL-listed, jacketed, metallic conduit capable of mechanically protecting cables from physical damage.

6.5.3. Winding Temperature Current Transformers

Detailed winding temperature current transformer requirements are listed in Appendix B for the Qualitrol IED-509, in Appendix C for the Schweitzer SEL-2414, and in Appendix D for the Advanced Power Technologies TTC-1000. The specific winding temperature current transformer shall be installed. Specific current transformers shall be installed to monitor winding currents in addition to those specified in EBU PX-S02A, Section 10.2.

6.5.4. Temperature Monitor Settings and Control Connections

Detailed connections to the temperature monitor are listed in Appendix B for the Qualitrol IED-509, in Appendix C for the Schweitzer SEL-2414, and in Appendix D for the Advanced Power Technologies TTC-1000.

6.6. Pressure-Vacuum Gauge

A pressure vacuum gauge shall be supplied.

6.7. Pressure-Vacuum Valve

A pressure vacuum bleeder valve shall be supplied.

6.8. Oil Level Indication

A dial-type oil level indicator of an approved type shall be furnished on the main transformer tank, and on each conservator tank (if applicable), and on the LTC oil-filled compartment if an LTC is specified. Each indicator on a conservator tank shall be shielded to prevent the bladder from interfering with the operation of the indicator. Each indicator shall be six (6) inches (152 mm) with a lever drive, two contacts, and a compatible connector and cable. The indicator mounting arrangement shall permit reading of the dial from the ground.

For all transformers, one contact shall be set to close at the minimum safe operating level, and will be used to activate the company's alarm. The second contact shall be set to close at a level below the minimum safe operating level but above the level that would result in transformer failure, and may be used to trip the company's switching device. On conservator units, the conservator gauge will be used for the alarm, and the main tank gauge will be used for the trip. The trip contact shall drive an Agastat time delay relay set for 15 seconds to provide the trip and alarm contacts. Each oil level gauge shall have a 25° C mark.

6.9. Pressure-Relief Device

One pressure-relief device shall be furnished for each 10,000 gallons of liquid capacity (or fraction thereof). The device shall be mounted on the top of the unit, operated at 10 psi, and able to exhaust 12,600 CFM at 15 psi. A separate device shall be installed on the LTC compartment (if installed on the unit). An 8-inch steel pipe on units installed on the main tank, or 4-inch steel pipe on units installed on the LTC compartment, shall be directed downward to 18 inches above the foundation, covered with a stainless steel screen.

6.10. Valves

All valves shall be full-port. All valves shall be ball-type except for the combination drain and lower filter valve described below, and the radiator valves, if applicable. All valves that are open on one or both sides to the interior of the transformer tank or other oil-containing components shall be flange-mounted, with a gasket on the side(s) open to the interior. Threaded fittings are not acceptable. All valves shall be located such that space for the attachment of fill or vacuum hoses is not obstructed by nearby accessories or components.

The upper filter valve shall be located on the tank cover in segment 1, in accordance with ANSI C57.12.10, and the valve size shall be two-inch (51 mm). The valve shall be installed parallel to the tank cover, such that the hose is attached from the side, to allow for easy access to oil-filling equipment. The opening of the upper filter valve shall not be pointed up. An angled bracket shall be welded inside the tank below the valve to spread the oil during filling. A four-inch (102 mm) valve (three inch valve for NV Energy only) for vacuum connection shall be furnished on the tank cover in segment 3. The valve shall be installed parallel to the tank cover, such that the hose is attached from the side, with a four-inch, female, camlock fitting and plug, located as far away from the upper filter valve as possible.

If a nitrogen gas pressure system is specified by the company or selected by the supplier in accordance with EBU PX-S02A, Section 10.4, *Liquid Preservation System*, the upper filter and vacuum connection may be furnished on the side wall, if approved by the company in the design review.

The combination drain and lower filter valve shall be globe-type, two-inch (51 mm) and shall be located in segment 3. A 90″ elbow assembly shall be furnished on the interior side of the valve, oriented downward with the bottom face (opening) of the elbow assembly parallel to the bottom of the tank to allow pumping the oil out of the transformer to within ⅜″ and ½″ (10 and 13 mm) from the bottom. A sampling valve shall be supplied, as specified by IEEE C57.12.10.

6.11. Sudden Pressure Relay

An under-oil sudden pressure relay shall be installed on the main tank and the LTC compartment on a two-inch ball valve to permit removal of the relay without draining oil from the tank. The relay shall be mounted between three (3) feet and six (6) feet from the transformer base. A manually reset seal-in relay shall be installed in the control cabinet to provide alarm and trip contacts.

If specified, provisions for future installation of the rapid-pressure-rise relay shall include the following items furnished on the transformer: the ball valve, the terminal blocks necessary to complete all future wiring, and provisions for future installation of the seal-in relay.

Buchholz-type pressure relays supplied shall be wired to trip through a Qualitrol 909-300 seal-in relay. The seal-in relays shall be located in the cabinet and shall be 125-volt, dc-operated. All seal-in relays require a Form C contact.

If a Constant Pressure System is provided, a sinking cell relay shall be provided that activates an alarm.

6.12. Bushings

Bushings shall be in accordance with the dimensional and performance requirements of IEEE C57.19.01.

Spare bushings shall be shipped in crates suitable for long-term storage (greater than five years), either in an upright position, or at an incline, as specified by the bushing manufacturer.

The current rating of each bushing shall be equal to or greater than the current it will carry at the maximum forced-cooled rating and overload rating. Additionally, the current rating of each neutral bushing shall not be less than the current rating of the associated line bushings. The H0X0 bushing, when required, shall be rated to sustain the maximum operating current of the common winding.

Bushings, except the core ground bushing, shall preferably be capacitor-graded, oil-impregnated, paper-insulated (OIP) type. Consideration will be given to resin-impregnated, paper-insulated (RIP) core, and other composite bushings, where sound service experience can be demonstrated, or where, due to installation constraints, there is a clear advantage in using such types. Bushings shall be manufactured by an approved supplier.

Bushing leads shall be accessible from the bushing cover. Accessibility to leads shall not require personnel to enter the transformer tank. A draw-lead connection is required for all bushings whenever possible. In cases where the transformer winding leads are bolted to the bottom of the bushings, two-bolt connections shall be used; single-bolt connections are not acceptable.

For X-winding and Y-winding nominal voltage ratings below 13.8 kV, the BIL of the phase and neutral bushings, as applicable, shall not be less than 150 kV BIL, unless the winding terminals are directly connected to enclosed bus.

A machine-tinned, bronze, straight flat-pad terminal with NEMA standard four-hole drilling shall be furnished for each bushing. The terminals shall have a machined contact surface and be bronze, copper, or aluminum, with tin plating; the minimum plating thickness shall be 0.001 inch (0.026 mm).

6.12.1. Bushings for Buried Y-Terminals

The two winding terminals at one corner of the tertiary delta shall be separately brought through 15 kV bushings mounted on the tank cover. Temporary bushings for the other two phases are to be furnished during testing to verify the MVA rating of the buried tertiary and the H-Y and X-Y impedances. After testing, one corner of the tertiary is to be opened and taken out through the transformer roof using two bushings. The other two corners of the delta are to be insulated and their location shall be identified on the outline drawing. Removable straps shall be furnished to connect the external bushing terminals together and to the tank. The bushings shall be located and labeled to avoid confusion with other bushings, and shall be protected with a removable, weatherproof metal cover.

An instruction plate shall be furnished and mounted near these bushings, specifying that the external bushing terminals must be connected together, and to the tank, whenever the transformer is energized. The same instructions shall be shown on the main transformer nameplate.

6.13. Clearances

External phase-to-phase and phase-to-ground clearances shall be based on the bushing BIL.

Minimum clearance between live parts of different phases of the same voltage shall be as listed in IEEE C57.12.00, and in no event less than 30 inches. If this requirement for voltages 69 kV or below cannot be met, the supplier shall state non-compliance to this requirement in the bid documents, and ensure that the live-part clearance is as large as possible.

Minimum clearance to ground shall be as listed in IEEE C37.32.

6.14. Bushing Current Transformers

Current transformers shall be provided as specified in EBU PX-S02A, Section 10.2. Secondary terminal blocks shall be installed in accordance with IEEE C57.148.

All current transformers, including the current transformer(s) for winding hot-spot control, shall have a continuous thermal current rating factor of 2.0 at an average ambient air temperature of 65° C.

The current transformer leads running from the CT to the feed-throughs on the tank and from the feed-throughs on the tank to the terminal blocks shall not be spliced. All bushing current transformer secondary leads shall be a minimum 10 AWG and shall have insulation rated for a minimum of 150°C, i.e. PTFE or ETFE.

6.15. Neutral Connections

Neutral terminations shall be provided on the tank cover.

Provisions shall be furnished for electrical isolation of the copper conductor(s) connecting the H0 or X0 neutral bushing terminal to the substation ground grid. The manufacturer shall provide a removable vertical length of two-inch schedule 80 gray PVC pipe mounted by straps bolted to supporting brackets. The pipe shall be located no more than 12 inches (305 mm) away from the transformer main tank side wall, and shall be securely fastened. The top of the pipe shall be approximately at the same level as the H0 or X0 neutral bushing terminal, and the bottom of the pipe shall be approximately one foot above foundation level. The manufacturer will furnish and install one or more 4/0 copper conductors from the bushing to the ground pad at the bottom of the tank and equivalent to the rating of the neutral bushing.

6.16. Moving Facilities

Per IEEE C57.12.10, facilities for lifting and moving the transformer shall be designed to move the transformer full of oil. Jacking pads shall be no less than 18 inches, and no greater than 24 inches above the foundation level.

6.17. Nameplate

6.17.1. Main Transformer Nameplate

The main transformer nameplate(s) shall contain the information required in IEEE C57.12.00. In addition, the following information should be listed on the main transformer nameplate:

1. Core form construction
2. Design altitude
3. Design seismic capability
4. Design special overload capability, if specified
5. Listing of the separate volumes and weights of:
    a. oil in the main transformer tank
    b. radiators
    c. conservator tank(s) (if applicable)
    d. LTC oil-filled compartment (if applicable)
6. Weight of the transformer prepared for shipment
7. Location of the buried tertiary bushing instruction plate
8. Y-winding voltage and capacity ratings and buried tertiaries
9. Location of the core and frame grounding bushing
10. Applicable instructions concerning the special bushings for a buried Y-winding and concerning the core and frame ground bushings
11. Transformer winding and current transformer polarity marks

12. Rated daily minimum and daily peak ambient temperature
13. Company equipment number (PacifiCorp only)
14. Company PO number
15. Overload rating of OLTC
16. Total dry weight of all insulation, excluding bushings

6.17.2. Valve Identification and Location Nameplate

A separate nameplate showing the valve locations, titled “Valve Identification and Location,” shall be furnished and mounted externally near the main transformer nameplate in a location that permits reading from the ground. The nameplate shall include a transformer outline drawing showing the location of all valves, and a chart identifying the type, size, and purpose of each valve, also specifying the initial position of each valve for field oil-filling, and the position of each valve when the transformer is energized.

6.17.3. Field Oil-Filling Procedure Nameplate

For a transformer with a conservator system, a separate nameplate describing the field oil-filling procedure, titled “Field Oil-Filling Procedure,” shall be furnished and mounted externally near the main transformer nameplate in a location that permits reading from the ground. The nameplate shall include: the complete procedure as listed in Table 1, the valve location schematic drawing (similar to that shown in Figure 1), and the list of initial valve positions as shown in Table 2. In the list of initial valve positions, the supplier’s valve numbers (from the supplier’s drawings) shall be shown next to the corresponding company valve numbers 1 through 9 where applicable.

Table 1—Field Oil-Filling Procedure for a Transformer with a Conservator System

1. Verify that all devices that cannot withstand full vacuum are isolated, including the rapid-pressure-rise relay(s).
2. Remove the dehydrating breather and install a nitrogen cylinder or dry air cylinder.
3. Start the vacuum pump.
4. After the required vacuum has been reached, introduce oil through valve 6.
5. Fill with oil to approximately two inches (51 mm) below the main cover.
6. Close valve 1 and shut down the vacuum pump.
7. Close valves 5 and 7.
8. Remove the sight tube.
9. Open valve 3 to equalize the pressure between the conservator bladder and tank.
10. Open valves 5 and 9.
11. Close valve 4 and pressurize the bladder to 0.5 psig.
12. Feed additional oil until air is bled off at valves 5 and 9.
13. Close valves 5 and 9.
14. Close valve 3 and disconnect the nitrogen cylinder or dry air cylinder.
15. Slowly open valve 3 to release the pressure on the bladder.
16. Continue to feed oil until the oil level is approximately at the 25° C level.
17. Adjust the oil to the correct level based on temperature. Use the oil level gauge to determine the level.
18. Close valve 6.
19. Reconnect the dehydrating breather to valve 3.
20. Bleed all cover items that do not have piping to the gas detector relay.
21. Verify that the oil level is at the 25° C level, that all valves are set to the normal transformer operating positions, and that all devices isolated in step 1 above are returned to normal operation.

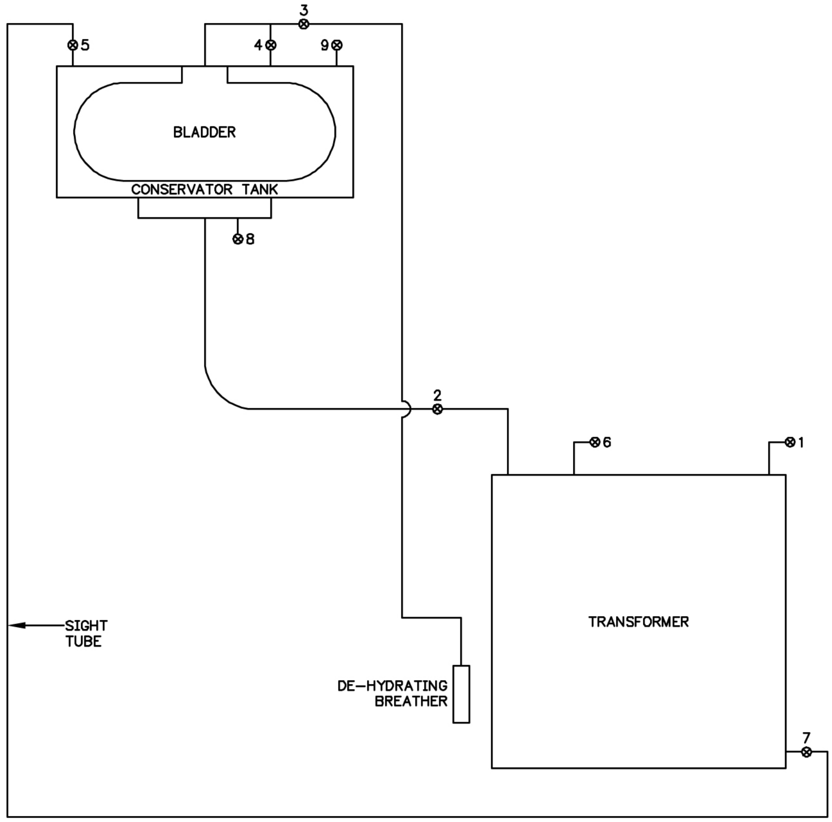

Figure 2—Valve Location Schematic Drawing

Table 2—Initial Valve Positions For Pulling Vacuum

Valve No.	Position	Function
1	Open	Permanent valve for vacuum connection
2	Open	Connecting valve between conservator and main tank
3	Closed	Connects to de-hydrating breather
4	Open	Equalizing valve between bladder and conservator
5	Open	Connects to temporary sight tube
6	Open	Upper filter valve; connects to oil supply hose
7	Open	Drain and lower filter valve; connects to temporary sight tube
8	Closed	Conservator drain valve
9	Closed	Conservator vent valve

6.18. Liquid Insulation System

6.18.1. Insulating Liquids

The type of insulating liquid shall be as stated in EBU PX-S02A, Section 10.3.

6.18.2. Insulating Liquid Preservation System

The insulating liquid preservation system shall be sealed-tank, nitrogen gas, or conservator with a bladder, as stated in EBU PX-S02A, Section 10.4.

A sinking cell or broken bladder shall activate an alarm. The conservator shall be able to withstand full vacuum. The transformer shall have means of isolating the auxiliary tanks during installation and inspections. The auxiliary tanks shall be equipped with a sump chamber and drain valve. A pressure-vacuum bleeder shall protect the system in the event of incorrect overfilling or under-filling during installation.

A nitrogen gas pressure system shall include a nitrogen cylinder installed as described below, with a three-stage pressure regulating system, a pressure vacuum gauge, pressure relief valves, and alarm contacts to indicate high and low nitrogen pressure in the transformer tank and low nitrogen pressure in the cylinder. The cylinder shall be furnished with the U.S. standard outlet connection for nitrogen gas, designated by the Compressed Gas Association as CGA 580. The thread specification is 0.965-14 NGO-RH-INT (0.965-inch [24.5 mm] diameter, 14 threads per inch, National Gas Outlet form, right-hand internal thread).

This system shall be furnished in two parts. The first part shall consist of a weatherproof compartment that contains the active parts, such as, but not limited to: the pressure regulator, gauges, high/low alarm contacts and empty cylinder alarm contact, space heaters, and gas sampling parts. This compartment shall not be located such that the top of the compartment is more than 6′ 0″ above the base of the transformer. The second part of the insulating liquid preservation system is a provision to secure the full-sized gas cylinder. This provision shall secure the cylinder to the side of the transformer tank by means of chains or clamps. The base of the cylinder shall rest either on the transformer foundation, or on grating furnished by the customer that is on top of the crushed rock oil containment. This grating could be as much as 12 inches below the transformer base. The provisions (two minimum) to secure the cylinder shall be adjustable such that the cylinder is plumb when it is secured. A flexible connection shall be supplied to connect the cylinder to the regulating and alarm equipment.

All bracings on the transformer tank walls used for gas space shall be stenciled with a warning to not drill, and shall be equipped with oil drain plugs.

6.18.3. Gas Collection Design

Transformers with conservator oil preservation systems shall be designed to allow gas collection adequate for transformer protection purposes. The transformer cover shall have a minimum upward slope of three degrees from the outer edges of segments 1 and 3 of the cover, toward the center of the cover. Gas collecting ports shall be furnished on the central ridge of the cover at intervals not exceeding 30 inches (762 mm). Additionally, all manholes and bushing turrets shall have collecting ports. All collecting ports shall be connected to the gas detector chamber with piping that has a minimum upward slope of three degrees. All gas piping, fasteners, and hardware shall be stainless steel with compression fittings. One gas detector relay of an approved type shall be furnished.

6.18.4. Dissolved Gas Monitor

If specified in EBU PX-S02A, Section 10.8, collector substation main power transformers shall be furnished with an approved online DGA monitor capable of monitoring specified gases. The monitor shall be mounted to the tank with brackets solidly mounted near the corner of the transformer on a stiffener and a dampening mounting structure to prevent vibration transfer to the monitor. The supply and return valves shall be located near the monitor. A set of contacts and a breaker shall be furnished in the control cabinet for providing power to the monitor. The DGA monitor should have communication ports available for remote monitoring of data and alarms. The preferred communication protocols are DNP3.0 and IEC 61850 via RS232, RS485, and Ethernet.

6.18.5. Alarm Monitor

If specified in EBU PX-S02A, Section 10.9, an approved type 12-point alarm monitor shall be furnished. The monitor shall include the following for each point:

1. One input contact
2. An individual indicating long-life, high-visibility LED
3. Individual points labeled as specified below
4. One retransmitting auxiliary contact

The monitor shall be mounted in the control compartment in such a manner that the monitor will be readily visible when the compartment door is open; the monitor shall not be located behind a hinged panel or other concealment. The supplier shall furnish individual wiring of alarm circuits from dedicated alarm terminal blocks in the control compartment to the monitor, and individual wiring from the monitor retransmitting auxiliary contacts to a separate terminal block in the control compartment for the company's use.

Applicable alarms shall be arranged on the monitor in the order listed below, and each point shall be labeled with the identification wording shown. In some cases more than one alarm is specified on a single point with the intent that any one of the specified alarms will activate that point (note that if LTC is not applicable, the words "OR LTC" shall be deleted from the nameplate for the point shown below as #8). All unused points shall be grouped together at the bottom of the monitor and shall serve as spares (with blank nameplates) or may be used by the supplier for other necessary alarms.

The supplier shall provide three CD's containing software and instructions, as well as three cables to connect the monitor to a laptop. The monitor shall be programmable by both push-button and touch-screen methods.

1. GAS DETECTOR RELAY GAS ACCUMULATION
2. COOLING EQUIPMENT POWER LOSS

3. MAIN TANK OIL LOW LEVEL
4. FORCED OIL LOW FLOW
5. MAIN TANK OIL HIGH TEMP
6. MAIN TANK / LTC OIL DIFFERENTIAL TEMP
7. WINDING HOT-SPOT HIGH TEMP
8. PRESSURE RELIEF MAIN TANK OR LTC
9. NITROGEN PRESSURE MAIN TANK HIGH OR LOW, OR CYLINDER LOW
10. LTC OIL LOW LEVEL
11. LTC VACUUM BOTTLE FAILURE
12. LTC DIRECTIONAL LOCKOUT OR CONTROL VOLTAGE LOSS

6.19. Tanks

The corner joints of the tank shall not be butt welds, but may be formed to make the corner with one piece of steel, or the panels may intersect in a “T” with inside and outside welds. Welders shall be certified in accordance with AWS D1.1 or its equivalent.

All openings in the tank for personnel entrance shall be designed for a minimum of 24 inches (610 mm) of the internal diameter. Manholes, handholes, and all other openings in the tank cover that employ gaskets shall be raised at least 0.75 inches (19.05 mm) above the cover surface to prevent moisture accumulation around the gasket joints. A warning sign shall be placed adjacent to each personnel entrance indicating that confined space entry procedures are to be followed before entering. The word “DANGER” is to be included, in white letters on a red background.

Four ground pads shall be provided: one on each corner of the transformer tank near the base. Each pad shall be suitable for a NEMA 2-hole grounding terminal.

For transformers designed with nitrogen pressure systems, if specified in EBU PX-S02A, Section 12.2, the transformer tank shall be designed with sufficient oil overfill volume to temporarily hold radiator oil during long-term storage, so that when radiators are installed, no additional oil needs to be added.

6.19.1. Tank Exterior Finish and Porcelain Color

The transformer tank exterior paint, the surge arrester ground bus bar paint, and all bushing and surge arrester porcelain shall be ANSI 70/Munsell 5.0 BG 7.0/0.4 light gray. The exterior paint on the transformer cover shall be of a nonskid composition. The minimum coefficient of friction for non-skid composition paint on the cover shall be 0.88 (dry). The exterior paint thickness on the transformer tank shall be minimum of 5-mils.

6.19.2. Tank Interior Finish

The transformer tank interior and winding clamps shall be painted white.

6.19.3. External Bolted Connections

All external bolted connections, including but not limited to, the assembly of external transformer accessories, manholes, throat connections, radiators, bushings, valves, conservator bracing, conduit supports and etc. shall be equipped with a locking mechanism, such as lock nuts, lock washers, split washers, double nuts and etc. For both metallic and non-metallic bolted connections, a minimum of two (2) bolt threads shall extend beyond the end of the nut.

6.19.4. Gaskets

Gaskets shall be of nitrile rubber. Metal surfaces to which gaskets are applied shall be finished smooth, seamless, and shall be designed with sufficient rigidity to assure proper compression of the gaskets. Machine grooves shall be provided so that over-compression of the gaskets cannot occur, unless it is demonstrated to the company's satisfaction that the manufacturer is using another gasketing system of high quality and reliability.

6.20. Fall Arrest Equipment

The fall arrest equipment shall be furnished as specified in EBU PX-S02A, Section 10.10.

6.20.1. Capital Safety Mast Anchor

The manufacturer shall provide sufficient mast anchors on the top of the tank so no point is more than 72″ from an anchor. The anchors shall be Capital Safety DBI SALA weld on mounting plate part number 8510816. Plates shall be centrally located and securely welded to the top cover of the transformer.

6.20.2. Pelsue Safety Mast Anchor

The supplier shall furnish a weld-on base plate of approved type on the top of the transformer cover for each manhole cover. The plate shall be permanently welded in a location not more than 12″ (305 mm) from each manhole cover, and shall comply with all requirements for fall arrest and confined space rescue as determined by Pelsue, the manufacturer of the company's OSHA-certified fall arrest equipment.

6.20.3. Safety Railing Equipment

The supplier shall supply safety railing equipment designed to provide perimeter fall protection for personnel on the tank cover, and to prevent tools from falling off the cover. The equipment shall comply with OSHA requirements. The safety railing equipment shall consist of posts located around the perimeter of the top of the main tank, three separated courses of rope barrier supported by eyes on the posts, and a kickboard located along the perimeter of the main tank cover (see Figure 3, Safety Railing System Overview, and Figure 4, Safety Railing Post and Kickboard Detail).

The railing posts shall be arranged for temporary installation on permanent supporting studs near the top of the tank side walls. The posts will be removed before energizing the transformer. A ladder opening of 24 inches shall be provided on the main tank side wall. The ladder opening shall be at a location such that the ladder will not interfere with any transformer component or hardware, and will provide sufficient free space for convenient access at both the bottom and top of the ladder. One post shall be located adjacent to each side of the ladder. The spacing between all other posts shall be as convenient for the transformer design, but not more than approximately 48 inches (1.2 m). Each post shall be round aluminum pipe, 1.5-inch (38.1 mm) ID, 52 inches (1.32 m) long, with three vertical eyes (1-inch / 25.4 mm) ID welded in line on the side of the post facing the transformer to support the rope; the eyes shall be located at 20, 35, and 50 inches (0.51, 0.90 and 1.27 m) from the bottom of the post. Two inches (51 mm) from the bottom of each post, the post shall be drilled in the direction parallel to the tank side wall, and a pin shall be furnished for securing the post to the supporting stud; to avoid loss, the pin shall be attached to the post by a short length of small chain. All welds shall be ground smooth, and the edges on both ends of each post shall be ground and reamed smooth for safety.

The supporting stud furnished for each post shall be welded to a standoff bracket welded to the tank side wall, with the top of the stud level with the top of the tank cover. Each stud shall be 1.4375-inch (36.5 mm) OD, 4 inches (102 mm) long, and drilled in the direction parallel to the tank side wall for the post securing pin. Each stud shall be located so as not to interfere with any transformer component or hardware, and so that there will be a gap between the installed post and the edge of the tank cover of approximately 0.5 inch (13 mm).

The kickboard shall be furnished in removable sections along the entire perimeter of the tank cover, except that no kickboard shall be furnished in the area between the posts at the ladder opening location. The kickboard shall be mounted by bolting to permanent supporting brackets welded in place near the edge of the cover. The kickboard will remain in place when the transformer is energized, and therefore shall be taken into account in the design of electrical clearances; the kickboard is intended to be temporarily removed only when necessary, such as for any modifications. The kickboard shall consist of vertical 0.25 × 3 inch (6.36 × 76.2 mm) steel bar. The spacing between the mounting brackets shall be as convenient for the transformer design, but not more than approximately 24 inches (610 mm). The bracket design shall be such that the bottom edge of the kickboard will be supported approximately 0.5 inch (13 mm) above the surface of the main tank cover to allow for drainage.

The rope shall be of approved type, 0.5-inch (13 mm) diameter, three-strand, polypropylene-polyester combination, and white color with red marker. Each of the three rope courses will be tied off at the posts adjacent to each side of the ladder. Each rope will be tied off so that it is taut, with a maximum deflection (including the free hanging sag in the rope) of three inches (76.2 mm) in any direction when a load of 200 pounds (91 kg) is applied in any direction at any point on the rope.

An aluminum cabinet shall be furnished and mounted on the transformer to store the removable equipment.

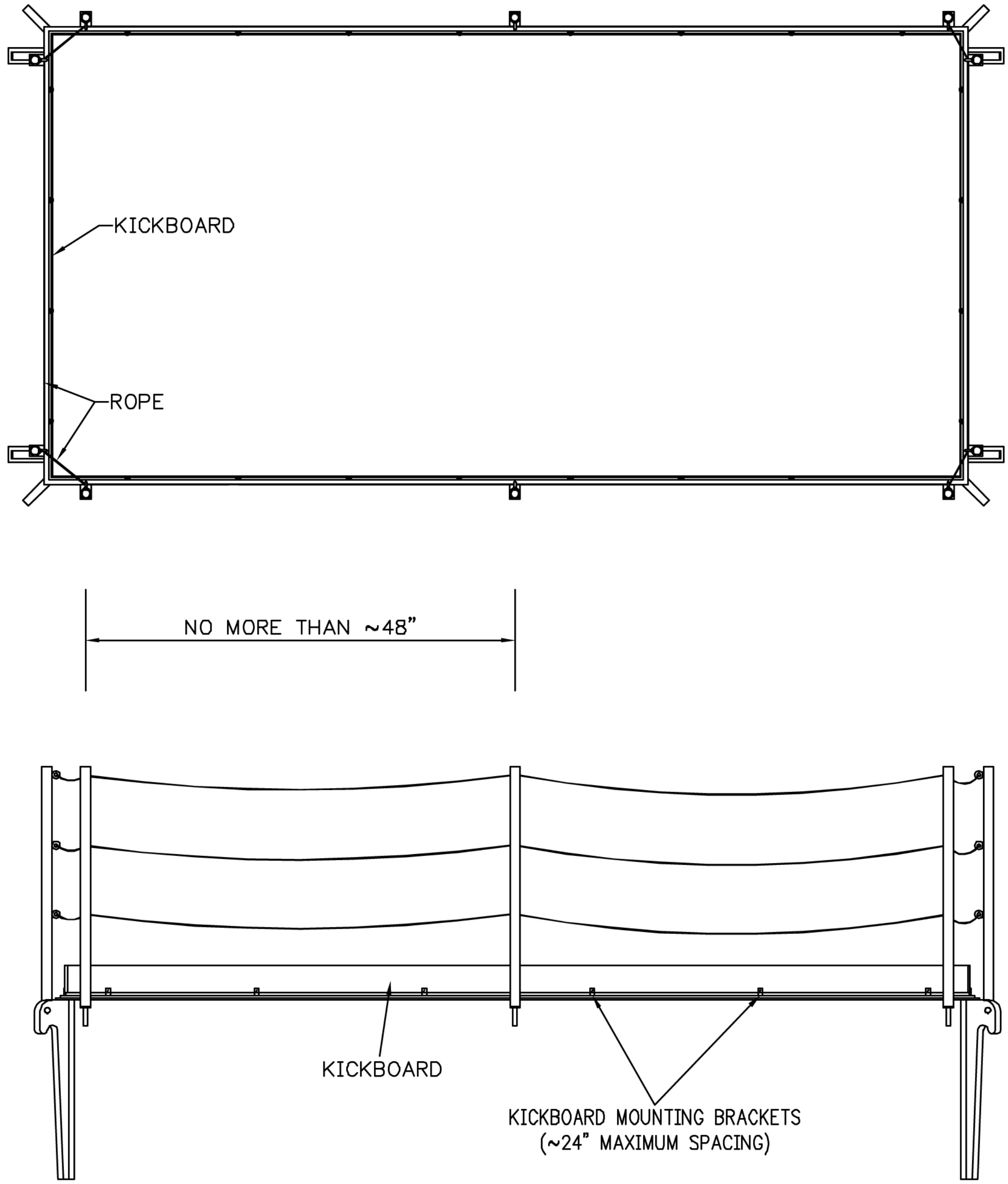

Figure 3—Safety Railing System Overview

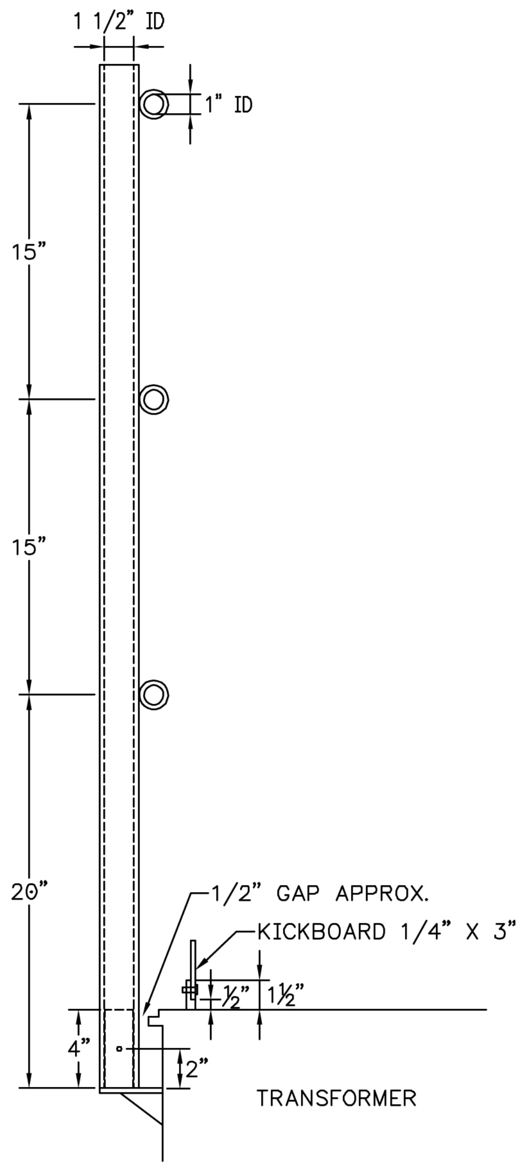

Figure 4—Safety Railing Post and Kickboard Detail

6.20.4. Tri-Post

One (1) or more Tuff-Built plates welded to the top of the transformer (not on a manhole lid); centrally located to accommodate a company-provided Tuff-Built tri-post for personnel lanyard attachments. Tuff-Built weld on base catalog # 30284. The base location shall be approved via the review drawings.

6.20.5. Exposed Fasteners and Hardware

If specified in EBU PX-S02A, Section 12.1, with the exception of nuts, all exposed fasteners and hardware (such as bolts, screws, washers, hinges, handles, brackets, and ground pads) shall be 300-series stainless steel, if not welded. If welded, 304L stainless steel shall be used. All nuts shall be silicon-bronze to prevent galling. Other stainless steel grades will be considered if equivalence to U.S. grades can be demonstrated. If the supplier prefers, the ground pads may instead be copper-faced steel as permitted by ANSI C57.12.10.

6.20.6. Accessory and Spare Part Storage

An aluminum cabinet shall be furnished and mounted on the transformer to store the small accessories and spare parts that are not normally attached or in service. This includes, but is not limited to, spare gaskets, blanking plates for the radiators and bushing turrets, etc. Instead of a separate cabinet, extra space may be provided in the aluminum cabinet already being furnished for the removable safety railing equipment but there shall be enough space to store all of the accessories and spare parts. All accessories shall be stored in such a manner that they can be easily removed from or returned to storage without causing damage to those parts or accessories or other parts or accessories stored in the same location. Gaskets and other environment-sensitive parts or accessories shall be packaged such that they are protected from damage or deterioration. The storage cabinet(s) shall be located such that parts and accessories can be accessed without interfering with the normal operation of the transformer.

6.21. Auxiliary Cooling Equipment

Auxiliary cooling equipment shall be controlled by the calculated winding temperature. Fans shall have a voltage rating as listed in EBU PX-S02A, Section 10.5.

If the cooling equipment includes oil circulating pumps, an oil flow indicator with an alarm contact shall be furnished for each pump, to indicate low oil flow. Oil pumps shall be located near the foundation level. The supplier shall furnish suitable valves on both sides of each pump, with an air bleed valve or plug at the highest point, and a pipe tap with plug (minimum 1/2-inch) at the lowest point on the pump section between the valves to permit draining, removal, and re-installation of the pump without draining oil from the radiators or the transformer tank. If the power supply to the pumps is made through connectors that must also seal the oil system, suitable mechanical guards shall be furnished to prevent breakage of the connectors and resultant oil leakage.

The oil circulating pumps shall be "Harley by Cardinal" or an approved equivalent, with the bronze sleeve type-bearing-system design.

A TecSonics precision bearing monitoring system shall be provided. The monitor shall be used to measure the bearing surface wear of the oil circulating pumps quantatively while they are operating.

The wiring to each circulating pump or fan, as applicable, shall consist of an approved-type power cord with a weatherproof plug and receptacle at the pump to provide a convenient and independent means for disconnection.

The transformer shall be designed so that streaming electrification is minimized and does not affect transformer operation or reliability within the specified temperature range. For transformers rated 345 kV and above with pumps, the bidder shall include a statement on the design philosophy (e.g., oil-flow velocities) employed to control this phenomenon.

The minimum clearance to the foundation for fans mounted under the radiators is 36″ for MidAmerican Energy, and 60″ for PacifiCorp.

The fan motors shall be fully supported to prevent shearing off during operation. The radiators or coolers shall be completely supported by their attachment to the transformer tank; external supports are not acceptable. The radiators or coolers shall be filled with 5-10 psi gauge (0.35-0.70 atm gauge) of dry nitrogen air with a nitrogen pressure valve, and a protective cover if removed for shipment. The supplier shall furnish suitable valves on the transformer side of the radiator or cooler mounting flanges, and the radiators or coolers shall be furnished with pipe taps and plugs (minimum ½ inch) on the top and capped valves (minimum ½ inch) on the bottom, to permit draining and removal of the radiators or coolers without draining oil form the transformer tank. The bottom of the radiator shall be no less than 18 inches (460 mm) above foundation level.

After all welding, the exterior surface of the radiators shall be hot-dip galvanized.

6.22. Power Supply for Transformer Auxiliary Equipment

Power supply voltages for auxiliaries and controls are listed in EBU PX-S02A, Section 10.6.

6.23. Surge Arresters

The supplier shall provide provisions for mounting and grounding high- and low-voltage surge arresters adjacent to the associated bushings. The supplier shall furnish suitable electrical ground connections, using a bus bar between the arrester ground terminals, and ground pads at the base of the transformer tank. The top of the high voltage arrester shall match the top of the high voltage bushing. If specified in EBU PX-S02A, Section 7.2, the supplier shall provide the surge arresters with directional venting, with vents to be pointed away from bushings and other arresters.

6.24. Load Tap Changer (LTC)

The LTC shall be designed in accordance with IEEE C57.12.00, IEEE C57.12.10, and IEEE C57.131. The LTC is intended as an alternative to the de-energized tap-changer, providing finer step regulation over a wider range.

The LTC is to be installed within the main step-up transformer associated with a distributed generation renewable energy project. The LTC shall regulate the high-voltage bus voltage while a separate system regulates the low-voltage power factor. Each high-voltage winding (HV) is to be tapped at either the neutral end or the midpoint.

The LTC shall have full capacity on taps below the neutral.

The supplier shall determine the appropriate BIL rating for the LTC depending upon the HV winding insulation level at the location selected. Subject to the limitations of IEEE C57.12.00 in regard to operation above rated voltage, the function of the LTC equipment shall be:

1. to follow the fluctuating voltage applied at the HV winding line terminals
2. to regulate the voltage at the low voltage winding (XV) line terminals for fluctuating VAR generation levels

6.24.1. Tap Voltages

The LTC shall regulate using 32-0.625% steps per the voltage range as specified in EBU PX-S02A, Section 9.1. The tap voltages on the nameplate shall be the theoretical values. The actual values shall be within 0.5% of the nameplate values. The volts-per-turn exception in C57.12.00 will not be accepted.

Provide a table of LTC tap positions on the transformer nameplate. The list of rated tap voltages and their corresponding full-load current values shall be for the terminals of the winding in which the LTC taps are located.

6.24.2. Tap Selector Switch

The tap selector switch shall be provided with a vacuum interrupter. The tap changer shall be rated for 500,000 operations before contact replacement (300,000 for Reinhausen Type VRC). Alarm contacts shall be fitted for indication of vacuum interrupter failure, and to prevent operation of the LTC in such a condition. The hand operating mechanism shall be mechanically interlocked with the electrical control to prevent concurrent operation electrically. The LTC motor drive compartment shall be located at a height, such that the bottom is no less than 36″ and the top is no more than 72″ above the foundation level. Draining the LTC compartment should not be required for access to the drive motor. The LTC motor shall be rated 208/240 VAC single-phase, to operate from either 120/240 VAC single-phase or from one phase of a 120/208 VAC three-phase supply.

6.24.3. Oil-Filled Tap Changer Compartment

The tap changer compartment must be capable of withstanding full vacuum in the main tank without removing the oil in the tap changer compartment. An approved maintenance-free, dehydrating breather shall be furnished. Oil filtration should be provided if deemed appropriate by the supplier.

6.24.4. Remote Indication of Tap Position

If specified in EBU PX-S02A, Section 8.2, the supplier shall provide the following equipment to remotely telemeter the tap position:

1. Control wiring from the LTC compartment and terminal blocks in the control compartment

2. An approved rotary-position transmitter with a surge-suppression circuit, to provide a local or remote rotary-position monitor of the electrical signals necessary for indication of LTC tap position.

6.24.5. Remote Control of Tap Position

If specified in EBU PX-S02A, Section 9.3, special additional provisions for remote control shall be furnished by the supplier as follows, complete with the necessary wiring via terminal blocks in the control compartment:

1. A 120 VAC programmable rotary-position monitor, of an approved type (4-20 mA analog output), to provide both local display and remote indication of LTC tap position. The monitor shall be mounted on a panel in the control compartment in such a manner that the monitor will be readily visible when the compartment door is open; the monitor shall not be located behind a hinged panel or other concealment.
2. A compatible surge protection module, mounted on the rotary-position monitor, to protect all monitor inputs and outputs from voltage surges.
3. A compatible AC-line power conditioner to provide a clean, stable AC voltage to power both the rotary-position transmitter and monitor.
4. An approved AC/DC power supply (input range 100-240 VAC, output adjustable 12-15 VDC), for the monitor output circuit.

6.24.6. Automatic Control of Tap Position

If specified in EBU PX-S02A, Section 9.4, the following equipment shall be installed:

6.24.6.1. Voltage Regulating Relay

The LTC shall be supplied with a controller/monitor device (CTLR), integral to the transformer, and located in the main control cabinet mounted on the transformer.

The CTLR shall be an MR Reinhausen Type TAPCON® 250, or an approved equivalent. The LTC controller/monitor device (CTLR) shall have means to coordinate operation with a separate VAR control system. The VAR control system is to be supplied by others. The CTLR shall provide tap-changer position indication. The position shall be derived from a direct-sensor reading from the motor drive unit rather than counting tap changes and calculation. The CTRL shall accept a 4 to 20 mA analog signal from the motor drive unit. Remote raise lower capability, and tap position indication shall be provided via the communication interface.

Provide a "Remote Disable" control switch adjacent to the CTLR to disable remote control of the LTC. Provide a blue indicating light adjacent to the remote disable switch, lighting when the remote control in enabled. Provide manual "Raise-Lower" control via a local operator interface on the CTLR front panel. Provide communication to and from the CTLR over multi-mode fiber optic cable using ST connectors. Additionally, provide an RS-232 and RS-485 copper wire interface.

6.24.6.2. Bus Potential Transformer

The company will furnish the necessary line-to-neutral or line-to-line control voltage transformer. The control voltage circuit in the LTC control shall be electrically isolated from the bus potential input furnished by the company; the electrical isolation provided in the Beckwith model M-2001C control satisfies the requirement.

6.24.6.3. Loss of Control Voltage Relay

An auxiliary relay shall be furnished to prevent automatic LTC operation in the event of loss of the control voltage input to the LTC control; the auxiliary relay shall be furnished with an alarm contact. The LTC manual control shall be independently-wired so as to remain operative during this condition. The auxiliary relay shall provide automatic return to normal operation upon restoration of the control voltage.

6.24.6.4. LTC Backup Control Relay

If specified in EBU PX-S02A, Section 9.5, a Beckwith LTC backup control relay model M-0329A shall be provided. The backup relay shall be calibrated for 1.0 per unit equals 120 V with a 2-volt fixed deadband. The relay shall be wired to block raise or lower as required. The backup alarm contact shall be wired to a terminal block.

6.24.7. LTC Alarms

The supplier shall provide the following alarms to terminal blocks:

1. Loss of AC power to the LTC control circuit
2. Loss of AC power to the LTC motor circuit

6.24.8. Control Wiring

All LTC controls shall be wired per the latest version of the company's standard LTC control schematic, PC510ABF or SSC-R481-1, as specified in EBU PX-S02A, Section 9.6.

The tap changer power supply shall be separate from the supply to other auxiliaries (lights, receptacles, heaters) or it shall be separately-fused and properly coordinated to isolate faults in other circuits. A terminal board for the termination of control and signal wiring shall be provided in the control compartment.

If PC510 is specified, the following shall be included:

1. Wiring from the contacts of the Beckwith control 'Auto−Off−Manual' switch to an auxiliary relay (90X), Siemens (Potter & Brumfield), type KRP−11AG−120 VAC to provide remote indication of the Auto−Off−Manual switch position in the control compartment.
2. An approved latching relay to permit remote selection for manual or automatic LTC control.
3. An approved auxiliary relay to permit remote blocking of LTC operation.
4. The LTC automatic raise and lower control circuits shall be wired to a terminal block in the control compartment for connection of the company's directional lockout

equipment for parallel operation. In parallel operation, if the LTC moves abnormally out of step with the parallel transformer(s), the directional lockout equipment will prevent automatic operation in the direction that would further increase circulating current, and will include an alarm contact. The LTC manual control shall be independently wired so as to remain operative during this condition.

6.25. Control Cabinet

The control cabinet shall be designed to meet the requirements of IEEE C57.148 and components shall be UL certified. The following additional requirements apply:

1. The cut out located at the bottom of the control cabinet shall be a minimum of 10″ × 24″ and shall include a removable plate that can be drilled for the installation of three 6″ conduits. There shall be no obstructing objects in front of this entry, preventing the company from installing conduits from the bottom of the control cabinet.
2. Each door shall be equipped with a handle-latching mechanism. Doors shall be designed to be held in the open position in a 35 mph wind and incur no damage.
3. Controls, terminal blocks, and other devices requiring access for operation and maintenance shall be mounted at a height between two (2) feet and six (6) feet above foundation level.
4. All AC circuits shall be protected with appropriately identified UL certified circuit breakers or hinged knife-blade disconnect switch and clip-mounted fuses. Fuses shall be Class RK-5. Fuse holders of the "pull-out" type shall not be acceptable. Breakers shall be rated 22 kA for 120/240 VAC and 10 kA for 125 VDC.
5. The compartment shall be furnished with a UL-certified duplex-GFI, 120-volt, single-phase convenience outlet.
6. All circuit breakers, contactors, auxiliary relays, switches and devices shall be UL-certified, NEMA-rated, and readily available and sold in the North American market. IEC-rated-only devices are not acceptable.
7. The compartment shall be furnished with two 240 VAC space heaters. For MidAmerican Energy and PacifiCorp, one heater shall be connected to operate continuously. The second heater shall be controlled by a thermostat. For NV Energy, both heaters shall be controlled by a thermostat. The thermostat shall be adjustable, and the adjustment provisions shall include clear indication of at least three specific temperatures on the adjustment range. The compartment shall be furnished with one 120 VAC, 20 A, duplex GFCI receptacle. Alternate heating options will be considered for approval. Space heaters shall be located on the side of the control cabinet, 5″ from the bottom, one space heater on each side of the cabinet. If the manufacturer is using a strip heater, a protective cover shall be installed to protect personnel from being burned.
8. Unless specified in EBU PX-S02A, Section 10.11, all wires shall be terminated with uninsulated, seamless, ring-tongue compression terminals, of an approved type; except where a device has terminal mountings with non-removable screws, the compression terminals shall be uninsulated, seamless, and locking-fork spade terminal lugs. Each terminal shall be the proper size for the associated wire, each terminal shall be installed on

only one wire, and the terminal installation on the wire shall be accomplished using the terminal manufacturer's recommended crimping tool with a full-cycle ratchet mechanism.

9. Wiring runs outside of weatherproof enclosures shall be in rigid steel conduit or for short distances (two to three feet) flexible, ultraviolet-resistant, properly-attached, UL-certified rigid steel conduit capable of mechanically protecting cables from physical damage. All conduit, fittings and connections shall be weatherproof and liquid-tight. For rigid conduit, all conduit and fitting connections shall be threaded; compression connections are not acceptable. All conduit ends shall be reamed or otherwise finished smooth to remove rough edges. Also for rigid conduit, a condulet outlet body (with an angled, domed cover) shall be furnished at each 90° change of direction; 90° bends in the conduit itself are not acceptable.
10. The transformer control cabinet shall have two (2) ground busses as specified in Appendix F, Figure F1. The ground bus shall be easily accessible from the front of the cabinet. A direct bolt shall be provided through the cabinet, connecting the internal ground bus to a NEMA two-hole pad on the outside of the control cabinet.
11. All wires shall be a minimum of 14 AWG, except CT wiring.

7. Tests

7.1. General

All applicable standard and special test requirements shall apply to each transformer, whether manufactured separately or at the same time as other identical units. Transformers shall be fully assembled including all auxiliary devices, surge arresters, DGA monitoring equipment, conduits and the wiring of the control cabinet, (the transformer shall be completely assembled and ready for energization) before testing. All test results, measurements, and calculated values shall be recorded on the supplier's certified test report. **A certified test report summary sheet (see Appendix E) shall be provided with the full certified test report.** All data shall be reviewed by the supplier before the transformer is shipped. The transformers shall not be shipped until the company has reviewed the test reports and released the transformer for shipment.

If a Y-winding is specified, the Y-winding voltage and capacity ratings shall be shown on the test report.

7.2. Routine Tests

Routine tests as specified in IEEE C51.12.90 and IEEE C57.150 (core ground test) shall be performed.

Note: All transformers rated for 650 kV BIL shall have a applied potential test of 275 kV at 60 hertz for one minute per the IEEE C57.12.00 2006 standard.

7.2.1. Positive-Sequence Impedance Test Clarification

Impedance shall be measured on all series, parallel, delta, and wye connections, as applicable. The H-winding to X-winding positive-sequence impedance shall be measured at

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the de-energized tap nominal-rated voltage connection and de-energized tap extremes with the LTC at neutral, and at the LTC tap extremes with the de-energized tap changer at the nominal rated voltage connection. For transformers with a buried tertiary, all three winding leads are to be brought out during testing to verify H-Y and X-Y impedances and to verify MVA rating. The positive-sequence impedance to the Y-winding shall be measured at the de-energized tap nominal rated voltage connection, and at the de-energized tap extremes and LTC tap extremes.

7.2.2. No-Load Loss and Excitation Current Test Clarification

No-load loss and excitation current shall be measured both at the nominal rated voltage and at 110% of the nominal rated voltage, both before and after impulse tests.

7.2.3. Insulation Resistance Test Clarification

Insulation resistance shall be measured at 2.5 kV DC.

7.2.4. Power Factor and Excitation Current Test Clarification

A power factor test shall be performed on all windings and bushings at 10 kV.
No winding shall exceed a 0.5% power factor. For each H-terminal, and for each H-winding connection if series-parallel, an excitation current test shall be performed at 10 kV on each de-energized tap with the LTC, if specified, in the neutral position. If an LTC is specified, the excitation current test shall also be performed with the LTC in each position from 16-lower through 16-raise with the de-energized tap changer connected at the highest ratio. Both the power factor and the excitation current tests shall be performed using Doble procedures and format. The supplier shall include the original electronic power factor and excitation current test results in Doble software format with the certified test report.

7.2.5. Normal Loss of Life Test Report

Normal loss of life charts shall be supplied with test reports for transformer orders. See the sample in Figure 5.

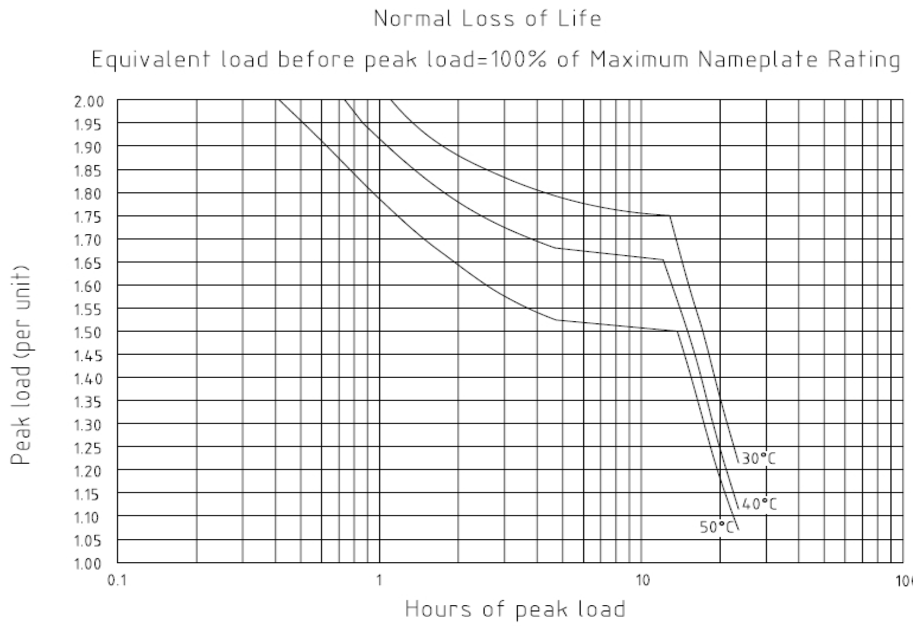

Figure 5—Normal Loss of Life, Sample

7.2.6. Partial Discharge Measurement Test Clarification

For Class I and Class II transformers, the measured partial discharge shall not exceed 200 microvolts and 500 picocoulombs during the enhancement level, and shall not exceed 100 microvolts and 300 picocoulombs during the one-hour level.

7.2.7. Temperature Rise Test

The winding average temperature rise for each phase of each winding shall be separately measured at the self-cooled rating and at the maximum forced-cooled rating, as applicable. If any temperature rise on one phase exceeds the corresponding temperature rise on any other phase by more than 4° C, the company shall be consulted, and further investigative tests shall be performed as necessary.

In addition to all standard temperature test data, the supplier shall furnish the bottom-oil temperature rise corresponding to each value of top-oil temperature rise. The supplier shall also furnish the calculated winding hot-spot temperature rise corresponding to the highest measured value of the winding average temperature rise, at both the self-cooled rating and the maximum forced-cooled rating.

The sequence of the temperature rise test shall be performed as shown in Figure 6.

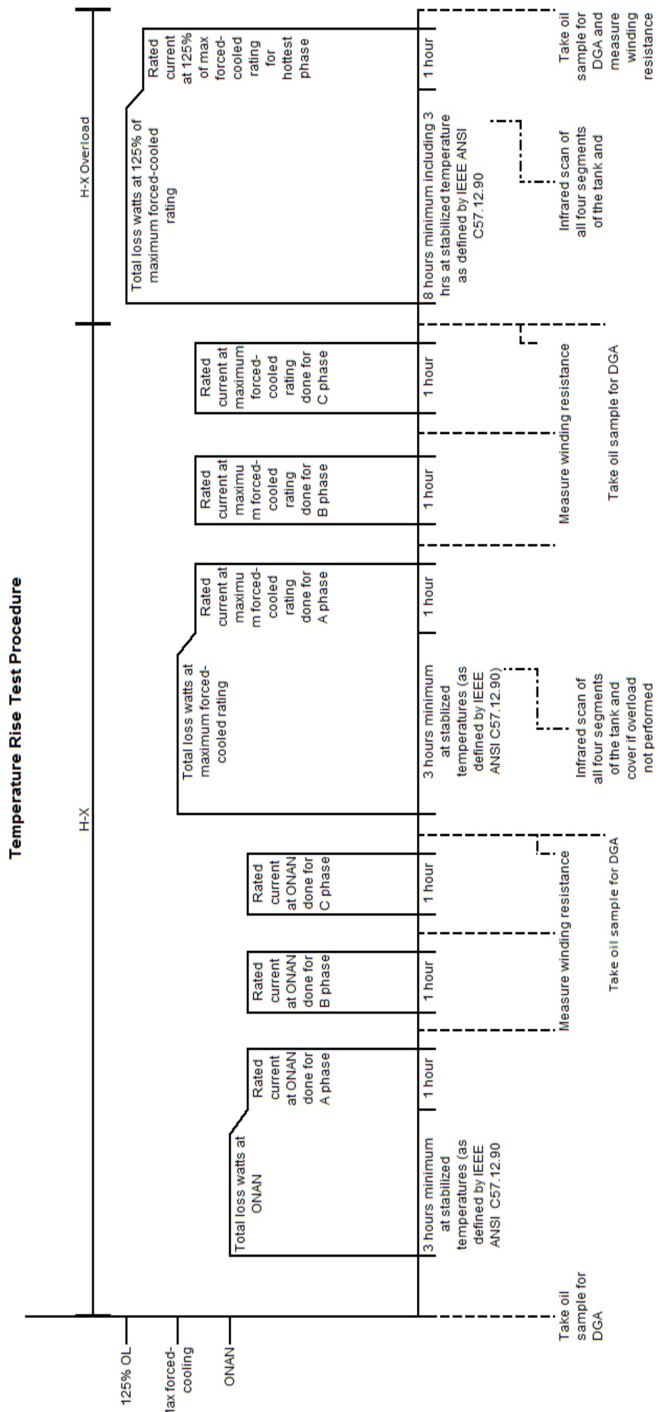

Figure 6—Temperature Rise Test Procedure Diagram

7.2.8. Test Data Required for Temperature Monitors

7.2.8.1. Qualitrol IED-509

To facilitate setting the advanced winding hot-spot temperature elements in the Qualitrol 509 temperature monitor, the supplier shall complete a reproduction of one of the following tables in Appendix B.3 with the specified temperature test data and attach the table to the certified transformer test report.

The data in Appendix B, Table B3 is required for transformers where a single hot-spot is being measured. This includes three-winding transformers with buried tertiaries.

See Section 6.5.3 for further explanation of which winding hot-spots are to be monitored for different transformer configurations.

7.2.8.2. Schweitzer SEL-2414

To facilitate setting the Schweitzer 2414 temperature monitor, the manufacturer shall complete the Temperature Monitor Data Sheet shown in Appendix C.2.

7.3. Optional Tests

The following optional tests as specified in IEEE C57.12.90 shall be performed:

1. Zero phase sequence impedance (Type I)
2. Temperature tests on each unit (thermal duplicates are not allowed)
3. Lightning impulse test (Type I) 12 MVA, ONAN, or above
4. Quality control lighting impulse test (Type I) below 12 MVA, ONAN
5. Partial discharge measurement (Type I) 7.5 MVA, ONAN, or above
6. Induced voltage test 12 MVA, ONAN, or above
7. Switching impulse test for 230 kV (60 MVA ONAN and above) and higher voltages
8. Audible sound test 12 MVA, ONAN, or above; test shall be performed with the unit directly on the floor
9. Auxiliary wiring test (IEEE C57.12.00)
10. Overload test (extension of temperature rise test)

The following additional tests shall be performed:

1. SFRA (per IEEE C57.149)
2. Core ground test
3. Core-form clamping system tightness test
4. Gas collection test (conservator units only)

7.3.1. Auxiliary Wiring Test Clarification

Auxiliary wiring shall be tested with 60-hertz voltage of 1500 volts applied for 60 seconds. Test jigs may be used to apply the test voltage to multiple terminals at the same time.

"Touch-testing" for periods less than 60 seconds is not acceptable. CT wiring shall be tested with 60-hertz voltage of 2500 volts applied for 60 seconds.

7.3.2. Temperature Rise Test Sequence

If the H-terminals are rated for a nominal system voltage of 69 kV or above, and the rated self-cooled capacity is 12 MVA or above, the duration and sequence of the temperature tests shall be as follows:

1. At the self-cooled rating (including full representation of the total losses at this rating) the test duration shall be a minimum of three (3) hours at stabilized temperatures. Shutdowns shall then take place for all three phases.
   a. Following shutdowns at the self-cooled rating, the temperature test shall immediately resume at the maximum forced-cooled rating.
2. At the maximum forced-cooled rating (including full representation of the total losses at this rating) the test duration shall be a minimum of three (3) hours at stabilized temperatures. Shutdowns shall then take place for all three phases.
   a. Following shutdowns at the maximum forced-cooled rating, the temperature test shall immediately resume at 125% of the maximum forced-cooled rating.
3. At 125% overload (including full representation of the increased total losses at this rating) the test duration shall be a minimum of eight (8) hours at stabilized temperatures.
   a. At the conclusion of the 125% overload test, one shutdown shall occur on the hot-test phase as measured and determined during the temperature test at the maximum forced-cooled rating.
   Note: The manufacturer shall consider temperature stabilization as defined by IEEE C57.12.90.

During the period of thermal stability and just before the load is cut back to rated current, infrared pictures shall be taken of the transformer's entirety, including all four segments of the tank wall and the tank cover. The measured temperatures at any point on the tank and cover shall not exceed an 80° C rise above ambient air temperature. A report with all of the thermograph pictures taken shall be provided to the company for review within 24 hours after the temperature rise test has been completed. Each picture in the report shall indicate, with a marker, where the hottest point is on the transformer according to the picture, and shall display what the temperature is at that location. Any spots above the 80° C limit shall also be clearly identified.

During the 125% overload test, the transformer shall meet the following requirements:

1. The hot-spot winding temperature rise shall not be greater than 110° C.
2. The top-oil temperature rise shall not be greater than 80° C.
3. The core hotspot temperature shall be as specified in PX-S02A, Section 11.1.

7.3.3. Infrared Picture

If the transformer is not receiving an overload temperature rise test, the manufacturer shall take infrared pictures of all four segments of the tank wall and tank cover during the highest temperature rise cooling rating that is undergoing the temperature rise test.

7.4. Frequency Response Analysis Test Requirements

A sweep frequency response analysis (SFRA) shall be performed at the factory after all other tests have been completed (except the unintentional-core-ground test) and prior to disassembling the transformer for shipment. If the supplier performs field transformer assembly and testing, an SFRA shall again be performed by the supplier in the field after the transformer has been completely reassembled and prepared for energization. Doble equipment shall be used for all SFRA measurements.

The supplier shall include the original SFRA electronic test results in Doble software format with the certified test report. The SFRA tests shall be done per the Doble Power Transformer—Test Specification, Transformer Sweep Frequency Response Analysis (SFRA) Test.

Prior to acceptance of the transformer by the company, the SFRA measurements shall be compared and analyzed to ensure compliance with Doble criteria as indication that the transformer has not been damaged during shipment.

7.5. Unintentional Core Ground Test Requirements

A final test for unintentional core grounds shall be performed after all other tests are complete and as late as practical in the handling sequence prior to shipment. The core ground insulation resistance test shall be performed at a minimum of 1,000 volts. The insulation resistance from core to ground shall read 1000 MOhm or greater for a new unit.

7.6. Core-Form Clamping System Tightness

Spring or isostatic pressure shall be applied during the winding sizing process. After final clamping, and before the core-and-coil assembly is placed inside the tank and released for testing, the tightness of the windings must be verified by a company representative. The transformer will not be accepted if any winding, block or spacer column is found to be loose.

7.7. Gas Collection Test

If a conservator oil preservation system is specified by the company or selected by the supplier, gas collection test provisions shall be furnished and tests performed as described below. A temporary fitting for gas injection shall be installed at each corner of the tank near the top of the tank wall; these fittings shall be welded closed after the completion of testing. Four separate gas collection tests shall be performed, using in turn the gas injection fitting furnished at each corner of the tank. With the oil circulating pumps turned off and without prior injection of nitrogen, each test shall be performed by rapidly injecting (within 20 seconds) 300 cc, or 100 cc more than the gas detector model's designed tripping point, of dry nitrogen into one of the gas injection fittings. Each individual test is successful if a trip occurs near the gas detector's designated trip point within two minutes after injection.

7.8. Test Sequence

The test sequence shall be in accordance with IEEE C57.90. In addition, the temperature tests shall precede all dielectric tests. The dielectric tests shall occur immediately following the conclusion of the final temperature test, so that the transformer is still at or near operating temperature. An oil leak test shall be performed at the conclusion of the dielectric test. The final dielectric test(s) shall be the induced voltage test(s).

7.9. Surge Protection Devices

Internal or external surge protection devices (varistors) shall not be used during transformer testing. If recognized as a special case (described in Section 6.2.4), the use of internal surge protectors may be necessary. The supplier shall include in the proposal a statement confirming compliance with this requirement.

For lightning-impulse tests, the reduced-voltage waveform and full-voltage waveform must match for a successful test. The reduced-current waveform and full-current waveform must also match.

7.10. Test Bushings

The bushings, radiators, fans, and any other components installed for transformer tests shall be those that will be furnished with the transformer.

7.11. Dissolved Gas Analysis

A dissolved gas analysis shall be performed on transformer oil samples taken:

1. after the unit is filled and before any tests are performed
2. immediately after the temperature tests at the maximum force-cooled rating or immediately after tertiary testing if a tertiary is present
3. six (6) hours after the end of the maximum temperature rise test
4. after all tests have been completed, except the unintentional-core-ground test

The total measured levels of gasses generated during the temperature tests, sample (2) levels minus sample (1) levels, and sample (3) levels minus sample (1) levels, shall not exceed the limits specified in Table 3.

At least one full set of oil quality tests shall be performed with the dissolved gas analysis.

Table 3—Dissolved Gas Limits

Gas	Maximum Level (PPM) Sample (2) minus Sample (1)	Maximum Level After Overload (PPM) Sample (3) minus Sample (1)
Hydrogen (H_2)	10	10
Carbon Dioxide (CO_2)	200	300
Carbon Monoxide (CO)	20	30
Methane (CH_4)	2	2
Ethane (C_2H_6)	1	1
Ethylene (C_2H_4)	< 0.5	< 0.5
Acetylene (C_2H_2)	(ND)	(ND)

7.12. Audible Sound Level Test

The test shall be conducted at the bridging tap position that gives the maximum flux density.

8. Technical Documentation

All documents shall be in English. The company recommends the use of translation service providers (TSPs) whose practices adhere to ISO 17100, Translation Services — Requirements for Translation Services, and who supplement computer-aided or machine translation tools with human translators. The company reserves the right to require corrective translation for manuals and reports it deems poorly-translated.

All drawings shall be full-size (not reduced). All documentation shall be printable in U.S. paper sizes (8 ½″ X 11″ or 11″ X 17″). All values on drawings and other materials shall be shown in U.S. customary units only, or in both U.S. customary and SI units.

Each item identification number on the collector substation main power transformer and component outline drawings shall be enclosed in a small circle and located outside the outline of the equipment for convenient reading and to avoid confusion with dimensions and other data. A fine line shall be drawn to connect each item identification number to the associated item on the equipment (in the original).

Changes made between revisions of drawings shall be identified by enclosing the modification with a cloud and locating the revision number/letter enclosed in a triangle next to the cloud. The cloud shall be used to identify changes from the previous revisions to the current revisions of the drawing only. The triangle and revision number shall remain to identify all revisions

The company purchase order number and installation location shall be shown on the title block on all drawings and on all transmittal and shipping documents. PacifiCorp orders shall include the work order number and equipment number, both supplied by the company. MidAmerican Energy orders shall include the manufacturer's order number, provided by the manufacturer, and project number to be supplied by the company. NV Energy orders shall include the manufacturer's order number, provided by the manufacturer, and project ID to be supplied by the company.

Technical documentation shall be furnished to the company as checked below:

MidAmerican Energy

All drawings and other information to be sent to MidAmerican Energy shall be mailed to the project manager at the address listed on the purchase order.

All electronic data shall be emailed to the project manager at the address listed on the purchase order.

NV Energy

All drawings and other information to be sent to NV Energy shall be mailed to the project engineer at the address listed on the purchase order.

All electronic data shall be emailed to the project engineer at the address listed on the purchase order and to NV Energy T&D Standards at mfgrecord@nvenergy.com.

PacifiCorp

PacifiCorp, Major Equipment Engineering

825 NE Multnomah St., Ste. 1500

Portland, OR 97232

Electronic copies shall be emailed to: _swag@pacificorp.com

Other:____

All drawings and other information to be sent to the project manager at the address listed on the purchase order.

All electronic data shall be emailed to the project manager at the address listed on the purchase order.

8.1. Drawing Types

8.1.1. Review Drawings

Review drawings are submitted to the company to check for general conformance with the contract and/or specification documents. Exceptions or comments made on these drawings do not constitute approval of the document or an amendment of the contract between the company and the parties producing the document.

The drawing review does not relieve such parties from compliance with the requirements of the plans and specifications, accuracy of dimensions and quantities indicated, suitability of construction materials, or fabrication and installation techniques. All review drawings submitted with revisions shall be identified with a letter, i.e. "A" for the first revision, "B" for the second revision, etc.

If specified in the purchase order, the following shall be furnished for review and shall be sent to the company as specified in Section 8 of this document:

1. One set of electronic copies submitted via email of applicable drawings and other information from Section 8.2 of this document.
2. The document for seismic qualification (PacifiCorp only) prepared per EBU SI-S02, checked, stamped, and signed by a professional engineer licensed in the United States shall be submitted by the equipment manufacturer at the same time as the review drawings.

8.1.2. Final-for-Manufacturing Drawings

Final-for-manufacturing drawings have been reviewed by the company and will be used for manufacturing the equipment. The company will use these drawings for engineering design. If changes are made to these drawings after they are issued, penalties may be incurred as stipulated in the contract. Manufacturing tolerances listed on these drawings shall be at an absolute minimum due to the implications this may have on engineering design work.

Applicable final-for-manufacturing drawings shall be identified with a revision number, i.e. “0” for the first final drawings submitted (replacing the lettered identifier of the review process), “1” for the first revision, etc. Applicable final-for-manufacturing drawings and all other information from Section 8.2 of this document shall be sent to the company as specified in Section 8 of this document:

1. One set of electronic copies submitted via email.
2. One compact disc (CD) of applicable drawings in AutoCAD or Microstation file format. DXF file format is acceptable only if the drawings are not available in CAD formats.
3. Certified seismic outline drawings per IEEE 693 and EBU SI-S02 shall be provided. These drawings (and additional drawings) shall include: total weight and location of center of gravity; anchoring details showing bolt sizes, their type, grade and locations on a plan view; controlling reactions at the base of the equipment for seismic, wind, and normal operating loads and; controlling forces used for designing anchors.

8.1.3. As-Built Drawings

As-built drawings are issued after the equipment has been manufactured and shall reflect the exact condition of the equipment at the time of shipment. There shall be no manufacturing tolerances listed on these drawings as they should be a direct representation of the equipment dimensions and the accessory locations.

As-built drawings shall be identified with revision numbers in the same fashion as final-for-manufacturing drawings. Applicable as-built drawings, instruction manuals, test reports, and other information from Section 8.2 of this document as specified in the following list:

1. One set of as-built drawings, instruction manuals, test reports, or other information shall be shipped with the equipment in a weatherproof envelope or in a compartment.

2. Three additional sets of as-built drawings, instruction manuals, test reports, and other information shall be sent to the company as specified in Section 8 of this document.
3. One compact disc (CD) of applicable drawings in AutoCAD or Microstation file format. DXF file format is acceptable only if the drawings are not available in these CAD formats. The CD is to be sent to the company as specified in Section 8 of this document.
4. One compact disc (CD) of instruction books, test reports, and other information specified in Section 8.2 shall be sent to the company as specified in Section 8.

8.1.4. AutoCAD Drawings

All AutoCAD drawings shall be produced with commercial AutoCAD software compatible with AutoCAD Release 2010. Using student or evaluation software is not acceptable.

8.2. Technical Documentation Description

8.2.1. Certification of Insulating Oil

The supplier shall furnish certification that the insulating oil used to fill the transformer for testing, and the oil supplied with the unit if applicable, contains less than 1.0 ppm polychlorinated biphenyl contamination.

8.2.2. Certified Test Report

The supplier shall furnish a complete certified test report (see Section 7.1 of this document) for the company's review before the unit is shipped.

8.2.3. Outline Drawing

The supplier shall furnish an assembled transformer outline drawing with all four sides and the top shown. Information shown on the drawing shall include the following items in addition to or in clarification of the information normally included:

1. Structural details of the transformer base
2. Weight and center of gravity of the installed unit and the unit prepared for shipment
3. Minimum dimensions of the unit prepared for shipment
4. Foundation reactions produced by equipment operation, and by wind and seismic forces

In addition, one electronic copy of the outline drawing shall be supplied to the company two weeks before the design review to allow appropriate time for review.

8.2.4. Nameplate and Instruction Plate Drawings

The supplier shall furnish a drawing of each nameplate and instruction plate. One electronic copy of the nameplate and instruction plate drawing shall be supplied to the company two weeks before the design review to allow appropriate time for review.

8.2.5. Bushing Outline Drawings

The supplier shall furnish detailed bushing outline drawings.

8.2.6. Surge Arrester Outline Drawings

The supplier shall furnish detailed surge arrester outline drawings.

8.2.7. Schematic and Wiring Diagrams

The supplier shall furnish schematic and wiring diagrams showing complete auxiliary equipment wiring, including:

1. Customer connection points
2. The number, size, and power requirements of fans and pumps
3. The fan and pump control
4. The alarm and relay connections
5. The current transformer connections
6. The load tap changing equipment control

8.2.8. Current Transformer Nameplate Drawings

The supplier shall furnish current transformer nameplate drawings or include this information on the main transformer nameplate drawing.

8.2.9. Current Transformer Information

The supplier shall furnish CT test certificates to include the following:

1. Current transformer resistance per winding tap
2. If lead provided, resistance of each lead
3. Curves showing ratio correction and secondary excitation for relaying
4. Curves showing ratio and phase angle correction for interchange, revenue, or tariff metering

8.2.10. Instruction Manuals

The supplier shall furnish instruction manuals covering the receiving, handling, installation, complete parts list, descriptive bulletins, test reporting, operation, and maintenance of the transformer and all auxiliary equipment. Instruction manuals shall also include manuals for abnormal operating conditions, troubleshooting guides, and detailed maintenance instructions and maintenance intervals, and requirements for long-term storage.

8.2.11. Spare Parts

The supplier shall furnish a complete list of spare parts for the transformer and all auxiliary equipment, including identification of each part by name and part number. The spare parts list for the LTC equipment shall be accompanied by detailed drawings and exploded views as required to facilitate complete maintenance by the company. Parts lists and drawings shall relate specifically to the equipment covered by this specification; typical drawings are not acceptable.

8.2.12. Final Drawings

Final drawing set should contain the review drawings listed in Section 8.1.1 plus internal drawings that show the location of no load tap changer (if applicable) and location of current transformers.

8.2.13. Geomagnetic Disturbance Withstand Calculations

Note: No changes to the design of the transformer are required for geomagnetic withstand. GIC (geomagnetic-induced current) calculations of the proposed design are to be provided for informational purposes only.

If specified in EBU PX-S02A, Section 14, the manufacturer shall provide calculations on geomagnetic disturbance withstand to be presented in a design review of the following:

1. Transformer winding and internal metallic part hot-spot temperature step response profile with 25 amps, 50 amps, 75 amps, and 100 amps of direct current in each phase of the transformer. This should include an incremental temperature increase from initial steady-state equilibrium, along with the time for temperature to move 63.2% of the increase from initial to new equilibrium temperature for each level of direct current injection.
2. The Vars required by the power grid to support the excitation kVA at each of the direct current values stated above.
3. The frequency spectrum of the exciting current for the transformer at the direct current values stated above. In addition to the frequency values, the magnitude of current shall be provided at discrete frequencies.

9. Shipping Requirements

9.1. Air-Filled or Oil-Filled

As specified in EBU PX-S02A, Section 12.4, the transformer prepared for shipment shall be filled with oil and with dry nitrogen in the gas space at a pressure of three psig (0.2 atm gauge), or if not oil-filled, shall be filled with dry breathable air at a pressure of three psig (0.2 atm gauge). If the manufacturer's standard delivery procedure employs a different pressure or method, approval for the shipment must be obtained from the company. A conspicuous tag shall be furnished identifying the gas contents of the transformer prepared for shipment and specifying the actual gas pressure and the ambient temperature at the time of filling.

9.2. Moisture Content

The water content of the paper at the time of shipment and receipt at the company site shall be 0.5% M/DW or less. The manufacturer shall provide a suitable testing process to demonstrate that the water content meets this limit.

9.3. Factory Assembly and Component Location Marking

The complete transformer, including all auxiliary power and control wiring, shall be completely assembled at the factory to ensure proper fit and operation of all components.

Major transformer components that must be shipped detached for field installation (including, but not limited to, components such as radiators, pumps, conservator supports, and surge arrester supports) shall be marked for installation by means of permanent metal stamping. This metal stamping shall include adjacent marks on the component and the main transformer assembly to show both component location and orientation. (For PacifiCorp provide a metal engraved stamp for each radiator set with the PacifiCorp transformer SAP number and serial number so each radiator set can be quickly identified.).

Major transformer components that must be stored detached before field installation in situations where temporary storage will occur shall be shipped properly packaged (e.g., placed on pallets) and covered with tarpaulins to protect them from damage and weather. The packaging shall be adequate to protect the components for a minimum of five years.

9.4. Shipping Crates

The manufacturer shall paint on each shipping crate, with weatherproof paint, the following documentation to easily identify the contents of each crate:

1. Work order number (PacifiCorp), project number (MidAmerican Energy), or project ID number (NV Energy)
2. Manufacturer's work order number or shop order number
3. Purchase order number
4. SAP equipment number (PacifiCorp)
5. Crate packing list (in a weatherproof envelope)
6. Equipment type, model, rating, and description
7. Installation location name

9.5. Notification of Shipment

The supplier shall notify the company two weeks prior to the expected arrival of the collector substation main power transformer. Additionally, the company contact named below shall be notified 48 hours prior to delivery and on the day of shipment to ensure provisions for unloading.

Technical documentation shall be furnished to the company as checked below:

MidAmerican Energy

Notification instructions will be on the purchase order.

NV Energy

Notification instructions will be on the purchase order.

PacifiCorp

PacifiCorp, Major Equipment Engineering
825 NE Multnomah St., Ste. 1500
Portland, OR 97232
Mjrequiptrchng@pacificorp.com

Other: ___________________________

Notification instructions will be on the purchase order.

9.6. Impact Recorders

For all modes of shipment, one electronic impact recorder and one mechanical impact recorder shall be furnished and installed by the supplier. The impact recorder shall be furnished with a sealed protective cover. Impact recorders from the railroad are not acceptable. Not less than one hour prior to scheduled pickup of the transformer or truck leaving the factory, the supplier shall start the recorder and verify that it is operating properly. The impact recorder shall record all impacts of 0.5 or greater. The electronic file provided by the impact recorder shall document the time and date when it started recording impact information and the time and date when the impact recorder stopped recording impact information.

The impact recorder shall be the latest model Lat-Lon or its equivalent, and able to operate continuously during any form of shipment. The impact recorder shall be supplied with the latest firmware update and a battery switch, to allow for shipments of extended periods without solar access. If the transformer will be located in areas with no solar access for extended periods, the impact recorder shall be charged for the appropriate amount of time before shipment to ensure that it will be operational throughout the entire trip.

The supplier shall send an email to the company stating that the transformer destination, SAP Equipment Number (PacifiCorp only), company PO#, Lat-Lon log-in information, and a statement confirming the impact recorder has been started at the factory, and is operating properly via the Lat-Lon website.

The electronic impact recorder trip information file shall become the property of the company at the time of delivery. If parts and accessories are shipped by rail, they shall be in the same train as the main unit. A single two-directional impact recorder shall be installed on each rail car if accessories are shipped on separate cars.

9.7. Acceleration Forces

Transformer core and coils shall be designed for shipment without temporary internal shipping braces. Temporary internal shipping braces may be used to support bushing leads. Any bracing used for leads shall be well-documented and flagged for removal before energization. The transformer shall be designed to withstand a minimum shipping force of 2G in the lateral direction, 5G in the longitudinal direction, and 3G in the vertical direction.

9.8. Rail Shipment

9.8.1. Unloading Allowance

For shipment by rail, three normal working days, Monday through Friday, shall be allowed for unloading the transformer from the railcar.

9.8.2. Supplier Representative

If specified in Section 4.1 of EBU PX-S02A, the supplier shall furnish a mutually agreed upon representative to be present at the delivery site to verify the transformer condition as received, before unloading from the railcar. A qualified factory representative shall: 1) review and sign any impact recorder chart(s) or electronic files, 2) witness the SFRA testing, 3) witness unintentional core-ground testing (using a 500-volt test voltage), and 4) perform the internal inspection and submit a report on findings.

9.8.3. Shipping Cover

The transformer shall be shipped in its own complete tank. The use of a shipping cover is not acceptable.

10. Other Inspection Requirements

10.1. Design Review

A design review will be conducted upon completion of the transformer design. The company may employ a consultant as its agent to oversee the review. The supplier shall include in the quoted schedule sufficient time for the review, and shall not order transformer materials prior to completion of the design review, or without the written approval of the company.

If the company, in its reasonable discretion, finds that the design does not conform to the contract requirements, then the supplier and the company will confer regarding the nonconformity and the supplier shall have the right to submit a corrected design to the company. If the company and the supplier cannot reach an agreement on the transformer design, the company reserves the right to cancel the order per the terms of the contract. The design review package shall be provided a minimum of two weeks before the design review meeting.

The design review meeting shall be at the company's facility or the manufacturer's facility at the company's direction.

10.2. Quality Assurance Inspections and Surveillance

The following quality assurance inspections shall be conducted during the manufacture of the equipment:

1. Winding inspection and core inspection (before windings are nested and before windings are installed on the core)
2. Pre-tanking inspection and witnessing the tanking of the core-and-coil assembly
3. Factory acceptance tests

4. Final inspection before shipment (optional, as determined by the company)

The supplier shall provide the company with a production schedule that specifies these quality assurance inspection hold points and shall provide updates of this schedule as manufacturing progresses. Updates shall be provided monthly and then weekly three weeks before core and winding inspection, and immediately if schedule changes. Inspection dates shall not be changed less than two weeks prior to the scheduled inspection.

The company may, in its sole discretion, waive any or all of the quality assurance inspections. If so decided, the waiver of these inspections does not alter the supplier's obligations per the terms of the contract, release and/or purchase order.

A quality surveillance representative (QSR) may be employed by the company to be present at the supplier's facility during the manufacturing and testing times. The QSR will comply with the supplier's safety and procedural requirements at all times while in the supplier's facility, and the following additional guidelines shall apply.

10.2.1. Cooperation with Quality Surveillance Representative

The supplier shall cooperate with the QSR and arrange a reasonable and mutually agreeable schedule for the required inspections and witnessing of tests, consistent with maintaining scheduled progress of the transformer through the supplier's facility. The supplier shall not pre-test transformer prior to the QSR witnessing tests. The company requires the QSR to witness all factory tests unless given written approval by the company not to witness specific factory tests.

10.3. Inspection Photographs

The manufacturer shall provide photographs of the following:

1. The core and coils before they are assembled. These photographs shall clearly show all pertinent information such as general construction and any taps.
2. The assembled core and coils before installation in the transformer tank, taken from each side, each end, top, and bottom.
3. The fully-assembled transformer after the dielectric tests have been successfully completed. A minimum of five photographs shall be taken from all four sides and from above to identify and locate all equipment on the transformer top.

Prints of the photographs shall be supplied for each instruction book furnished. A compact disc containing a digital copy of each photograph is to be furnished at time of shipment. Resolution on each digital photograph is to be a minimum of 5.0 megapixels.

10.4. Field Engineer

Services of the supplier's field engineer(s), if specified in EBU PX-S02A, Section 4, shall be furnished for supervision of field installation of all parts detached for shipment, and for complete pre-energization inspection of the transformer. The field engineer(s) shall have a thorough working knowledge of the complete transformer (all internal and external components, including load tap changing equipment).

11. Evaluation

11.1. Loss Evaluation Method

An Equivalent Total Owning Cost (ETOC) will be calculated from the bid price and the present value of the supplier's guaranteed maximum losses as shown below. The ETOC will be used in determining bid awards.

ETOC = BID PRICE + (A × NL) + (B × LL)

where:

ETOC	=	Equivalent total owning cost in dollars
BID PRICE	=	Supplier-quoted bid price in dollars + any adders
A	=	Loss cost multiplier for no-load losses in dollars per kilowatt
B	=	Loss cost multiplier for load losses in dollars per kilowatt
NL	=	Guaranteed maximum no-load losses at 20° C in kilowatts
LL	=	Guaranteed maximum load losses at 85° C in kilowatts, excluding auxiliary power.
		(The load losses shall be quoted at the self-cooled rating for a substation transformer with radiators. For a substation transformer with coolers instead of radiators, or for any generator step-up transformer [whether with coolers or with radiators], the load losses shall be quoted at the maximum forced-cooled rating.)

11.2. Loss Cost Multipliers

The loss cost multipliers to be used in the loss evaluation method will be as specified in EBU PX-S02A, Section 13.

In the event that the combined evaluated cost of actual tested no-load losses (NL) and load losses (LL), exceeds the combined evaluated cost of the respective guaranteed maximum losses, credit shall be given to the company for the dollar difference. Any dollar difference shall be deducted from the transformer invoice by the supplier.

11.3. Method of Shipment

The company prefers the transformer to be shipped upright. If horizontal shipment must be employed, the supplier shall clearly state that fact in the proposal. A transformer with the H-terminals rated for a nominal system voltage of 161 kV or above shall be shipped without oil and filled with dry breathable air.

The method of shipment for a transformer with the H-terminals rated for a nominal system voltage below 161 kV shall be as specified below:

1. A transformer with a self-cooled rating above 18,000 kVA shall be shipped without oil and filled with dry breathable air.
2. For a transformer with a self-cooled rating of 18,000 kVA or below and above 12000 kVA, it is preferred that the transformer is shipped by truck, oil-filled.
3. A transformer with a self-cooled rating of 12,000 kVA or below shall be shipped by truck, oil-filled.

12. Transformer Performance

The following combustible gas levels are based upon normal loading and shall be used to initiate the warranty:

Gas	Maximum Level
Methane	24 ppm/year
Ethane	15 ppm/year
Ethylene	10 ppm/year
Acetylene	0.5 ppm for five years
Hydrogen	20 ppm/year
Carbon Monoxide	300 ppm for five years
Carbon Dioxide	1000 ppm for five years
Oxygen	below 3000 ppm/year

Discussion regarding the warranty, root causes and remediation will follow the warranty initiation.

13. Issuing Department

The engineering publications department of PacifiCorp published this material specification. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be submitted by email to: TDManufacturerSubmittal@pacificorp.com.

This material specification shall be used and duplicated only in support of company projects.

Appendix A—Schedule of Pre-Qualified Suppliers

The following schedule is a list of suppliers and materials pre-qualified by the company. Manufacturers wishing to supply materials not listed must receive the express permission of the company, showing experience list and NEMA or other recognized accreditation.

Table A1—List of Pre-Qualified Material Suppliers

Material	Manufacturer	Product Ref.	Comments
A1. Insulation/Conductor			
Conductor insulation paper	Weidmann		
	Tullis - Russell Munksjo		widely used in Europe
CTC conductor insulation	Weidmann	Dennison type	
	Tullis - Russell Munksjo		widely used in Europe
CTC			Phelps-Dodge material has proven to be of inadequate quality in the past and, consequently, is not currently approved
Pressboard insulation	EHV-Weidmann	TIV, TX2	
Cooling duct material	Weidmann Klackband	TIV, TX2	
Laminated board	Weidmann	TIV, TX2	
A2. Cooling			
Top-oil resistance temperature detector (RTD)	Qualitrol	103-023	100-ohm platinum - to include connector and shielded cable
Ambient air resistance temperature detector (RTD)	Qualitrol	103-049-01	100-ohm platinum - to include connector and shielded cable
Winding hot-spot clamp-on current transformers	Qualitrol	TRA-017-01	0-10 amp input range
Liquid Oil Temperature Gauge	Qualitrol	104-321-01	
Transformer monitor	Schweitzer	Model SEL2414 Part # 241421B3B9X74CB1030 Model SEL2505301XX	Transformer monitor Remote I/O (LTC units)
Transformer monitor	Qualitrol	Model # IED509-00243499 Config # IED509-3384	100-ohm platinum – two-winding or three-winding transformer with buried tertiary panel mount in control compartment
	Qualitrol	Model # IED509-00243501 Config # IED509-3386	100-ohm platinum – two-winding or three-winding transformer with buried tertiary panel mount in control compartment
Radiator fans	Krenz-Vent		To be OSHA approved

Material	Manufacturer	Product Ref.	Comments
Circulating Pumps	Cardinal	Harley™ sleeve bearing	
A3. Tap Changer			
Load tap changer (LTC) - Resistance or Reactance Type, cover-mounted	MR	VR (all MR type)	Vacuum switch
Load tap changer (LTC) - Reactance Type, tank wall-mounted	MR	RMV - II (1500 A minimum)	Vacuum switch
Diverter switch automatic oil filter	Velcon	TP-2	
Maintenance-free dehydrating breather	Messko	MTraB	Shall be HT type for temperatures below 0° C
LTC control adaptor panel	Beckwith	M2001C, with part M-2270B	
Parallel balancing module	Beckwith	M-0115A	
Rotary-position transmitter	Incon	Synchro (selsyn)1292-KS	With surge suppression circuit
Rotary-position monitor	Incon	1250B-0-R	120 VAC
Surge protection module	Incon	1280	
AC-line power conditioner	Incon	1932	
Power supply	Sola	SLS-12-017T SDP-06-24-100T	
Latching relay	Siemens (Potter and Brumfield)	KBP-11A-120	120 VAC
Auxiliary relay	Siemens (Potter and Brumfield)	KRP-11DG	
LTC Pressure relief	Messko		
LTC Pressure relief	Qualitrol	208-60E	
Pressure relief directional shield	Qualitrol	SLD-603-1	
Pressure relief screen	Qualitrol		Stainless steel
A4. Surge Arresters			
Station Class Arrester	ABB Power	EXLIM/PEXLIM-Q, -P, -T TEXLIM/PEXLIM-Q, -P, -T	Plant Location: Youngwood, PA
Station Class Arrester	Cooper Power Systems	AZES, US, UH	Plant Location: Waukesha, WI
Station Class Arrester	General Electric	ZT, ZG, HM, XP	Plant Location: Ft. Edward, NY
Station Class Arrester	Joslyn	ZSP	Plant Location: Cleveland, OH
Station Class Arrester	Hubbell	Dynavar VL, VN SVN, VN	Plant Location: Aiken, SC; Wadsworth, OH
Station Class Arrester	Siemens	3EQ, 3EP	Plant Location: Jackson, MI
A5. Wiring			
Compression terminals	Burndy	YAV HYLUG	Ring tongue
Compression terminals	Burndy	YAV-T-HYLUG	Fork-tongue
Crimping tool	Burndy	HYTOOL	

Material	Manufacturer	Product Ref.	Comments
Terminal Blocks	GE	EB-25 or EB-27	
Terminal Blocks	Buchanan	2B or 4B	
Terminal Blocks	Penn Union	Cat. #6006	Shorting or non-shorting
Fan wiring	Krenz-Vent	Power cord	
Pump wiring	Harley	WeatherAll power cord	
A6. Oil Preservation System			
Pressure-vacuum gauge	Qualitrol	070-35C 050-35E	
Bleeder device	Qualitrol	351-2A	
A7. Conservator (Oil Preservation System)			
Dehydrating Breather	Messko	MTraB	Maintenance-free type
Pressure-vacuum gauge	Qualitrol	050-35E	For transport
A8. Fall Arrest Equipment/Safety Railing			
Base Plate	Pelsue	FB-SW1 (PPNUH4000-2 = obsolete)	
Base Plate	DBI-SALA	8510816	
Rope for safety rail	U.S. Rope & Cable		
Base Plate	Tuff-Built	#30284	
A9. Auxiliary Protection Devices			
Dial type oil-level indicator	Qualitrol	Series 032 or similar Series 042 or similar	To include connector and cable
Time Delay Relay	Agastat	7012PD	Oil level trip time delay
Pressure relief device	Qualitrol	XPRD00-00016608	For main tank, 10 psi
Pressure relief device	Qualitrol	XPRD00-00021642	For main tank, 12 psi
Stainless steel screen for pressure relief device pipe	Qualitrol	SCN-600-1	
Rapid-pressure-rise relay	Qualitrol	900-009-03	
Connector and cable assembly	Qualitrol	CON-603	For rapid-pressure-rise relay
Seal-in relay	Qualitrol	909-300	For control compartment
Gas detector indicator	Qualitrol	038	
Gas detector relay	Buchholtz	BF80	NV Energy substation requirement
Sinking cell relay			
12-point alarm monitor 48 VDC	Rochester Instrument Systems	AN6100B; Part Number: B2HX1WINTS12W24WMN/ OF48C12FODC1FPLPCPPL	
12-point alarm monitor 125 VDC	Rochester Instrument Systems	AN6100B; Part Number: B2HX1WINTS12W24WMN/ OF125C12FODC2FPLPCPPL	
A10. Bushings*			
Bushings	ABB Power		
Bushings	Siemens		COTA-type and OTAA-type bushing are not allowed

Material	Manufacturer	Product Ref.	Comments
Bushings	AREVA		Previously Passoni & Villa
Bushings	PCORE		
A11. On-Line DGA Monitors			
Monitor	Kelman/GE	TRANSFIX, TAPTRANS, MINITRANS, MULTITRANS	
Monitor	Morgan Schaffer	Calisto 2	
Monitor	Serveron/Siemens	TM8	
A12. Connectors			
Connector	Anderson Electric, SEFCOR, HOMAC, TRAVIS	HDSF, SNFT, ASNFHV, KSLC, BSTB	With machine-surfaced option
A13. Bushings CTS			
Bushing CTs	ABB		
Bushing CTs	Associated Engineering		
Bushing CTs	General Electric		
Bushing CTs	Merramac		

* Specific bushings must be submitted in the proposal phase and approved by the company prior to the transformer manufacturer placing an order for bushings.

Appendix B—Qualitrol 509 Details

Appendix B.1—Qualitrol 509 Winding Current Transformers

For a two-winding transformer, or a three-winding transformer with the tertiary buried, one current transformer shall be furnished in the low-voltage winding for simulation of the low-voltage winding hot-spot temperature.

All current transformers shall have a 5 amp secondary and have an approved 10 amp clamp-on current transformer, input range 0-10 amp. The current transformer secondary leads shall be wired to terminal blocks in the control compartment and connected to the temperature monitor.

Appendix B.2—Qualitrol 509 Temperature Monitor Settings and Control Connections

The temperature monitor settings and cooling equipment control connections required for the most common transformer cooling classes are as specified below.

Note that the actual values of the temperature settings will be selected by the company; the temperatures specified below are the normal values used for most applications:

1. For all transformers, one temperature monitor output relay operated from the main tank top-oil temperature will be used to activate the company's alarm (normally at 90°C).
2. For a transformer with a self-cooled rating and one forced-cooled rating, three temperature monitor output relays operated from the winding hot-spot temperature (or the hottest of the three winding hot-spot temperatures) will be utilized: one shall be connected by the supplier to start the forced-cooling equipment (Temperature Monitor Output Relay 1, normally at 80°C); one will be used to activate the company's alarm (Temperature Monitor Output Relay 4, normally at 110°C); and one will be used to trip the company's switching device (Temperature Monitor Output Relay 5, normally at 130°C).
3. For a transformer with a self-cooled rating and two forced-cooled ratings, four temperature monitor output relays operated from the winding hot-spot temperature (or the hottest of the three winding hot-spot temperatures) will be utilized: one shall be connected by the supplier to start the first stage of forced-cooling equipment (Temperature Monitor Output Relay 1, normally at 75°C); one shall be connected by the supplier to start the second stage of forced-cooling equipment (Temperature Monitor Output Relay 2, normally at 80°C); one will be used to activate the company's alarm (Temperature Monitor Output Relay 4, normally at 110°C); and one will be used to trip the company's switching device (Temperature Monitor Output Relay 5, normally at 130°C).
4. For a transformer with two forced-cooled ratings (no self-cooled rating), three temperature winding hot-spot temperatures) will be utilized: one stage of forced cooling shall be permanently fixed in the "on" position through a switch in the control cabinet; one shall be connected by the supplier to start the second stage of forced-cooling equipment (Temperature Monitor Output Relay 2, normally at 80°C); one will be used to activate the company's alarm (Temperature Monitor Output Relay 4, normally at 110°C); and one will be used to trip the company's switching device (Temperature Monitor Output Relay 5, normally at 130°C). Each stage of cooling equipment must be connected to a Temperature Monitor Output Relay such that the automatic bank switching feature may be enabled.

All transformers with a low voltage secondary of 46 kV and above shall have a temperature monitor output profile with dual winding trips. All other transformers shall have an output profile with only one winding trip.

Detailed temperature monitor input and output requirements are as follows:

1. The eight input modules shall be connected as follows. See Section 6.5.3 to determine applicable current transformer quantity, type, and locations:

Input 1	Main oil temperature RTD
Input 2	NO CONNECTION
Input 3	Ambient temperature RTD
Input 4	Low-voltage or common winding CT (depending on transformer type, see Section 6.5.3)
Input 5	High-voltage or series winding CT or NO CONNECTION (depending on transformer type and configuration, see Section 6.5.3)
Input 6	Tertiary winding CT or NO CONNECTION (depending on transformer configuration, see Section 6.5.3)
Input 7	NO CONNECTION
Input 8	NO CONNECTION

2. The eight output control/alarm contacts shall be wired to terminal blocks and connected as follows:

Output 1	Start first stage of forced-cooling equipment
Output 2	Start second stage of forced-cooling equipment
Output 3	Future use
Output 4	Activate the company's winding hot-spot temperature alarm
Output 5	Initiate winding hot-spot temperature trip of the company's switching device
Output 6	Activate the company's main tank top-oil temperature alarm
Output 7	Initiate winding hot-spot temperature trip of the company's switching device if dual-winding trip output (see notes above) or future use
Output 8	Initiate winding hot-spot temperature trip if dual-winding trip output (see notes above) or future use

3. The diagnostics alarm contact shall be wired to a terminal block.
4. The RS-485 communication terminals shall be wired to a terminal block.
5. The four mA outputs shall not be wired to the terminal blocks.

Appendix B.3—Qualitrol 509 Temperature Monitor Test Data Sheet

Table B3—Winding Transformers, 3-Winding Transformers with Buried Tertiaries

<table>
<tr><th>MVA</th><th>Winding</th><th>Top-Oil Temperature Rise (Degrees C)</th><th>Ambient Temperature (Degrees C)</th><th>Winding Hotspot Temperature Rise (Degrees C)</th><th>Winding Time Con-stant (Minutes)</th></tr>
<tr><td rowspan="2">Self-Cooled Rating</td><td>HV</td><td rowspan="2">(A)</td><td rowspan="2">(B)</td><td>(C)</td><td>(D)</td></tr>
<tr><td>LV</td><td>(I)</td><td>(J)</td></tr>
<tr><td rowspan="2">Maximum Forced Cooled Rating</td><td>HV</td><td rowspan="2">(E)</td><td rowspan="2">(F)</td><td>(G)</td><td>(H)</td></tr>
<tr><td>LV</td><td>(K)</td><td>(L)</td></tr>
</table>

(A) and (E): The top-oil temperature rise above ambient temperature at the specified MVA rating.

(B) and (F): The ambient temperature at the time of measuring the temperature rises at the specified MVA rating.

(C), (G), (I), and (K): The winding hot-spot temperature rise above ambient temperature at the specified MVA rating for the specified winding.

(D), (H), (J), and (L): The time required to reach 63.2% of the final winding temperature rise at the specified MVA rating for the specified winding (also known as the winding temperature time constant value). This will require a non-boosted heat run so that a smooth heating curve can be recorded for time-constant measurement.

Appendix C—Schweitzer SEL-2414 Details

Appendix C.1—Schweitzer SEL-2414 Winding Current Transformers

1. All current transformers shall have a 5 A secondary. The current transformer secondary leads shall be wired to terminal blocks in the control compartment and connected to the temperature monitor .
2. Outputs shall be connected as follows:

OUT101	High temperature (for customer use)
OUT102	Critical temperature (for customer use)
OUT103	Monitor failure (for customer use)
OUT601	Spare (for customer use)
OUT602	Fan group 1 initiate (normally closed contact)
OUT603	Fan group 2 initiate (normally closed contact)

3. RTD leads shall be connected directly to RTD inputs (no intermediary terminal blocks) as follows:

RTD1	Ambient temperature
RTD2	Main tank top oil temperature
RTD3	LTC tank top oil temperature (for transformers with LTC)
RTD4	Not used
RTD5	Not used
RTD6	Not used
RTD7	Not used
RTD8	Not used
RTD9	Not used
RTD10	Not used

4. A SolaHD catalog number SDP 06−24−100T 125 VDC to 24 VDC convertor shall be provided to supply 24 VDC wetting voltage to the SEL-2414 transformer monitor inputs.

5. Inputs shall be connected as follows:

IN101	Fan group 1 status
IN102	Fan group 2 status
IN301	Oil level warning (for customer use)
IN302	Oil level critical (for customer use)
IN303	Pressure relief (for customer use)
IN304	Sudden pressure (for customer use)
IN305	Cooling power (for customer use)
IN306	Nitrogen system OR conservator system (for customer use)
IN307	Loss of AC (for customer use)
IN308	Loss of DC (for customer use)
IN601	Loss of 24 VDC (for customer use)
IN602	Gas monitor failure (for customer use)
IN603	Combustible gas warning (for customer use)
IN604	Combustible gas critical (for customer use)

For transformers with an LTC, a SEL-2505 remote I/O module shall be provided in addition to the SEL-2414 transformer monitor. Connections to the SEL-2505 remote I/O module are shown on drawings FAC XR48X-X and FAC XR48X-Y and are detailed as follows. All connections noted as "for customer use" shall be wired out to terminal blocks.

1. Outputs shall be connected as follows:

OUT1	Supervisory raise LTC (for customer use)
OUT2	Supervisory lower LTC (for customer use)
OUT3	Spare (for customer use)
OUT4	Not used
OUT5	Not used
OUT6	Not used
OUT7	Not used
OUT8	Not used

2. The SolaHD catalog number SDP 06−24−100T 125 VDC to 24 VDC convertor provided with the SEL-2414 transformer monitor shall also be used to supply 24 VDC wetting voltage to the SEL-2505 remote I/O module inputs.

3. Inputs shall be connected as follows:

IN1	LTC Auto-manual switch (for customer use)
IN2	LTC power (for customer use)
IN3	LTC at limit (for customer use)
IN4	LTC loss of potential (for customer use)
IN5	LTC blocking relay (for customer use)
IN6	LTC trouble (for customer use)
IN7	LTC filter system (for customer use)
IN8	LTC out of step (for customer use)
IN1-IN8	Specific alarms will be provided with review drawings

Appendix C.2—Schweitzer SEL-2414 Temperature Monitor Settings and Control Connections

The manufacturer shall complete this worksheet utilizing design and test data and shall include it in the test report. This information will be used to program a SEL-2414 Transformer Monitor. The Transformer Monitor will control the activation of the Group 1 and Group 2 cooling stages. Failure of the Transformer Monitor will result in activation of both stages of cooling. A current transformer shall be placed on the center phase bushing of each loadable winding for thermal monitoring.

This worksheet shall be filled out in its entirety and shall be specific to each transformer ordered.

	Manufacturer ______________________		
	______________________		
	Serial Number ______________________		
	Primary Winding Nominal Voltage (Line-to-Line)		(1.00-1000.00 kV)
	Secondary Winding Nominal Voltage (Line-to-Line)		(0.20-1000.00 kV)
	Tertiary Winding Nominal Voltage (Line-to-Line)		(0.20-1000.00 kV)
	Primary Winding MVA Rating (ONAN/ONAF1/ONAF2)	/ /	(1.00-1000.00 MVA)
	Secondary Winding MVA Rating (ONAN/ONAF1/ONAF2)	/ /	(1.00-1000.00 MVA)
	Tertiary Winding MVA Rating (ONAN/ONAF1/ONAF2)	/ /	(1.00-1000.00 MVA)
	Primary Winding Hot-Spot Thermal Time Constant		(0.01-20.00 Hours)
	Secondary Winding Hot-Spot Thermal Time Constant		(0.01-20.00 Hours)
	ONAN		
	Top-Oil Rise over Ambient		(0.1–100.0°C)
	Primary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)
	Secondary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)
	Ratio of Load Losses to No-Load Losses		(0.1–100.0)
	Oil Thermal Time Constant		(0.10–20.00 hours)
	Oil Exponent		(0.1–5.0)
	Primary Winding Exponent		(0.1–5.0)
	Secondary Winding Exponent		(0.1–5.0)
	ONAF1		
	Top-Oil Rise over Ambient		(0.1–100.0°C)
	Primary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)
	Secondary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)

	Ratio of Load Losses to No-Load Losses		(0.1–100.0)
	Oil Thermal Time Constant		(0.10–20.00 hours)
	Oil Exponent		(0.1–5.0)
	Primary Winding Exponent		(0.1–5.0)
	Secondary Winding Exponent		(0.1–5.0)
	ONAF2		
	Top-Oil Rise over Ambient		(0.1–100.0°C)
	Primary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)
	Secondary Winding Hot-Spot Rise over Top Oil		(0.1–100.0°C)
	Ratio of Load Losses to No-Load Losses		(0.1–100.0)
	Oil Thermal Time Constant		(0.10–20.00 hours)
	Oil Exponent		(0.1–5.0)
	Primary Winding Exponent		(0.1–5.0)
	Secondary Winding Exponent		(0.1–5.0)
	Group 1 Control		
	Recommended Oil Temperature to start Group 1		(°C)
	Recommended Primary Winding Temperature to start Group 1		(°C)
	Recommended Secondary Winding Temperature to start Group 1		(°C)
	Group 2 Control		
	Recommended Oil Temperature to start Group 2		(°C)
	Recommended Primary Winding Temperature to start Group 2		(°C)
	Recommended Secondary Winding Temperature to start Group 2		(°C)
	High Temperature (Alarm)		
	Recommended Oil Temperature to Initiate Alarm		(°C)
	Recommended Primary Winding Temperature to initiate Alarm		(°C)
	Recommended Secondary Winding Temperature to initiate Alarm		(°C)
	Critical Temperature (Trip)		
	Recommended Oil Temperature to Initiate Trip		(°C)
	Recommended Primary Winding Temperature to initiate Trip		(°C)
	Recommended Secondary Winding Temperature to initiate Trip		(°C)

Appendix D—Advanced Power Technologies TTC-1000-333 Temperature Monitor

The temperature monitor shall be an Advanced Power Technologies model TTC-1000-333 with probe TTC-PROBE-12-zzz (zzz being the probe lead length to be determined by the manufacturer). Monitor shall be housed in a NEMA 4X enclosure or located in a transformer control cabinet, with three (3) analog outputs, Aux CT, 3-Temperature Probes, and six (6) control outputs. The six (6) Form C outputs should be programmed as follows:

1. Hot-spot winding temperature, 75 Degree C (Stage 1 fans), Fail safe mode
2. Hot-spot winding temperature, 90 Degree C (Stage 2 fans), Fail safe mode
3. Hot-spot winding temperature, 115 Degree C (Alarm), Fail safe mode
4. Top oil temperature, 110 Degree C (Alarm), Fail safe mode

The TTC-1000 monitor can be programmed to automatically swap between lead and lag fan banks. The manufacturer shall program the monitor to utilize this feature, provided both fan banks have equal cooling capabilities.

The monitor shall be mounted in or near the transformer termination cabinet.

Appendix E—Transformer Test Summary Sheet

A certified test report summary sheet (below) shall be provided with the full certified test report.

Transformer Test Report

Date

Equipment # :

Serial # :

PacifiCorp/MECW.O. #:

Rating		Class	H - Winding	X - Winding	Y - Winding
Type			V	V	V
Phase			kVA	kVA	kVA
Hertz			kVA	kVA	kVA
Temp. Rise			kVA	kVA	kVA
Insul. Liquid					

ADDITIONAL TAP VOLTAGES	
H Winding	
X Winding	

CONNECTIONS FOR OPERATION						
Transformers in Bank	Transformer From	Phase	Connected	Transformer To	Phase	Connected

PERFORMANCE BASED ON A LOADING OF				
H Winding		kV		kVA
X Winding		kV		kVA
Y Winding		kV		kVA

DIELECTRIC TESTS			
Applied Voltage	H Winding		kV
	X Winding		kV
	Y Winding		kV
Induced Voltage	Line to Line		kV
	Line to Ground		kV

INSULATION LEVELS		
ITEMS	BIL	Low Frequency Voltage
H line		
H neutral		
X line		
X neutral		
Y line		
Y neutral		

PERFORMANCE DATA, Based on ____ °C Reference Temperature

	Losses and Exciting Current				Regulation at Base kVA	
Excitation	% Exciting Curr	No Load	Load Loss	Total Loss	Power factor	% Regulation
100%					1.0	
110%					0.8	

AUXILIARY LOSSES		
Transformer kVA	Class	Watts Aux. Loss
		W
		W
		W
Average Sound Level		

PERCENT IMPEDANCE VOLTS					
Positive sequence			Zero sequence		
$\% IZ_1$	Between Windings	At kVA	$\%IZ_0$	Between Windings	At kVA
	H-X			H-X	
	H-Y			H-Y	
	X-Y			X-Y	

EFFICIENCIES					
Load		Full Load	3/4 Load	1/2 Load	1/4 Load
%					

WINDING DC RESISTANCES (OHMS PER PHASE)	
H WINDING	
X WINDING	
Y WINDING	

MECHANICAL DATA (Not For Construction Purposes)

Outline Drawing No.

Core Construction

Dimensions (Approximate) Ft (m)

Height	(A)	
Width	(B)	
Depth	(C)	
Height Over Cover	(D)	
Untanking (Plus Slings)	(E)	

Masses (Approximate) pounds (kg)

Core and Coils		
Tank and Fittings		
Liquid	Gallons (m^3)	
Total Mass		
Shipping Mass lb (kg)		
Shipped lb (kg)		

Transformer conditions

Elevation		
Temperature ratings	Low	High
Seismic		

Appendix F—Control Cabinet Ground Bus

Purpose

To provide a connection point that provides a positive low resistance path to the station ground grid in the control cabinet of a transformer or circuit breaker for the purpose of grounding current transformer secondaries and other ground connections.

Method

The ground bus shall be positioned, physically, as close as possible to the current transformer terminal blocks. In cabinets with no current transformer terminal blocks, the ground bus shall be mounted in a location that eases the connection from incoming customer installed control cable shields.

The ground bus shall be manufactured from copper bar stock with the following dimensions, ¼″ × 2″ × ≥ 8″.

The ground bus shall have eight (8) connection points, 10-32 tapped holes and supplied with brass screws.

The ground bus shall be mounted with ½″ Everdure bolts as shown below. The length of the bolt shall be of sufficient length to allow for the external grounding connection during installation. The external portion of the mounting bolts shall be painted. A barrier of RTV silicone shall be provided around the bolt, between the cabinet wall and the flat washer to prevent moisture from entering the cabinet. The connection from the ground grid shall be made through one of the Everdure mounting bolts.

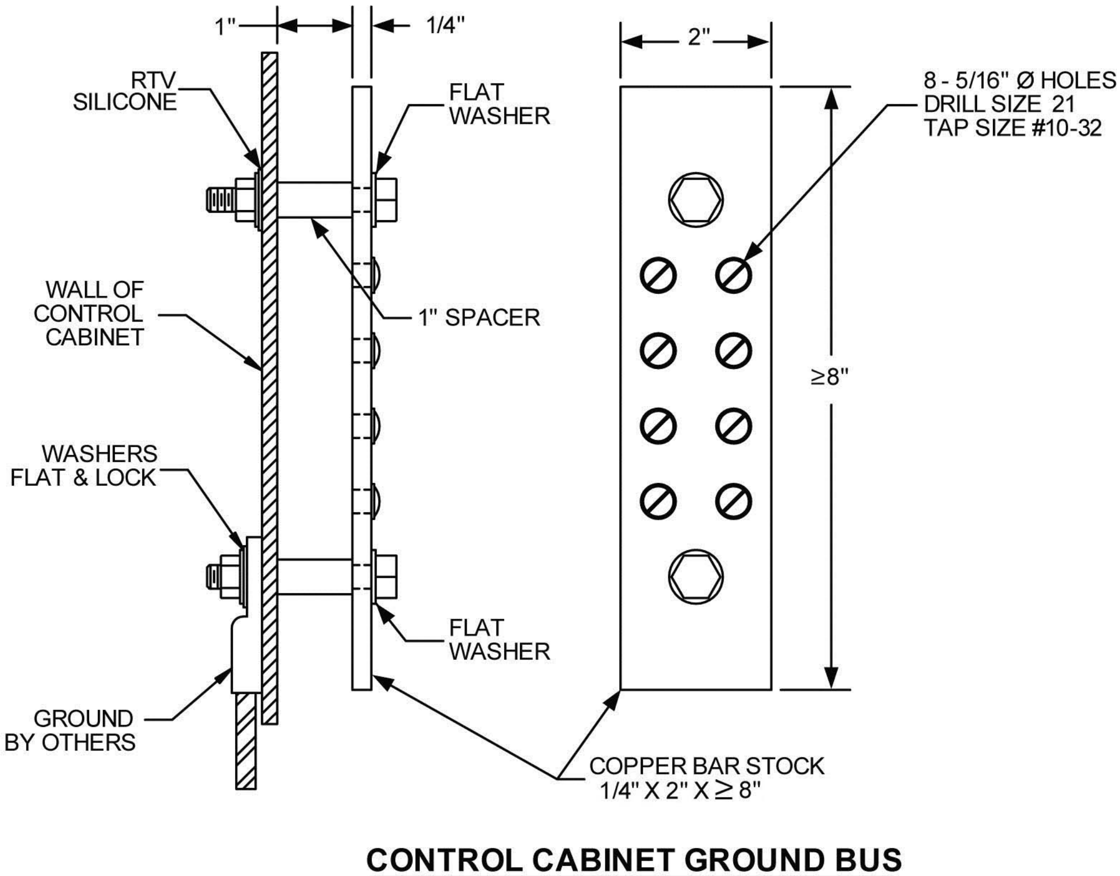

Figure F1—Typical Ground Bus

EBU PX-S02A Substation Equipment—Collector Substation Main Power Transformer—Specific Requirements

1. Requirements

The transformer information and specifications in this section are for the equipment referenced in Material Specification EBU PX-S02, and shall be used in conjunction with the requirements of EBU PX-S02.

In this section, a box checked (✔) next to an item indicates that the item is required or applicable; a box not checked indicates that the item does not apply or is not acceptable.

The meanings of the following symbols used by the company are defined as:

✔	Denotes a normal requirement.
*	Denotes a requirement which will be specified at the time of order.
**	Denotes a requirement to be specified by the supplier.
•	Denotes a requirement which may be specified at the time of order; the supplier shall provide an adder.

2. Renewable Energy Type

The renewable energy facility type shall be as checked (✔) below:

Solar (photovoltaic)

Wind

3. General Requirements

Work order number: ____________________

REQ number: ____________________ PO number: ____________________

Equipment number(s): ____________________

Location: ____________________

4. Equipment Identification and Order Requirements

Delivery location: ____________________

Delivery date: ____________________ Notice of shipment: ____________________

Supplier representative: ____________________ Field engineer: ____________________

Installation: ____________________

4.1. Supplier's Representative

If checked (✔) , the supplier shall furnish a mutually agreed upon representative to be present at the delivery site as specified in Section 9.8.2 of EBU PX-S02.

4.2. Field Engineer

If checked (✔) , the supplier's field engineer(s) shall furnish supervision for field installation as specified in Section 10.4 of EBU PX-S02.

5. Service Conditions

5.1. Ambient Temperature

If checked (✔) below, the transformer and all associated components shall be designed for special low-temperature and/or high-temperature operation without de-rating.

-50° C daily minimum

-40° C daily minimum

-30° C daily minimum

+45° C daily maximum

+50° C daily maximum

____

5.2. Elevation

The transformer shall be designed for special high-elevation operation without de-rating, up to the specified elevation, if checked (✔) below.

_____________feet

5.3. Contaminated Environment Protection

If checked (✔) the transformer shall be suitable for operation in contaminated environments.

5.4. Unusual Service Conditions

List any unusual service conditions, and refer to IEEE C57.12.00.

Wind generation outlet collector substation main power transformers

Solar generation outlet collector substation main power transformers

____

The transformer serves as the step-up transformer for a wind or solar generator system. The generators have full or partial converter output and are connected to a 34.5 kV grounded wye collection system. The transformer will also act in stepdown mode when supplying station power to the generator system. The transformer will be subject to low power factor (high VAR) flow when the generators are not producing power.

6. Service Class

6.1. Phase Designation

The phase of the transformer shall be as checked (✔) below.

Single-phase

Three-phase

6.2. Cooling Class

The cooling class shall be as checked (✔) below.

Self-cooled rating and two forced-cooled ratings

ONAN / ONAF / ONAF

____

7. Winding Designation

The IEEE winding designation per IEEE C57.12.00 shall be as follows:

H-winding____

X-winding____

Y-winding____

7.1. Voltage, Basic Insulation Level, and Surge Arrester Ratings

The transformer shall be furnished with the voltage ratings, BIL ratings, de-energized taps, and surge arrester ratings for each terminal designation, specified in the rows and columns checked (✔) below in Table 1, *Transformer Voltage and Surge Arrester Ratings*. If applicable, specific de-energized tap ratings shall be as specified.

If series-parallel reconnection is specified for a three-phase transformer for H-winding, X-winding, or both windings, the two associated voltage ratings for each winding, as applicable, are specified in Table 4, *De-Energized Tap Voltage Ratings (kV, L-L)*. If wye-delta reconnection is specified for a three-phase transformer for H-winding, X-winding, or both windings, the voltage rating specified in Table 1 for each winding, as applicable, is for the wye connection.

Table 1—Transformer Voltage and Surge Arrester Ratings

(✔) Desired Rating	Nominal System Voltage (kV)	Center Tap Voltage Rating (kV)	De-energized Taps Table 4 (yes/no)	Winding BIL (kV crest)	Arrester Duty Cycle Rating (kV)		Maximum Continuous Operating Voltage (MCOV) (kV)		
					Grounded System	Ungrounded System	Grounded System	Ungrounded System	
$H_{1,2,3}$ or H_1 Terminal(s)					Station Class				
	525			1425	n/a	n/a	n/a	n/a	†§
	345			1050	264	n/a	212	n/a	†
	345			1050	258	n/a	209	n/a	‡
	230			900	180	n/a	144	n/a	
	230			825	180	n/a	144	n/a	§
	230			750	180	n/a	144	n/a	†
	220			750	180	n/a	144	n/a	§
	161			650	132	n/a	106	n/a	†
	161			650	144	n/a	115	n/a	‡
	161			650	120	n/a	98	n/a	‡
	138			550	120	n/a	98	n/a	†§
	125			450	96	120	76	98	§
	120			450	96	120	76	98	§
	115			450	96	120	76	98	†§
	69			350	60	72	48	57	†‡§
	63			350	60	72	48	57	§
	60			350	60	72	48	57	§
	46			250	39	48	31.5	39	†
H_0, H_0X_0, H_2, or H_2X_2 Terminal					Station Class				
	n/a	n/a	n/a		n/a		n/a		
$X_{1,2,3}$ or X_1 Terminal(s)					Station Class				
	34.5			200	30	36	24.4	29	†‡§
X_0 or X_2 Terminal					Station Class				
	n/a	n/a	n/a		n/a				
$Y_{1,2,3}$ or $Y_{1,2}$ Terminal(s)					Station Class				
	34.5	n/a	n/a	250	n/a	36	n/a	29	§
	25.0	n/a	n/a	150	n/a	27	n/a	22	§
	13.8	n/a	n/a	110	n/a	15	n/a	12.7	†
	13.8	n/a	n/a	110	n/a	18	n/a	15.3	‡§
	13.2	n/a	n/a	110	n/a	15	n/a	12.7	†
	13.2	n/a	n/a	110	n/a	18	n/a	15.3	‡
	12.5	n/a	n/a	110	n/a	15	n/a	12.7	†§
		n/a	n/a						
	Y terminals buried								†‡
	Wall-mounted LV bushings								‡
	Bus duct LV bushings								

Note: All LV neutral bushings are to be roof-mounted.
†PacifiCorp
‡MidAmerican Energy
§NV Energy

7.2. Arrester Provisions

Transformer arresters shall, or shall not, be provided as follows:

Provide arresters with transformer

Do not provide arresters with transformer

7.3. Capacity Ratings

The average winding temperature rise shall be 65°C unless checked (✔) below with the capacity rating as specified in Table 2, Transformer Capacity Ratings.

45°C average winding temperature rise, 55°C hot-spot winding temperature rise, and 45°C top-oil temperature rise

55°C average winding temperature rise, 65°C hot-spot winding temperature rise, and 55°C top-oil temperature rise

The transformer shall be capable of operating at a continuous 55°C winding rise at 112% of the ratings in Table 2

Table 2—Transformer Capacity Ratings

Terminals	Self-Cooled (MVA)	First Stage Forced-Cooled (MVA)	Maximum Forced-Cooled (MVA)	(✔)
H & X				
Y	See Note 2.			
Y				

Note 1. If designated by "**" in the table, the self-cooled and first-stage forced-cooled capacity ratings shall be selected by the supplier and need not be the standard values normally associated with the specified maximum forced-cooled capacity rating(s).

Note 2. If this row is checked, the Y-terminal capacity ratings shall be 35% of the ratings of the H and X terminals.

7.4. Impedance(s)

Transformer impedance(s) shall be as checked (✔) below.

Selected by the supplier

As specified below in Table 3

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Table 3—Transformer Impedance(s)

Winding to Winding	V_{LL}	Percent Impedance	Base kVA
1. H to X	________to________	____________	_________
2. H to Y	________to________	____________	_________
3. X to Y	________to________	____________	_________

____

____

7.5. Bank Operation and Parallel Operation

7.5.1. Bank Operation

If the transformer is single-phase, and if checked (✔), the transformer shall be suitable for operation in a three-phase bank with similar transformers as specified. The similar transformers are identified below, and the associated impedance test data and nameplate drawings are attached. __

____

____

7.6. Audible Sound Level

The transformer shall be designed to comply with the decibel rating as checked (✔) below.

NEMA TR1 (____/____/____) __

10 dB below NEMA TR1 (____/____/____) __

75 dB (____/____/____) __

Other (____/____/____) __

8. De-Energized Tap Changers

8.1. DETC Tap Voltages

If checked (✔), the transformer shall have a de-energized tap changer. __

The de-energized tap rating shall be as specified by the row check (✔) in Table 4.

Table 4—De-Energized Tap Voltage Ratings (kV, L-L)

(✔) Desired Rating	Nominal System Voltage (kV, L-L)	Center Tap Voltage Rating (kV, L-L)	De-Energized Tap Voltage Ratings (kV, L-L)	
	525	525	550 / 537.5 / 525 / 512.5 / 500	†
	345	345	362.25 / 353.625 / 345 / 336.375 / 327.75	†‡§
	230	230	241.5 / 235.75 / 230 / 224.25 / 218.5	†
__	220	220	231.0 / 225.5 / 220 / 214.5 / 209	§
	161	161	169 / 165 / 161 / 157 / 153	†
__	161	161	173.1 / 169.1 / 165 / 161/157.0	‡
	138	138	145 / 141.5 / 138 / 134.5 / 131	†
	125	125	131.25 / 128.1 / 125 / 121.9 / 118.8	§
__	120	120	126 / 123 / 120 / 117 / 114	§
__	115	116	122 / 119 / 116 / 113 / 110	†
__	69	67	70.6 / 68.8 / 67 / 65.2 / 63.4	†
	69	69	74.2 / 72.5 / 70.7 / 69 / 67.3	‡
__	63	62.5	66.5 / 64 / 62.5 / 61 / 59.5	§
__	60	60	63 / 61.5 / 60 / 58.5 / 57	§
__	46	46	48.3 / 47.2 / 46 / 44.9 / 43.7	†
__	34.5	34.5	36.2 / 35.4 / 34.5 / 33.6 / 32.8	†
__				

†PacifiCorp
‡MidAmerican Energy
§NV Energy

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9. Load Tap Changer

If checked (✔), the following LTC equipment shall be furnished.

Type

Wall-mounted]

Cover-mounted]

Manufacturer specified]

Location

High-side]

Low-side]

9.1. Tap Range and Capacity

The LTC shall regulate the terminal voltage +10%/-10%.

The LTC shall regulate the terminal voltage +15%/-5%.

The LTC shall regulate the terminal voltage +_____% / -_____%.

The LTC shall have full capacity on taps below the neutral

9.2. Remote Indication

If checked (✔), provisions for LTC remote indication shall be furnished in accordance with the requirements of Section 6.24.4 of EBU PX-S02.

9.3. Remote Control

If checked (✔), provisions for LTC remote control shall be furnished in accordance with the requirements of Section 6.24.5 of EBU PX-S02.

9.4. Automatic Control

If checked (✔), automatic control using a Beckwith M2001C shall be supplied.

9.5. LTC Backup Control Relay

If checked (✔), a Beckwith LTC backup control relay model M-0329A shall be furnished.

9.6. LTC Control Wiring Schematic

The supplier shall furnish the LTC control wiring per the schematic as marked (**) below:

PC510ABF (PacifiCorp)]

SSC-R481-1 (MidAmerican Energy)]

____________________Manufacturer specified (NV Energy)]

10. Auxiliary Equipment

10.1. Bushings

The bushing BIL requirements shall be as specified in Table 5, Bushing BIL Requirements.

Table 5—Bushing BIL Requirements

(✔) Desired Rating	Nominal System Voltage(kV)	Bushing BIL (kV crest)	Min. Live-to-Live[1] Clearances at 3300′	Min. Live-to-Live[1] Clearances at 7000′	
$H_{1, 2, 3}$ or H_1 Terminal(s)					
	525	1800[2]	13′-10″	15′-4″	†
	525	1675	13′-10″	15′-4″	§
	345	1300	9′-11″	11′-1″	†§
	345	1175	9′-11″	11′-1″	‡
	230	900	7′-5″	8′-3″	†§
	161	750	6′-0″	6′-8″	†‡
—	161	650	6′-0″	6′-8″	‡
	138	650	5′-3″	5′-10″	†§
	115	550	4′-5″	4′-11″	†§
	69	350	2′-7″	2′-11″	†‡§
	46	250	2′-6″	2′-6″	†
H_0, H_0X_0 Terminal(s)					
	n/a				
H_2, H_2X_2 Terminal(s)					
—	n/a				
$X_{1, 2, 3}$ or X_1 Terminal(s)					
	34.5	200	2′-6″	2′-6″	§†‡
X_0 or X_2 Terminal					
	n/a				
$Y_{1, 2, 3}$ or Y_1 Terminal(s) Since the tertiary is always buried, only two small bushings are brought out for testing and grounding one corner of the buried delta. These bushings are grounded and covered by a metal box.					

†PacifiCorp
‡MidAmerican Energy
§NV Energy

[1]Minimum live-to-live clearance adapted from IEEE C37.32 Table 5. Minimum clearances for PacifiCorp do not go below 2′-6″ (30″) due to company avian protection requirements.

[2]Bushing BIL at 525 kV shall be 1800 kV at elevations of 3,300 feet. Section 5.2 of this document does not apply for this size bushing. The supplier shall provide the same 525 kV bushing rated for 1800 kV BIL at 3,300 feet regardless of the elevation at the intended transformer site.

10.2. Current Transformers

The supplier shall furnish five-tap multi-ratio bushing current transformers (BCT) as specified below in Table 6, Bushing Current Transformers.

Table 6—Bushing Current Transformers

Terminals	BCT Position	Full-Winding Amperes	Relaying Accuracy
$H_{1,2,3}$ or H_1	Top		
$H_{1,2,3}$ or H_1	Middle		
$H_{1,2,3}$ or H_1	Middle		
$H_{1,2,3}$ or H_1	Middle		
$H_{1,2,3}$ or H_1	Bottom		
H_0	n/a		
$X_{1,2,3}$ or X_1	Top		
$X_{1,2,3}$ or X_1	Middle		
$X_{1,2,3}$ or X_1	Middle		
$X_{1,2,3}$ or X_1	Bottom		
X_0 or X_2	n/a		

The supplier shall also furnish five-tap multi-ratio current transformer(s) inside the Y-winding delta, if applicable, as specified below in Table 7.

Table 7—Y-Winding Internal Current Transformers

Number	Full-Winding Amperes	Relaying Accuracy

10.3. Insulating Liquid

Insulating liquid shall be:

Mineral oil

Other ________________________

10.4. Liquid Preservation System

The type of oil preservation system shall be as checked (✔) below:

Nitrogen gas pressure system

Conservator system

Nitrogen gas pressure or conservator system (supplier's choice)

10.5. Cooling Fans

Cooling fan(s) shall be designed for the voltage and phase type checked (✔) below:

240 V single-phase

208 / 240 V single-phase

208 V three-phase

240 V three-phase

480 V three-phase

Other: ________________________

10.6. Auxiliary Power

10.6.1. AC Voltage

The AC power supply shall be as checked (✔) below:

120 / 240 VAC, three-wire

208 VAC, single-phase

120 / 208 VAC, three-phase

_________ VAC, single-phase

_________ VAC, three-phase

10.6.2. DC Voltage

The DC power supply will be as checked (✔) below:

48 VDC

125 VDC

10.7. Temperature Monitor

If checked (✔) below, the temperature monitor shall be:

Qualitrol IED-509 (PacifiCorp)
Schweitzer SEL-2414 (MidAmerican Energy)
Advanced Power Technologies TTC-1000 (NV Energy)

10.8. Dissolved Gas Monitor

If checked (✔) below, the transformer shall be furnished with an on-line DGA monitor with the features specified in Section 6.18.4 of EBU PX-S02. Additionally, transformers shall have the following features if checked (✔) :

Monitors for one main tank and at least eight (8) gases
Monitors for one main tank and at least four (4) gases
Monitors for up to three separate single phase tanks and at least eight (8) gases
Monitors for one main tank and at least two (2) gases
Monitors for one main tank, one selector and diverter tank for a tap changer, and at least eight (8) gases
Other features: ____

10.9. Alarm Monitor

If checked (✔), the transformer shall be furnished with an alarm monitor per Section 6.18.5 of EBU PX-S02.

10.10. Fall Arrest System

If checked (✔) below, the transformer shall be furnished with the fall arrest equipment specified:

Capital Safety DBI SALA mast (MidAmerican Energy)
Pelsue mast (PacifiCorp)
Safety railing (NV Energy/PacifiCorp)
Tuff-Built tri-post (NV Energy)

10.11. Control Compartment

If checked (✔), all wires shall be terminated with insulated, seamless, ring-tongue compression terminals per Section 6.25 of EBU PX-S02.

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11. Core Temperature

11.1. Core Hotspot Temperature

The core hotspot temperature shall adhere to the measurements as checked (✔) below.

Core hotspot shall not exceed 130°C with a 30°C ambient temperature at 125% of full load and a voltage excitation of 100%

Core hotspot shall not exceed 130°C with a 40°C ambient temperature at 125% of full load and a voltage excitation of 100%

Other ____

12. Tank

12.1. Exposed Fasteners and Hardware

If checked (✔), the transformer tank shall be furnished with exposed stainless steel fasteners and hardware.

12.2. Extra Oil Capacity

If checked (✔), the transformer tank shall be furnished with extra oil capacity per Section 6.19 of EBU PX-S02.

12.3. Location of Accessories

All accessories shall be located per IEEE Standard C57.12.10 unless otherwise requested as checked (✔) below:

	S1	S2	S3	S4
Liquid level indicator				
Liquid temperature indicator				
Winding temperature indicator				
Nameplate				
Auxiliary cooling control (control cabinet)				
LTC equipment (if wall-mounted)				
Conservator (if specified)				

The following equipment shall share a common centerline with that of the transformer base if checked (✔) below:

HV bushings
LV bushings
LTC equipment (if specified)
Auxiliary cooling control (control cabinet)
Conservator (if specified)

12.4. Contents for Shipment

The transformer tank shall be filled for shipment with contents as checked (✔) below:

Oil
Dry air
Supplier's choice: ____________________

13. Loss Cost Multipliers

The loss cost multipliers are as follows:

		Suppliers' guaranteed losses
No-load loss cost multiplier	(A) = $ ____.___ / kilowatt	____________ kW
Load loss cost multiplier	(B) = $ ____.___ / kilowatt	____________ kW

14. Geomagnetic Disturbance Withstand Calculations

If checked (✔), the supplier shall provide geomagnetic disturbance withstand calculations GIC (geomagnetic-induced current)

15. Receiving, Installation and Energization Requirements

The supplier shall be responsible for delivering the unit to the pad, assembling, oil filling, testing, and providing certification that the transformer can be energized as checked (✔) below:

According to the company's Substation Operations Procedure SP-TRF-INST
According to the supplier's standard methods
Delivery to pad only (field assembly work not required)
Other____

16. Site-Specific Requirements

List any site-specific requirements below:

____

____

____

17. Issuing Department

The engineering publications department of PacifiCorp published this material specification. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be submitted by email to: TDManufacturerSubmittal@pacificorp.com.

This material specification shall be used and duplicated only in support of company projects.

SPECIFICATION

TWO-WINDING DISTRIBUTION TRANSFORMER

INVERTER STEP-UP LIQUID-IMMERSED

(PAD MOUNTED, COMPARTMENTAL TYPE)

ZS-102

Version number: Version

Approval date: Date Approved

Authoring department: Generation Engineering Electrical & Relay Support

Approved location:

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Revision Log		
1	04/25/2014	Original specification file “ZS-102” created.
2	04/04/2016	Revised for use with PV and Wind Farms. – J. Bohrn
3		
4		

Scope

This material specification states the requirements for two winding, three phase, liquid-immersed, step-up distribution outdoor transformers (pad-mounted, compartmental type) for use on the output of low voltage utility grade inverters.

References

The following publications shall be used in conjunction with this material specification, and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

Industry Publications

Referenced industry publications are:

IEEE P60076-16, Wind Turbine Generator Transformer Standard

IEEE C37.74, Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV

IEEE C57.12.00, Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.10, Standard Requirements for Liquid-Immersed Power Transformers

IEEE C57.12.28, Standard for Padmounted Equipment Enclosure Integrity

IEEE C57.12.29, Standard for Padmounted Equipment Enclosure Integrity for Coastal Environments

IEEE C57.12.34, Standard Requirements for Padmounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below

IEEE C57.12.35, Standard for Barcoding for Distribution Transformers and Step-Voltage Regulators

IEEE C57.12.70, Standard Terminal Markings and Connections for Distribution and Power Transformers

IEEE 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V DOE 10 CFR Part 431, Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation; Final Rule

Company Publications

Applicable MidAmerican Energy / PacifiCorp documents may include, but shall not necessarily be limited to, those listed below:

Material Specification 510−1 / ZS 061, Electrical Equipment—Insulating Oil

Material Specification 210−1 / ZS 065, Wind, Ice, and Seismic Withstand

Material Specification 210−2 / ZS 066, Contaminated-Environment Protection

PacifiCorp Procedure SP−TRF−INST, Transformer Receiving, Installation and Energizing

PacifiCorp Design Review Data Sheets (revision 4, dated December 23, 2009)
PacifiCorp Engineering Form 006F, Meter and Relay Equipment Memorandum
PacifiCorp Specification ZG 532, *Flat Pad — Three-Phase Transformer*
Company Specification ZG 113/12–4000, *Signage, Padmounted Electrical Equipment*

General

This specification includes approximate metric conversions of American units and gauges that are for guidance only; the American standard shall take precedence. Transformers shall be designed to withstand geomagnetic disturbances per NERC requirements.

Except as required otherwise by this Material Specification the transformer and individual components shall be furnished in accordance with the latest applicable industry codes and standards.

Company: Refers to PacifiCorp, Pacific Power, Rocky Mountain Power and MidAmerican Energy Company.

Ratings

Table 1 through 3 provide the standard voltage and kVA ratings

Table 1
Transformer Ratings and Electrical Characteristics

Transformer		
	Basic Impulse Insulation Level – BIL (kV)	
Voltage Ratings (volts)	Distribution Transformers	Power Transformers
Low Voltage Ratings (V)	30	45
208Y/120		
480Y/277		
690Y/398		
___________ Other Voltage		
High Voltage Ratings (V)		
4160GrdY/2400	60	75
8320GrdY/4800	75	95
12470GrdY/7200	95	110
13200GrdY/7620	95	110
13800GrdY/7970	95	110
22860GrdY/13200	125	150
23900GrdY/13800	125	150
24940GrdY/14400	125	150
34500GrdY/19920	150	200
43800GrdY/25300	-	250

** Note – The above table is not meant to list every voltage available

1.1 The secondary voltage shall be one of the above from Table 1.

- For a Secondary Unit Substation Transformer (Secondary voltage below 1000 V):
- The secondary voltage and the basic impulse insulation level (BIL) shall be in accordance with the secondary voltages listed in Table 1 and shall be specified on the data sheet.

1.2 The transformer shall either be furnished with a grounded Wye primary winding (HV winding) or a separate grounding transformer (Grounded Wye primary / Delta secondary) shall be provided for connection on the station side of the breaker.

1.3 The transformer shall be furnished with four (4) 2.5 percent taps, two (2) above and two (2) below, full capacity high-voltage taps; with externally operable five (5) position tap changer for de-energized use and with position indicator and padlock hasp. The tap-changer shall be clearly labeled to reflect that the transformer must be de-energized before operating the tap-changer as required in Section 4.3 of ANSI C57.12.34.

1.4 The transformer, filled with fluid, shall have a 65 ^{o}C average winding temperature rise rating. The above winding temperature rise shall not exceed 65 ^{o}C when loaded at base kVA rating

1.5 The percent impedance voltage, as measured on the rated voltage connection, shall be per ANSI C57.12.10.

1.6 The transformer shall be cooled by the natural circulation of air over the tank surface and any corrugate or radiators if required, allowing only the base kVA rating shall be provided with Class ONAN.

Construction

1.7 The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the windings will be energized to heat the coils and drive out moisture, and the transformer will be filled with preheated filtered degassed insulating fluid. The core shall be manufactured from burr-free, grain-oriented silicon steel and shall be precisely stacked to eliminate gaps in the corner joints. The coil shall be insulated with B-stage, epoxy coated, diamond pattern, insulating paper, which shall be thermally cured under pressure to ensure proper bonding of conductor and paper.

1.8 Panel type radiators or corrugate type cooling are welded directly to the tank when additional cooling is required.

1.9 In addition to the requirements of IEEE C57.12.29, transformer component materials shall be as described below, or shall be company approved equivalents.

- Transformer tank, enclosure and control panel components shall be 304-L stainless steel.
- All welds shall be continuous. Spot or skip welds are not acceptable.
- Ground pads shall be 300-series stainless steel, copper, or bronze.

- All bolts, washers, hinges and door lifting provisions shall be 300-series stainless steel or silicon bronze. Compatible metals shall be used to prevent galling.

1.10 The tank shall be welded using precision cut, cold-rolled steel plate and equipped with extra-heavy duty, welded-in-place lifting lugs and jacking pads. The tank base shall be designed to allow skidding or rolling in any direction.

1.11 The transformer shall be of sealed tank construction of sufficient strength to withstand a pressure of 7 psig without permanent distortion, and 15 psig without rupturing.

1.12 The tank shall include a pressure relief device as a means to relieve pressure in excess of pressure resulting from normal operation. The venting and sealing characteristics shall be as follows:

Cracking Pressure: 10 psig +/-2 psig
Resealing Pressure: 6-psig minimum
Zero leakage from reseal pressure to -8 psig
Flow at 15 psig: 35 SCFM minimum

1.13 The exterior color shall be Munsell Green.

1.14 The tank shall be cleaned with an alkaline cleaning agent to remove grease and oil. An iron phosphate coating shall then be chemically bonded to the metal to assure coating adhesion and retard corrosion. The tank shall be primed with an electrodeposited powder epoxy to provide a barrier against moisture, salt, and corrosives. The tank shall then be coated with an electrostatically-applied, oven-cured polyester powder coat to enhance abrasion and impact resistance. The top-coat shall be a liquid polyurethane coating to seal and add ultraviolet protection. The tank coating shall meet all requirements in IEEE C57.12.28 – latest revision.

1.15 The tank shall be complete with an anodized aluminum laser engraved nameplate. This nameplate shall meet IEEE C57.12.25.

1.16 The transformer nameplate shall contain a company assigned ID (Equipment Number), Project Number, and Date of Mfr. It shall also contain all applicable weights, volumes, voltages, impedances, cautions, warnings, winding configurations, cooling information, and anything else that may be helpful when performing maintenance and troubleshooting.

1.17 A duplicate stainless steel nameplate shall be affixed to the exterior of the transformer. The duplicate nameplate shall remain intact and legible for the life of the equipment.

1.18 The transformer’s warranty duration or expiration date shall be provided on the transformer nameplate or on a separate nameplate or signage permanently affixed to the interior termination compartment for the transformer.

1.19 The overload sensing fuse type for each high voltage rating specified shall be listed on the nameplate.

1.20 Bushings shall be replaceable externally or access shall be provided through a hand-hole. To facilitate field replacement bushings shall be externally secured to the transformer tank.

1.21 Bushings shall be marked in accordance with IEEE C57.12.00

1.22 High Voltage Bushings and Terminals

- High voltage terminals shall utilize 200A loadbreak bushings, bushing wells, and bushing inserts complying with IEEE 386. They shall be radial fed and in compliance with IEEE C57.12.18. The high voltage bushings shall be mounted in Segment 2, Segment 3, or Segment 4 of the transformer.

1.23 Low Voltage Bushings and Terminals

- Low voltage line and neutral terminals shall be a staggered arrangement as specified by Figure 4(a) of IEEE C57.12.34. Terminal supports and the neutral bushing grounding strap shall not interfere with the use of terminal spade positions. Bracing shall be provided on secondary with eight or more hole positions.

1.24 The low voltage line and neutral terminals shall be 10 hole NEMA spade terminals.

1.25 Overcurrent Protection and Switching

- The high-voltage overcurrent protection scheme provided with the transformer shall be a loadbreak Bay-O-Net assembly with a flapper valve to minimize oil spillage. Overcurrent protection shall be provided by a Bay-O-Net expulsion fuse mounted in series with partial range under-oil ELSP current-limiting fuses with an interrupting rating of 30,000 A.

Finish Performance Requirements

1.26 The tank coating shall meet all requirements in ANSI C57.12.28 including:

- Salt Spray
- Crosshatch adhesion
- Humidity
- Impact
- Oil resistance
- Ultraviolet accelerated weathering
- Abrasion resistance – taber abraser

Production Testing

1.27 All units shall have routine tests performed as specified in IEEE C57.12.90 and IEEE C57.150 (core ground test):

1.28 In addition, all units shall be tested for the following:

- No-Load (85 °C or 20 °C) losses at rated current, 110% rated voltage
- Total (85 °C) losses at rated current
- Percent Impedance (85 °C) at rated current
- Excitation current (110% voltage) test
- Winding resistance measurement tests
- Ratio tests using all tap settings
- Polarity and phase relation tests
- Induced potential tests
- Full wave and reduced wave impulse test

1.29 Minimally, transformers shall conform to efficiency levels for liquid immersed distribution transformers, as specified in Table I.1 of the Department of Energy ruling. "10 CFR Part 431 Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule; October 12, 2007." Manufacturer shall comply with the intent of all regulations set forth in noted ruling. This efficiency standard does not apply to step-up transformers.

1.30 In addition, the manufacturer shall provide certification upon request for all design and other tests listed in C57.12.00, including verification that the design has passed short circuit criteria per ANSI C57.12.00 and C57.12.90.

1.31 The manufacturer shall furnish specifications for coordinated current limiting fuses and isolation links for each transformer design.

1.32 The manufacturer shall furnish copies of routine tests in conformance with IEEE C57.12.25 representative designs proposed to be supplied to the company. Copies of routine production tests for transformers purchased by the company shall be made available upon request.

1.33 The manufacturer shall furnish detailed drawings clearly depicting the compatibility between the transformer, mounting hardware, and specified equipment bases.

1.34 The manufacturer shall furnish certified test reports showing transformer designs compliant with this Material Specification are compliant with IEEE C57.12.28 and IEEE C57.12.29.

1.35 The manufacturer shall furnish drawings showing physical dimensions of assembled transformers and all user accessible components, markings and labels.

1.36 The manufacturer shall furnish instruction manuals that cover receiving, handling, installation, operation and maintenance of the transformers.

1.37 The manufacturer shall furnish complete lists of renewal parts for the transformers, including identification of each part by name and part number. Parts Lists and drawings shall relate specifically to the equipment covered by this specification.

1.38 The manufacturer shall furnish an exceptions report itemizing all exceptions or nonconformance with this Material Specification. Bids submitted without exception shall indicate “No Exceptions” on the exceptions report.

Accessories

The following standard accessories and options shall be provided:

- De-energized Tap-Changer
- 1.0” Upper Fill Plug with Filter Press Connection
- 1.0” Drain/Sampling Valve
- Cover-Mounted Automatic Pressure Relief Device
- Welded Cover with Bolted Manhole
- Lifting Lugs (4)
- Liquid Level Gauge
- Dial Type Thermometer
- Pressure/Vacuum Gauge
- SS Ground Pads (4)

Optional Accessories

The following optional accessories and options shall be provided if specified:

[ ] Low Voltage 6-Hole Spade
[ ] Low Voltage 12-Hole Spade
[ ] Copper Low Voltage Bushings (standard with all-copper windings)
[ ] Bleeder Valve (Standard on 2500 kVA and above)
[ ] Nitrogen Blanket with Bleeder and Purge Valve
[ ] Touch-up Paint (aerosol cans)
[ ] NEMA 4 Control Box (standard with forced air fan cooling package and required for auxillary contacts or rapid rise relay)
[ ] NEMA 4X Control Box (stainless steel)
[ ] NEMA 7 Control Box (explosion proof)
[ ] Rapid Pressure Rise Relay
[ ] Seal-In Panel for Rapid Pressure Rise Relay
[ ] Forced Air Fan Control Package
[ ] Winding Temperature Indicator
[ ] Auxiliary Contacts for Liquid Level Gauge
[ ] Auxiliary Contacts for Dial Type Thermometer (standard with fan package)
[ ] Auxiliary Contacts for Pressure/Vacuum Gauge
[ ] Auxiliary Contacts for Pressure Relief Device
[ ] Globe Type Upper Fill Valve

Special Features

1.39 The following special features shall be provided if specified:

[ ] All Copper Windings
[ ] Primary Air Disconnect Switch
    [ ] 1200 A Loadbreak Rating (requires 1200 A copper bus bar)
    [ ] Outer Front Door (covers viewing area and switch)

    [ ] Key Interlocks for interlocking switch with secondary
    [ ] Porcelain Bus Insulators
    [ ] Copper Bus Transition to Transformer (required for 600 A and greater)
    [ ] Auxiliary Switch (remote indication of primary switch position)
    [ ] Line-side Bus (bottom entry only)
    [ ] Thermostat for Space Heater
[ ] Vacuum Fault Interrupter, 600 A Continuous, 12000 A RMS Interrupting
[ ] Dead Front HV Termination
    [ ] Loop Feed
    [ ] Radial Feed
[ ] Stainless Steel Cabinet
    [ ] Tank Base
    [ ] Primary Enclosure
    [ ] Secondary Enclosure
[ ] Cooling
    [ ] Mild Steel Radiators
        [ ] Welded
        [ ] Removable
    [ ] Stainless Steel Radiators
        [ ] Welded
        [ ] Removable
    [ ] Galvanized Steel Radiators (removable and unpainted)
[ ] K-Factor Transformer
[ ] Positive Nitrogen Pressure Oil Preservation System
[ ] Current Transformers for Relaying/Metering
[ ] Containment Pan for indoor use for 100% fluid containment
[ ] Factory Mutual (FM) Approved transformer (for NEC Code-listed installations on, near, or inside of buildings)
[ ] UL Listed and Classified transformer (for NEC Code-listed installations on, near, or inside of buildings) per UL XPLH
[ ] UL Listed transformer (certifying compliance with ANSI standards only) per UL XPLH

Shipping

1.40 Transformers shall be loaded and unloaded with overhead cranes.

Data with Proposal

1.41 The following data shall be submitted with the proposal:

- Core losses (when requested per Sections 6.4 and 11.0).
- Winding losses (when requested per Sections 6.4 and 11.0).
- Percent Impedance
- Typical bid drawing

1.42 The following checked data shall be submitted with the proposal:

[ ] Exciting Current @ 100% and 110% rated Voltage.
[ ] Efficiencies must be provided at loading levels of 100%, 75%, 50%, and 25%.
[ ] Percent regulation must be provided at 0.8 PF and 1.0 PF.

Drawings

1.43 The following will be provided by request after receipt of order:

[ ] Construction Drawings
[ ] Record Drawings
[ ] Approval Drawings
[ ] CAD Drawings on diskette
[ ] CD available upon request

TRANSFORMER DATA SHEET 112.5-10000 kVA
THREE-PHASE UNIT SUBSTATION DISTRIBUTION TRANSFORMER

In the case of contradictory specifications, this Data Sheet takes precedence over the Specification.

ITEM______OF______
Scope: [X] Outdoor
[ ] Outdoor, on or adjacent to building
[ ] Indoor
kVA:____________ [ ] 60 Hz [ ] 50 Hz
Temperature Rise: [X] 65 °C
[ ] 75 °C
[ ] 55/65 °C
[ ] 55/75 °C (KNAN only)
Special Altitude: _6000___ft (m)
Cooling Class: [X] ONAN
[ ] ONAN/ONAF 15% or 25% Capacity
[ ] ONAN/ONAF 33% Capacity
[ ] ONAN/ONAF (Future)
Liquid Type: [ ] Envirotemp™ FR3™ Fluid
[X] Oil
Primary Voltage: ________ϕ-ϕ V BIL: ______kV [ ] Aluminum [X] Copper
Connection: [ ] Delta - Wye
[ ] Delta - Delta
[ ] Delta - Grounded Wye
[ ] Grounded Wye - Delta
[ ] Grounded Wye - Grounded Wye
[ ] Grounded Wye - Wye
Primary Taps: [ ] None
[ ] 2 @ +/-21/2%
[ ] 4 @ - 21/2%
[ ] NEMA Taps
[ ] Other: ____________
Secondary Voltage: _______ϕ-ϕ V BIL: ________kV [ ] Aluminum [ ] Copper
Impedance: _______ [ ] ANSI Standard [ ] Minimum [ ] Maximum [ ]+/-7.5% Tolerance
Loss Evaluation: [ ] Efficiency per DOE (10CFR Pat 431)
[ ] Dollars/Watt (No Load): __________
[ ] Dollars/Watt (Load): _____________
Primary Location: Cover-Mounted
[ ] Segment 2 [ ] Segment 3 [ ] Segment 4

Primary Bushings: [ ] Eyebolts
[ ] 2-Hole Spade
[ ] TBI Style Bushings
Secondary Location: Cover-Mounted
[ ] Segment 1 [ ] Segment 2 [ ] Segment 4
Secondary Bushings: [ ] Eyebolts
[ ] 2-Hole Spade
[ ] 6-Hole Spade
[ ] 12-Hole Spade
[ ] TBI Style Bushings
Primary Overcurrent Protection:
[ ] Vacuum Fault Interrupter
Time Current Curve: [ ] EF [ ] TF [ ] KF [ ] F [ ] H
[ ] TPG Control
[ ] TPG Control w/SCADA
[ ] IDEA iDp-210 Feeder Protection Relay (Cooper Power Systems)
Arresters: [ ] Heavy Duty MOV Distribution-Class Arrester
[ ] MOV Intermediate-Class Arrester
[ ] Station-Class Arrester
[ ] Arrester Mounting Provisions
Arrester Duty Cycle Rating: ________kV
Optional Accessories:
[ ] Copper Low Voltage Bushings (standard with all-copper windings)
[ ] Bleeder Valve (standard on 2500 kVA and above)
[ ] Nitrogen Blanket with Bleeder and Purge Valve
[ ] NEMA 4 Control Box (standard with forced air fan cooling package and required for auxiliary contacts or rapid rise relay)
[ ] NEMA 4X Control Box (stainless steel)
[ ] NEMA 7 Control Box (explosion proof)
[ ] Rapid Pressure Rise Relay
[ ] Seal-In Panel for Rapid Pressure Rise Relay
[ ] 120 Vac [ ] 240 Vac [ ] 24 VDC [ ] 48 VDC [ ] 125 VDC
[ ] Forced Air Fan Control Package
[ ] Winding Temperature Indicator
[ ] Auxiliary Contacts
[ ] Liquid Level Gauge
[ ] Dial Type Thermometer (standard with fan package)
[ ] Pressure/Vacuum Gauge
[ ] Pressure Relief Device
[ ] Globe Type Upper Fill Valve
[ ] Touch-up Paint (aerosol cans)

Special Features: [ ] Stainless Steel Cabinet
[ ] Tank Base
[ ] Primary Enclosure
[ ] Secondary Enclosure
[ ] Cooling
[ ] Mild Steel Radiators
[ ] Welded
[ ] Removable
[ ] Stainless Steel Radiators
[ ] Welded
[ ] Removable
[ ] Galvanized Steel Radiators (removable and unpainted)
[ ] Positive Nitrogen Pressure Oil Preservation System
[ ] K Rated Transformer [ ] K4 [ ] K9 [ ] K13 [ ] K20
[ ] Current Transformers [ ] Relaying [ ] Metering
Quantity___ Bushing_______ Ratio_______ Accuracy Class___

[ ] IDEA iXP-420 Differential Protection Relay (Select appropriate Current Transformers for Application)

Colors: [ ] ANSI #61 Light Gray
[ ] ANSI #70 Sky Gray
[ ] Standard Munsell No. 7GY3.29/1.5 Green
[ ] ANSI #24 Dark Blue Gray
[ ] ANSI # 49 Medium Gray
[ ] Other: ___________________________

Testing: [ ] Routine (ANSI Standard)
[ ] Special: ____
____
____
[ ] Certified Test Results

Drawings: [ ] Approval
[ ] Record
[ ] CAD Drawings on CD

Mail Drawings To:
____
____
____
Attn.: ______________________

Required Documentation

Completed Test Form PCF- RLY-MAINT-XFMR – Transformer and Reactor Relay Package Maintenance

Completed Test Form PCF-RLY-INSRVC – In Service Load Check Form

EBU SI-S04 Electrical Equipment—Insulating Oil

1. Scope

This material specification states the requirements for insulating oil to be used by the company in energized electrical equipment.

2. Applicable Documents

The following publications shall be used in conjunction with this material specification, and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

2.1. Industry Publications

Referenced industry publications are:

OSHA 29 CFR 1910, 1200, Hazard Communication Standard

ASTM D 117, Standard Guide to Tests Methods and Specifications for Electrical Insulating Oils of Petroleum Origin

ASTM D 877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ASTM D 923, Standard Test Method for Sampling Electrical Insulating Liquids

IEC WG-35, Covered Conductor Deposition Test

ASTM D3487, Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

3. General

3.1. Application Information

This material specification states the general requirements for insulating oil for energized electrical equipment. The insulating-oil-specific requirements that vary depending on the project shall be stated in the purchase order.

4. Manufacturing Requirements

4.1. Codes and Standards

Except as required otherwise by this material specification, electrical equipment insulating oil requirements shall be in complete accordance with the latest applicable industry codes, ANSI, IEEE, NEMA, and ASTM standards, and company construction standards and material specifications in effect on the date of invitation to bid. When these standards do not agree, the more stringent standards shall apply.

4.2. Type

The insulating oil supplied under this specification shall be non-corrosive, light mineral insulating oil for use as a dielectric medium in an energized electrical apparatus. The oil shall also be naphthenic and inhibited, as specified in Sections 4.3 and 4.5.

4.3. Raw Material and Processing

The insulating oil shall be manufactured from predominantly naphthenate-base crudes. Distillates from these crudes may be acid-refined, hydrogen-treated, solvent-extracted, or processed by other industry-accepted methods that will yield mineral insulating oil that meets the testing requirements in Section 5 of this specification at the point of delivery to the company. No changes in the approved crude used or the approved refining methods shall be made without prior written acceptance by the company.

4.4. Impurities

Insulating oil shall be clear and free from all injurious impurities, such as metallic or nonmetallic particles or other foreign substances.

4.5. Additives

Insulating oil shall contain no additives other than the oxidation inhibitor. Certification shall be provided stating that the additive Dibenzyl Disulfide (DBDS) is not contained in the insulating oil.

4.6. Oil Sampling

Oil samples shall be taken in accordance with ASTM D 923 and shall be taken such that they represent the oil at the point of delivery to the company.

5. Testing and Certification

The supplier shall provide a certificate or a Material Safety Data Sheet (MSDS) stating that the insulating oil provided is not required to carry a cancer warning label in accordance with OSHA 29 CFR 1910, 1200. The supplier shall guarantee conformity to this specification at the point of delivery. Each individual container shall be accompanied by a certificate showing that the insulating oil in that container conforms to this specification at the point of loading, and giving all results of tests made on the oil. A copy of all documentation shall be submitted to the company as specified in Section 6 of this document. The certificates shall include the results of the following tests, made on bottom samples taken after filling of each container of oil prior to shipment to the company:

1. PCB analysis
2. Dielectric breakdown voltage (ASTM D 877)
3. Flash point
4. Dissipation (power) factor
5. Color
6. Visual examination
7. Neutralization number
8. Water content
9. Corrosive sulfur

The certificate shall also include the results of the tests specified in Table 1, made on samples from the manufacturing batch from which the shipment is drawn, and the following shipment identification information:

1. Company purchase order number
2. Supplier's order number
3. Consignee
4. Date of shipment
5. Destination
6. Refinery lot number
7. Trailer or equipment serial number
8. Filling date
9. Volume of oil shipped

All insulating oil that does not conform to this specification at the point of delivery will be returned to the supplier collect. The company shall be kept fully informed by the supplier as to the method and frequency of quality control employed for certification of these properties.

Table 1 specifies the properties to be tested, the test methods to be employed, and the test criteria for acceptance. The ASTM test methods listed in Table 1 may be found in abbreviated form in ASTM D 117.

Table 1—Test Requirements

Properties	Test Method	Test Criteria
Electrical		
Dielectric breakdown at 60 Hz: Disc electrodes 0.100-inch gap	ASTM D 877	30 kV min.
VDE electrodes 0.040-inch gap	ASTM D 1816	28 kV min.
Dielectric breakdown voltage impulse at 25°C needle-to-sphere ground 1-inch gap	ASTM D 3300	145 kV min.
Dissipation (power) factor at 25° C at 100° C	 ASTM D 924 ASTM D 924	 0.05% max. 0.30% max.
Gassing tendency Procedure A Procedure B (use either procedure A or B)	ASTM D 2300 ASTM D 2300	+15 ml/minute max. +30 ml/minute max.
Physical		
Aniline point	ASTM D 611	63-80°C
Color	ASTM D 1500	0.5 max.
Flash point	ASTM D 92	145 C
Interfacial tension at 25° C Pour point	ASTM D 971 ASTM D 97	40 dynes/cm min -40° C max.
Specific gravity at 15/15° C	ASTM D 1298	0.865-0.910
Viscosity at 100° C at 40° C at 0° C	 ASTM D 445 ASTM D 445 ASTM D 445	 3.0/36 cST/SUS max. 12.0/66 cST/SUS max. 76.0/350 cST/SUS max
Visual examination	ASTM D 1524	Clear and bright
Chemical		
Corrosive Sulfur	ASTM D 1275B ASTM D 2668 IEC WG-35	Noncorrosive
Inorganic chloride ion	ASTM D 878	0.10 ppm
Inorganic sulfate ion	ASTM D 878	None
Neutralization number	ASTM D 974	0.03 mg KOH/g max.
Oxidation inhibitor content % by weight	ASTM D 1473 ASTM D 2668	0.3% max.
Oxidation stability testing 72 hour test: Sludge weight % Neutralization number 164 hour test: Sludge weight % Neutralization number Rotating bomb test, minutes	 ASTM D 2440 ASTM D 2440 ASTM D 2112	 0.10% max. 0.30 mg KOH/g max. 0.20% max. 0.40 mg KOH/g max. 195 min.
Polychlorinated biphenyl (PCB)	ASTM D 4059	Not detectable
Total sulfur, weight %	ASTM D 989	0.15 % max.
Water Content, ppm	ASTM D 1315 ASTM D 1533	30 ppm max. before processing

6. Technical Documentation

All values in documentation shall be shown in US customary units only, or in both US customary and SI units.

A certified oil test report is required with delivery of the oil, or with the delivery of the oil-filled equipment.

7. Shipping Requirements

All insulating oil shall be shipped via common-carrier truck or factory-filled electrical apparatus purchased by the company or as specified in the purchase order. All insulating oil shipped by any other means will be returned to the supplier collect. The supplier shall carefully inspect each container to assure that it is free of injurious foreign matter. The inspection shall include, but shall not be limited to, a visual internal inspection of the container, valves, and piping. Inspection shall occur immediately prior to loading of the insulating oil.

7.1. Notification of Shipment

The supplier shall notify the company two weeks prior to the expected arrival of the insulating oil. Additionally, the company contact named below shall be notified 48 hours prior to delivery and on the day of shipment to ensure provisions for unloading.

NV Energy

Notification instructions will be on the purchase order.

MidAmerican Energy

Notification instructions will be on the purchase order.

PacifiCorp

PacifiCorp Project Services Department, Senior Materials Analyst
Lloyd Center Tower
825 NE Multnomah St., Ste. 1500
Portland, OR 97232
(503) 813-7061; fax (503) 813-6596

8. Supplier Approval

All suppliers must be approved by the company prior to receiving an order. Approval is issued to a supplier for a given crude source, refining process, conformity to the requirements of this specification, and performance deemed essential by the company. Suppliers may be required to submit a one-gallon sample, for independent testing, and test certificates representing the quality of insulating oil to be delivered. The test certificates shall include the test requirements found in Section 5. The test sample submitted to the company shall be clearly marked with the refinery name, refinery location, crude source, and refining process.

9. Issuing Department

The engineering publications department of PacifiCorp published this material specification. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be submitted by email to: TDManufacturerSubmittal@pacificorp.com.

This material specification shall be used and duplicated only in support of company projects.

EBU SI-S02 Wind, Ice, and Seismic Withstand

1. Scope

This material specification states the requirements for the wind, ice, and seismic withstand capability of substation equipment to be purchased by the company.

2. Applicable Documents

The following publications shall be used in conjunction with this material specification, and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

2.1. Industry Publications

Referenced industry publications are:

IEEE Std. 693, Recommended Practices for Seismic Design of Substations

ASCE 7-05, Minimum Design Loads for Buildings and Other Structures

AISC, Steel Construction Manual (ANSI/AISC 360)

AISI, American Iron and Steel Institute (Specification S100-07)

ACI 318, Building Code Requirements for Structural Concrete

IBC, International Building Code

ICC-ES, International Code Council Evaluation Services, Inc., (Evaluation Reports for post-installed anchors)

OSHA, Occupational Safety and Health Administration

3. General

3.1. Application Information

This material specification states the general requirements for the wind, ice, and seismic withstand capability of substation equipment. The equipment-specific requirements that vary depending on the particular equipment and application shall be stated in the purchase order. This material specification must accompany a company material specification for specific substation equipment identified in the purchase order.

4. General Wind, Ice, and Seismic Withstand Requirements

4.1. Codes and Standards

Except as required otherwise by this material specification, the general wind, ice, and seismic withstand requirements shall be in accordance with the latest applicable industry codes/standards, ANSI, AWS, IBC, ASTM, IEEE, ASCE, AISC, AISI, ACI, NEMA, OSHA, and company construction standards and material specifications in effect on the date of invitation to bid.

4.2. Wind and Ice Performance Criteria

Substation power equipment and supporting structures shall be designed for wind and ice loadings in accordance with the application of ASCE 7, Chapter 6, Wind Loads, and Chapter 10, Ice Loads—Atmospheric Icing. The basic wind speed (for a three-second gust) shall be 100 mph (as opposed to the values given in Figures 6-1, 6-1a, 6-1b and 6-1c of ASCE 7, Chapter 6). The nominal ice thickness and simultaneous wind speed shall be based on the values shown in ASCE 7, Chapter 10, Figures 10-2 through 10-5, except the nominal ice thickness shall not be less than 1/4I, and the nominal wind speed shall be no less than 40 mph. The “importance factor” shall be 1.15, and shall be in accordance with ASCE 7 for occupancy category IV.

4.3. Seismic Performance Criteria

Substation power equipment and supporting structures shall meet the requirements of IEEE Std. 693 seismic qualification level as checked (n) below:

Low seismic qualification level	☐
Moderate seismic qualification level	☐
High seismic qualification level	☐

The seismic qualification and design of the equipment, with the exception of standby generators, shall be in accordance with the applicable provisions in IEEE Std. 693 and the supplementary requirements per Section 4.3.1. For equipment meeting the moderate or high seismic qualification, the nameplate shall indicate the seismic qualification level to which the equipment was designed and built. Standby generators identified to be qualified to the moderate or high seismic qualification level shall be qualified in accordance with the IBC, ASCE 7, and ICC-ES AC 156 as outlined in Appendix D.

Equipment Specifier Note: When selecting the seismic performance criteria for spare equipment, the following items shall be considered:

- The peak ground acceleration at potential locations of equipment installation
- The current stock of spare equipment and corresponding seismic qualification levels
- Justification for selecting a higher seismic qualification level equipment based on the cost difference of equipment qualified to different seismic qualification levels (equipment qualified to the high or moderate seismic qualification levels from some manufacturers may cost the same)
- The need for robust performance of mobile units may justify a higher seismic qualification level

4.3.1. Supplementary Seismic Qualification and Design Requirements

Supplementary seismic qualification and design requirements applicable to certain equipment identified to be qualified to the high or moderate qualification level are included in appendices as listed below:

- Appendix A – Special Anchorage Requirements
- Appendix B – Control House Equipment Panels and Racks
- Appendix C – Series Capacitor Bank Support Structures
- Appendix D – Standby Generators

4.4. Foundation Design

The foundation design engineer of record shall be fully responsible for the performance of the foundation system. The equipment manufacturer and anchor bolt designer shall not be held responsible for the performance of the foundation system provided the anchorage supplied is in compliance with these provisions. The foundation design engineer shall obtain equipment-specific loading conditions from the manufacturer to ensure that all load cases are considered. The foundation design engineer shall also review the foundation's design requirements or any constraints listed in the geotechnical engineering report.

4.5. Required Documentation

- Documentation for seismic qualification shall be prepared per IEEE Std. 693 Annex S and Annex T for analysis and test reports
- If the qualification is by analysis, the report shall be submitted on a mutually-agreed-upon date after the award of contract
- If the qualification is by testing, the test plan and test report shall be submitted on a mutually-agreed-upon date
- Documentation for the wind and ice calculations shall be submitted on the same date as the final seismic report
- Calculations for anchorage design shall be included
- Drawings shall indicate the maximum forces at each anchorage location (tension, shear, compression)
- Drawings shall indicate forces to be used for designing foundations (shear, overturning moments, axial forces)
- It shall be the responsibility of the equipment manufacturer to ensure that the calculations and other documents required to qualify equipment to 210-1 / ZS 065, Wind, Ice, and Seismic Withstand are prepared in strict accordance with the applicable standards, are complete, accurate, checked, stamped, and signed before submitting to the company for review
- For moderate and high seismic level qualifications, checked in Section 4.3, all calculations, test results, and drawings shall be checked, stamped, and signed by a professional engineer licensed in the United States

- Allow a minimum of four (4) weeks in the schedule for company review of the calculations and other documents submitted. The manufacturer shall assume all responsibility for any additional calculation and document review time that may result from errors and omissions in the submittals
- The company has in the past accepted equipment qualification calculations and other documents prepared by several consultants. The familiarity of these consultants with the company requirements for qualifying substation equipment could potentially result in shorter document preparation time for manufacturers and review times for the company. The company can provide this list of consultants to manufacturers who request this information. There is no requirement that a manufacturer use one of these consultants

4.6. Copies of Wind, Ice, and Seismic Analyses

The manufacturer shall furnish one hard copy and two PDF copies (on two CDs) of the analyses of wind and ice loading and seismic effect, including all calculations and drawings. Copies shall be sent with equipment approval drawings.

4.7. New Equipment Qualifying Requirements

IEEE Std. 693 requires some equipment to be seismically-qualified by time history shake-table testing. If equipment tested accordingly is currently not available, the company will not require the manufacturer to conduct shake-table testing. In such cases the equipment to be installed at the substation will be determined by the company project team. This determination will be based on available equipment options, the site specific ground accelerations, criticality of this substation, system redundancy, availability of spares, replacement/repair durations, and associated risks.

5. Issuing Department

The engineering publications department of PacifiCorp published this material specification. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be submitted by email to: TDManufacturerSubmittal@pacificorp.com.

This material specification shall be used and duplicated only in support of company projects.

Appendix A—Special Anchorage Requirements

A.1. General

These provisions are applicable only to the following equipment identified as being qualified to the high or moderate seismic qualification level per Section 4.3:

- Transformers
- Oil-filled reactors
- Three-phase voltage regulators
- Phase shifters
- Power circuit breakers
- Shunt capacitor banks

The type of anchorage on company-supplied flat concrete slabs shall be in accordance with the voltage classifications in the sections below.

A.1.1. Transformers / Reactors / Voltage Regulators / Phase Shifters Larger Than 138 kV (Nominal High-Side Voltage)

Equipment bases shall be designed to be anchored by welding to steel embedments in the concrete foundation, unless the cast-in-place bolted anchorage or post-installed bolted anchorage box is checked below:

In lieu of welded anchorage use cast-in-place bolted anchorage ☐

In lieu of welded anchorage use post-installed bolted anchorage ☐

Requirements for welded, cast-in-place bolted, and post-installed bolted anchorages are provided in sections A2.1, A2.2, and A2.3 respectively.

A.1.2. Transformers / Reactors / Voltage Regulators / Phase Shifters 138 kV (Nominal High-Side Voltage) or Smaller

Equipment bases shall include tabs with holes (“anchor tabs”) for anchoring the equipment to a concrete foundation using post-installed steel rods, bolts, special anchors, or welds.

Anchor tabs shall be designed such that they can be either bolted or welded to a foundation, depending on the particulars of an installation. If bolting anchorage is most suitable, the company will drill the foundation and install anchors through the holes provided in the equipment base. If welding is most suitable, the company will weld the anchor tabs directly to the steel embedments in the foundation. Locations of anchor tabs shall be coordinated with the embedded steel locations indicated in Figure A1. The company will choose the method of attachment after the transformer is delivered to the site.

Requirements for welded and post-installed bolted anchorages are provided in sections A2.1 and A2.3 respectively.

A.1.3. Power Circuit Breakers of All Voltage Classes

Manufactured equipment bases for power circuit breakers of all voltage classes shall include holes for anchoring the equipment to a concrete foundation using post-installed steel rods, bolts, or special anchors per Section A2.3.

A.1.4. Shunt Capacitor Banks of All Voltage Classes

Equipment bases for shunt capacitors of all voltage classes shall include holes for anchoring the equipment to a concrete foundation using post-installed steel rods, bolts, or special anchors per Section A2.3.

A.2. Anchorages

A.2.1. Welded Anchorage

All welding shall be performed according to AWS D1.1 by a certified welder and inspected by a certified welding inspector (CWI).

Selection of the size and length of prequalified field welds shall be included in the engineering analysis and calculations for qualification of the equipment. The welds shall be made to locations that are selected and designed to transfer forces. The heat caused by welding shall be considered. Welding to an embedment shall be completed in a manner not to produce sufficient heat to compromise the concrete substrate. When required, extended base plate tabs (may be the same plate as for the bolted options) shall be provided.

Company foundations will feature embedded steel, a minimum of 1/2I thick, 6I wide and spaced center-to-center at 2i-6I. Steel embeds will run parallel to each other and fit across the entire width of the foundation from the high- to low-voltage side. The manufacturer shall provide weld locations where the steel embeds cross. A typical foundation plan is provided for illustration of this concept (see Figure A1).

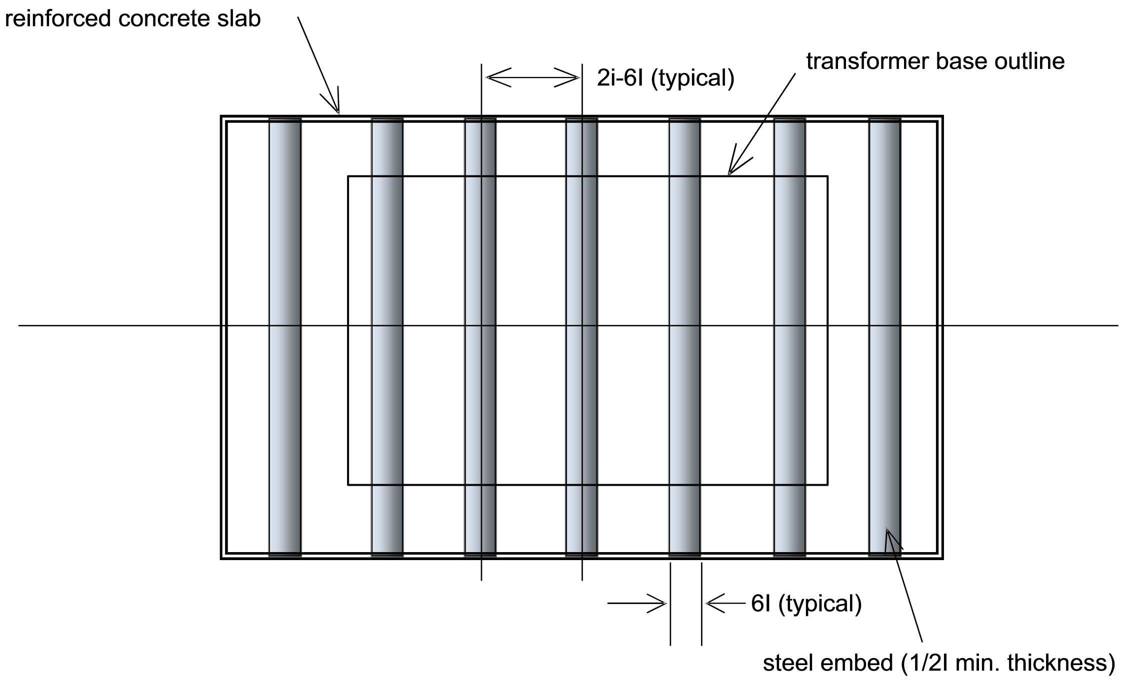

Figure A1—Foundation Plan with Embedded Steel

A.2.2. Cast-in-Place Bolted Anchorages

The selection of the number, positions, and diameters of anchors shall be included in the engineering analysis and calculations for qualification of the equipment. Contrary to IEEE Std. 693, selection of anchor diameter shall be based on the design procedure in ACI 318, Appendix D, and not on the ASCE 113, Substation Structure Design Guide. The anchor demands shall be calculated using the load combinations specified in IEEE Std. 693. For anchor design purposes, the following criteria shall be used to determine the steel and concrete capacities per ACI 318, Appendix D:

- Anchor material shall be assumed to be steel meeting the requirements of ASTM F1554
- Supplemental reinforcement will be provided by the foundation designer such that concrete breakout failure mode can be ignored
- Adequate edge distance shall be provided by the foundation designer such that the side-face blowout failure mode can be ignored
- Minimum concrete compressive strength shall be 4000 psi (pounds per square inch)
- Minimum thickness of foundation is at least 25 times the diameter of an anchor
- Concrete is considered “cracked”
- Anchors will be installed in a high seismic region

In addition to calculations for steel failure modes, calculations for anchor pry-out and pullout failure modes shall be provided. Anchor spacing and effective embedment depth, in accordance with ACI 318, Appendix D, shall be considered.

Anchor rod/bolt hole size in the equipment base shall be at least 3/8l in diameter larger than the diameter of the rod/bolt to facilitate installation.

Plate washers appropriately sized (but not less than 1/2l thick) with holes no more than 1/16l greater than the bolt diameter shall be provided with each bolt. These plate washers will be field-welded to the equipment base. Calculations and drawings shall indicate the washer and field weld details.

A.2.3. Post-Installed Bolted Anchorage

The selection of the number, positions, and diameters of post-installed anchors shall be included in the engineering analysis and calculations for the qualification of equipment. The design shall facilitate the installation of post-installed anchors, i.e. adhesive, expansion, or undercut anchors installed after placing equipment on the foundation. The minimum clearance space required to install this type of anchor in concrete is 9l between the equipment face and the anchor, 15l to either side of the anchor, and 84l above the anchor (see Figure A2 below). The anchor demand shall be calculated using the load combinations specified in the IEEE Std. 693. For anchor design purposes, the following criteria shall be used to determine the steel and concrete capacities per ACI 318, Appendix D, and the International Code Council ICC-ES ESR report for the post-installed anchors:

- Anchors positioned in groups shall have a minimum center-to-center spacing of six times the diameter of an anchor
- Anchor material shall be assumed to be steel, meeting the requirements of ASTM F1554
- Supplemental reinforcement will be provided by the foundation designer such that concrete breakout failure mode can be ignored
- Adequate edge distance will be provided by the foundation designer such that the side-face blowout failure mode can be ignored
- Minimum concrete compressive strength shall be 4000 psi
- Minimum thickness of the foundation is at least 25 times the diameter of an anchor
- Concrete is considered "cracked"
- Anchors will be installed in high seismic regions

In addition to calculations for steel failure modes, calculations shall also consider:

- Anchor pry-out failure mode. Anchor spacing and effective embedment depth, in accordance with ACI 318, Appendix D, shall be considered
- Adhesive bond or pullout strength calculations required per the ICC-ES ESR report
- Anchor diameters may not exceed maximum allowed by ICC-ES ESR report

Finally, holes larger in diameter than the proposed anchors (by 1/4l or more) are considered oversized. Oversized holes may result in shear forces distributed unevenly amongst the anchors. Oversized holes are permitted if plate washers are used, with holes no more than 1/16I greater than the bolt diameter, field-welded to the equipment base.

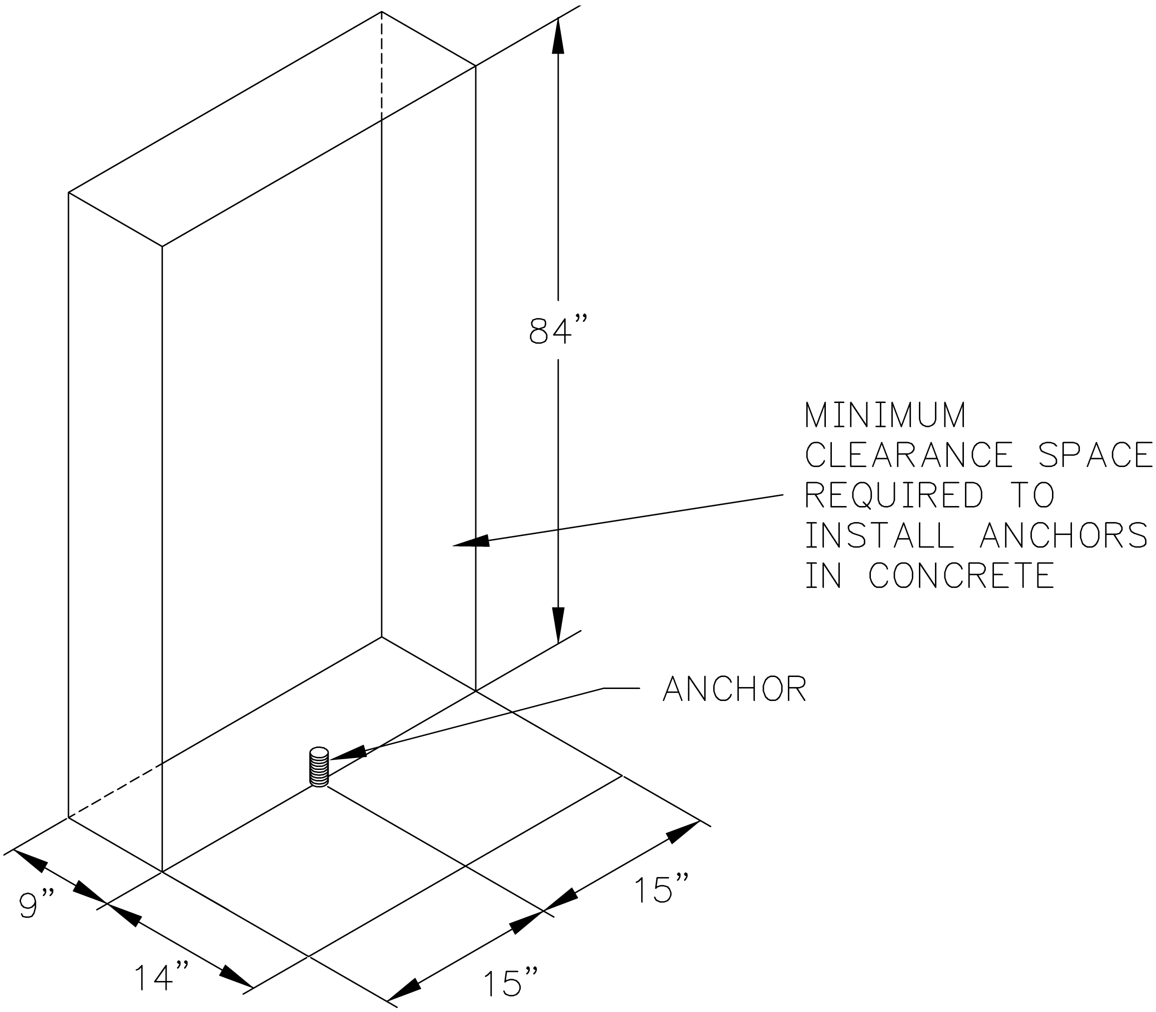

Figure A2—Anchor Clearance Zone for Post-Installed Anchors

Appendix B—Control House Equipment Panels and Racks

B.1. General

These provisions are applicable only to the seismic evaluation of control house equipment panels and racks identified as qualified to the high or moderate seismic qualification level per Section 4.3.

B.2. Seismic Qualification and Design

IEEE Std. 693 requires certain panels and racks to be seismically qualified by shake-table testing. As an alternate to this testing requirement, the company will accept seismic qualification calculations and design performed to the high seismic qualification level loading per IEEE Std. 693, Annex L.4.2 (Static analysis per A.1.3.1 at 1.5g in each horizontal direction and 1.2g in the vertical direction). Finite element models (FEMs) of the panels and racks should be developed using STAAD software. If some other software is used (please specify), then electronic files of the FEMs that include information of model geometry, loading, etc., that can be imported into STAAD shall be provided (ex. CIS/2 format). Forces shall be combined by the SRSS method or 100/40/40 combination.

Allowable stresses, which account for local buckling effects of the sheet metal panels, racks and components, shall be evaluated per AISI S100-07, North American Specification for the Design of Cold-Formed Steel Structural Members. Typically, panels and racks are fabricated with ASTM A1011 Grade SS (structural steel grade). However, ASTM A1011 Grade CS (commercial grade) steel will be acceptable provided coupon tests are performed to prove that the minimum yield strength is 30 ksi (kips per square inch). A plate bending radius of 1xt (thickness) may be assumed for 90 degree bends for shapes. Design shall include reinforcements required at panel cutouts for instruments, and anchorage of the panels.

Appendix C—Series Capacitor Bank Support Structures

C.1. General

These provisions are applicable only to the seismic evaluation of series capacitor bank support structures identified as qualified to the high or moderate seismic qualification level per Section 4.3.

C.2. Seismic Qualification and Design

The fixed series capacitor bank platform and support structure shall be qualified in accordance with IEEE Std. 693, Annex O, and the provisions contained herein. All capacitor bank platform structures shall utilize columns and diagonal bracing systems built with insulators between the platform and foundation for lateral force resistance. Bracing systems can utilize either tension-only or tension-compression members.

For structures with tension-only diagonal bracing systems, structural analysis shall be performed utilizing either site-specific developed time response histories, or IEEE Std. 693 developed time response history record. The seismic response history procedures in the latest version of ASCE 7 shall be used. Time histories shall be scaled to envelope the IEEE Std. 693 performance level response spectrum for 2% damping. For tension-only bracing systems, the loss of pre-tensioning during response history analysis shall be explicitly modeled. All connections and components of the bracing system shall be modeled.

For diagonal bracing members consisting of materials other than structural steel, structural capacity shall be established by means of testing and shall include all connection components that comprise the bracing assembly (i.e. shackles, pins, clevises, etc.). Testing shall include the development of load-deflection curves (loading and unloading) required for the structural analysis model. Results of test data shall be included in the final seismic qualification report. All bracing member capacities shall have a tested minimum factor of safety of 1.2 at the IEEE Std. 693 performance level demands. Further, for tension-only bracing, the minimum factor of safety shall be 1.5. Shackles, pins, clevises and other hardware shall be provided with a minimum 2.0 factor of safety at the IEEE Std. 693 performance level demands.

The use of supplemental damping or response modification devices shall be acceptable provided the demonstrated system response meets the IEEE Std. 693 performance level requirements. All nonlinear components of the lateral force resisting system shall be explicitly modeled to capture behavior and effect on the support structure system. The performance characteristics of all supplemental damping or response modification devices, both linear and nonlinear, shall be established by component testing and shall demonstrate adequacy for entire range of expected forces and displacements. The performance characteristics shall be explicitly used in the computer model.

The top of the capacitor bank platform shall not deflect in any horizontal or vertical direction more than H/50 when subject to IEEE Std. 693 performance level demands, where "H" is equal to the height of the capacitor bank/support structure platform interface as measured from the top of the foundation.

The company recommends the support structure columns and diagonal braces be connected to and supported by steel pedestals embedded in the concrete foundation, rather than directly connected to concrete pedestals. The use of cast-in-place anchor rods or post-installed anchors is discouraged due to difficulty in satisfying requirements of ACI 318, Appendix D provisions. However, if either cast-in-place or post-installed anchors are provided, the ACI 318, Appendix D provisions shall be used and all concrete shall be assumed to be cracked for purpose of analysis.

Calculations shall be submitted to demonstrate the performance of the capacitor bank system as specified above. The submittal shall include a Seismic Qualification Report prepared in accordance with IEEE Std. 693, Annex S. The Report shall contain a comprehensive narrative that clearly explains all analysis & design assumptions along with final conclusions and recommendations. In addition, electronic file copies of input and output used for the structural analyses shall be provided on CDs or DVDs such that the company can review the computer file in STAAD. If software other than STAAD is used for analyses, then electronic versions of files importable into STAAD (ex. CIS/2 format) shall also be included (in addition to original files). Computer files will be used as part of technical review and validation of proper modeling methodology and analysis results.

Appendix D—Standby Generators

D.1. General

These provisions are applicable only to the seismic evaluation of standby generators identified as qualified to the high or moderate seismic qualification level per Section 4.3.

Generator configuration shall meet the project specific requirements which may include one of the following:

- Generator mounted directly on a concrete foundation with a separate fuel tank
- Generator mounted on a sub-base fuel tank that is supported by a concrete foundation, where the top of the fuel tank is used as a working/walking platform
- Generator mounted on a sub-base fuel tank that is supported by a concrete foundation, with a separate grated platform used as a working/walking platform

Seismic qualification of the generator, sub-base fuel tanks and platforms shall be in accordance with the applicable provisions in IBC, ASCE 7, ICC-ES AC 156 and Section D.2.

All working/walking platform surfaces and approach steps shall be OSHA compliant, free of slip/trip hazards and be equipped with fall protection when applicable. Platforms and approach steps shall be designed for a minimum snow load of 30 pounds per square foot (psf), uniform live load of 50 psf and concentrated live load of 500 pounds.

Steel design shall be in accordance with the applicable provisions in AISC and AISI, with due consideration to effects of buckling and pryout at bolted connections.

Post-installed anchors (adhesive or mechanical anchors) shall be used to anchor the generator, fuel tank, and platform support steel to concrete foundations. Adequate clearance shall be provided to enable the installation of the anchors after the equipment is set in place on the concrete foundation.

D.2. Seismic Qualification Methods

1. The generator set should be qualified by shake-table testing that meet or exceed the parameters below:

   a. Building code/referenced standards, IBC 2009/ASCE 7

   b. Test criteria, ICC-ES AC 156

   c. S_{DS} (g) = 1.67

   d. z/h = 1.0

   e. A_{FLX-H} (g) = 2.67

   f. A_{FLX-V} (g) = 1.12

   An I_p = 1.5 shall be assumed for evaluating functional requirements after testing (Ref ICC – ES AC156 Section 6.8.2).

For generators supported on top of sub base fuel tanks additional calculations shall be provided to verify that the support system is dynamically better (will transmit lower accelerations to the generator) than the support used for the shake-table test.

2. The enclosure, fuel tank, other components, connections and anchorages that are not shake table tested must be analyzed and designed to the following ultimate (LRFD) seismic forces:
   a. $F_{p\text{-}hori} = 3.76\ W_p$
   b. $Fp_{\text{-}vert} = 1.12\ W_p$

EBU SI-S03 Contaminated Environment Protection

1. Scope

This material specification states the requirements for contaminated-environment protection of substation equipment to be purchased by the company.

2. Applicable Documents

The following publications shall be used in conjunction with this material specification and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply.

2.1. Industry Publications

Referenced industry publications include:

1. ANSI/NFPA 70, National Electrical Code
2. ASTM B 117, Standard Method of Salt Spray (Fog) Testing
3. ASTM D 1654, Standard Method of Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
4. ASTM D 2247, Standard Method for Testing Coated Metal Specimens at 100% Relative Humidity
5. ASTM D 2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
6. ASTM D 3359, Standard Methods for Measuring Adhesion by Tape Test
7. ASTM G 53, Standard Recommended Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials

3. General

3.1. Application Information

This material specification states the general requirements for contaminated- environment protection of substation equipment. The equipment-specific requirements, which may vary depending on the particular equipment and application, shall be stated in the purchase order. The purchase order shall specify whether the equipment shall be designed to withstand a marine or sulfur-contaminated environment, in which case this material specification must accompany the company material specification for specific substation equipment identified in the purchase order.

4. General Contaminated-Environment Protection Requirements

4.1. Codes and Standards

Except as required otherwise by this material specification, the general contaminated-environment protection requirements shall be in accordance with the latest applicable industry codes, including ANSI, IEEE, and NEMA standards, as well as any company construction standards and material specifications in effect on the date of invitation to bid.

4.2. Bushing and Insulator Creep Distance

Unless checked (✔) below, a heavy contamination level of 44 mm/kV per IEEE C57.19.100, based on nominal line-to-ground kV, shall be the minimum bushing and insulator creep distance.

Extra heavy contamination (54 mm/kV or greater per IEEE C57.19.100) ☐

4.3. Accessory Compartment(s)

The control compartment and other accessory compartment(s) shall be NEMA 4X.

4.4. Corrosion Resistance of Exposed Metal Parts

4.4.1. Required Metals and Coatings

All exposed, bronze and copper parts shall be galvanized, or plated with tin or cadmium to a minimum plating thickness of 0.001 inch. All other exposed, unpainted metal parts shall be aluminum; stainless steel in compliance with type 302, 304, or 316; or galvanized steel in compliance with ASTM A123, A653, or A924. The hardware shall mechanically comply with A153 or B693. All exposed, painted metal parts shall have a minimum total coating thickness of 5 mils.

4.4.2. Additional Requirements for Painted Parts

To verify the capability of the paint coating to withstand corrosive environments, the supplier shall certify that painted test specimens have passed the tests specified in sections 4.4.2.1 through 4.4.2.3 of this document.

4.4.2.1. Marine or Sulfur Environment Tests

For either a marine or sulfur-contaminated environment, applicable tests shall include the following:

1. ASTM D 2247, Humidity Test: 1000 hours with no blisters
2. ASTM D 2794, Impact Test:
   a. 2 inch-pound reverse impact, without cracking or losing adhesion
   b. 160 inch-pound direct impact, without cracking or losing adhesion
3. ASTM D 3359, Adhesion Test: no peeling or removal

4. ASTM G 53, Light and Condensation Test: 500 hours with no more than 50% loss of gloss

4.4.2.2. Salt Spray Test

If suitability for marine environment is specified in the purchase order, painted test specimens shall also pass the ASTM B 117, Salt Spray Test, for a minimum of 1000 hours with the following results:

1. For an unscribed specimen, there shall be no blisters or corrosion of the specimen.
2. For a scribed specimen, loss of adhesion shall not be more than 1/8 inch from scribe, and the underfilm corrosion shall not be more than 1/16 inch from scribe.

4.4.2.3. High Sulfur Environment Protection

If suitability for sulfur-contaminated environment is specified in the purchase order, the manufacturer shall submit documentation showing the corrosion resistance of all exposed materials used in the equipment to be reviewed and approved by the company.

Exposed metal not suitable for a sulfur-contaminated environment shall be protected using a sulfur-resistant epoxy coating. The manufacturer shall submit their proposed coating and coating-application system in writing, to be approved by the company.

5. Issuing Department

The engineering publications department of PacifiCorp published this material specification. Questions regarding editing, revision history and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be submitted by email to: TDManufacturerSubmittal@pacificorp.com.

This material specification shall be used and duplicated only in support of company projects.

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PROCEDURE

TRANSFORMER and OIL-FILLED REACTOR INSTALLATION PROCEDURE

SP-TRF-INST

Version number: 12

Approval date: 02/06/2013

Authoring department: Substation Technical Services

Approved location: PolicyTech

File name: SP-TRF-INST Transformer Installation

Revision Log		
5	11/06/2008	Ownership changed to substation technical services
6	04/17/2009	Updated oil processing requirements, section 6.9
7	08/11/2009	Format revisions
8	12/3/2009	Format revisions, corrections to sections 7, 8
9	02/18/2011	Format revisions
10	06/11/2012	Added to PolicyTech in procedure template
11	01/02/2013	Relay references updated
12	02/06/2013	Added revision log, form version number

TRANSFORMER INSTALLATION PROCEDURE

1 Scope

The scope of this procedure is to provide general guidelines for receiving; installation; and baseline testing prior to initial energizing of all relocated and new substation class transformers, shunt reactors, large voltage regulators and other similar oil filled devices. Throughout this procedure, the term transformer is used in the generic sense and is meant to include all the equipment types listed above. For most of these devices, the installation activities are essentially similar to that of an oil filled transformer. Exceptions to this are for example: specific testing requirements and items that may not apply to a particular device, such as the testing of a load tap changer, which is not present on some transformers or on any reactors.

This procedure may not cover all types of transformers and/or accessories. Most transformer manufacturers require specific tests for validation of warranty. The manufacturer's guidelines may include additional tests or procedures that exceed this guideline. Obtain the manufacturer's installation guidelines before work is begun. When there is a conflict between the owner procedures and the manufacturer procedures, the owner procedures shall prevail unless specifically otherwise agreed to by owner's substation technical services.

2 Purpose

The purpose of this procedure is to ensure that PacifiCorp-owned transformers are properly installed and tested prior to placing them in service.

Specific instructions for transformers that are to be stored as spares, or for those for which the final installation is deferred temporarily, are listed in section 8 of this document.

Completion of owner forms will be required as part of the transformer receiving, installation and energizing work scope. These forms are listed in this document in section 4. Form SF-TRF-INST is required to be filled out per this transformer receiving, installation, and testing procedure.

3 References

3.1 Equipment manufacturer instruction manuals;

3.2 Confined space entry procedure;

3.3 PacifiCorp procedure SP-INSRES Insulation Resistance Testing;

3.4 PacifiCorp procedure SP-OIL-QUAL Oil Quality Analysis Sampling;

3.5 PacifiCorp procedure SP-TTR Transformer Turns Ratio (TTR) Test;

3.6 PacifiCorp contractor procedure SPC-TRF-OILPROC Transformer Vacuum Processing;

3.7 PacifiCorp procedure SP-OIL-DGA Dissolved Gas Analysis (DGA) Sampling;

3.8 PacifiCorp procedure PCP-CT-INST Current Transformer Installation;

3.9 PacifiCorp procedure PCP-RLY-INST-Q509 Qualitrol 509-100 Installation;

3.10 PacifiCorp procedure PCP-MTR-INST-INCON Incon 1250 Installation;

3.11 PacifiCorp procedure PCP-RLY-INST-M2001C Beckwith M-2001B/C Installation;

3.12 Exhibit A, section 16 – substation testing and commissioning specifications for contractors and / or Exhibit X – SLA substation testing and commissioning specifications; and

3.13 Equipment manufacturer's installation / maintenance manual and procedures.

4 Required documentation

The forms and electronic test results listed below shall be completed and submitted to the owner for review before the transformer installation work can be accepted by the owner. Refer to section 10 for submittal instructions.

4.1 PacifiCorp form SF-TRF-INST Transformer Installation, Version 12;

4.2 PacifiCorp form SF-OIL-DGA Dissolved Gas Analysis (DGA) Sampling;

4.3 Laboratory generated DGA and oil quality data;

4.4 PacifiCorp form SF-TTR Transformer Turns Ratio Test;

4.5 PacifiCorp form SF-INSRES–XXX Insulation Resistance Test, where XXX is substituted with the letters corresponding to the specific form for the specified winding configuration.

4.6 PacifiCorp form SFC-TRF-OILPROC Vacuum Processing Log;

4.7 PacifiCorp form PCF-CT-INST Current Transformer Installation;

4.8 PacifiCorp form PCF-RLY-INST-Q509 Qualitrol 509-100 Installation;

4.9 PacifiCorp form PCF-MTR-INST-INCON Incon 1250 Installation;

4.10 PacifiCorp form PCF-RLY-INST-M2001C Beckwith M2001B/C Installation;

4.11 Field Sweep Frequency Response test reports generated from the test set, in both PDF and electronic raw data file format;

4.12 Power factor and excitation test results in both PDF and in electronic raw data files from Doble M4000 software; and

4.13 Impact recorder print-out or electronic recorded data file, if applicable.

5 Equipment used

5.1 Handheld digital multimeter;

5.2 TTR tester;

5.3 Sweep Frequency Response analyzer;

5.4 Insulation resistance tester;

5.5 Current transformer tester;

5.6 Oil quality sample containers;

5.7 DGA sample syringes;

5.8 Oil processing equipment, including cold trap unit;

5.9 Power factor testing equipment; and

5.10 Other equipment specific testers as may be needed.

6 Precautions

6.1 Follow all applicable PacifiCorp safety procedures.

6.2 Follow all testing precautions in referenced manuals, standards and procedures.

6.3 Follow all requirements from the confined space entry procedure.

7 Assembly and acceptance testing

7.1 Owner-installed transformers:

The activities listed in section 7.3 – 7.6 shall be performed and the results approved by the owner before the transformer is removed from the rail car or truck.

7.2 Vendor-installed transformers:

The activities listed in section 7.3 - 7.6 shall be performed as shortly as possible after the transformer has been placed on the pad or defined storage location.

7.3 Visual inspection – outside of transformer

7.3.1 Verify that the transformer main tank has a positive pressure. If pressure is not positive, contact the owner immediately.

7.3.2 Verify that there are no oil leaks.

7.3.3 Inspect for signs of impact or any other damage such as broken tie downs, movement, etc.

7.3.4 Inventory and inspect the auxiliary components (bushings, radiators, radiator fans, surge arrestors, device supports and braces, grounding materials, etc.). Refer to the manufacturer's parts list to inventory parts shipped separately from the transformer.

7.4 Impact recorder

7.4.1 For contractor-installed transformers, it is preferable for a PacifiCorp representative to witness the impact recorder inspection if mechanical chart-type impact recorders were used. Contact the project manager to make arrangements for a PacifiCorp representative to witness the impact recorder inspection. For electronic impact recorders for which the data can be interrogated remotely, copies of the data recording shall be submitted to owner for review before dress-out of the transformer may begin.

7.4.2 Obtain and review the impact recorder data. Paper recorders must be operational and recording. Data from electronic recorders must be downloaded and reviewed. If the equipment did not record or is not operational, contact the owner.

7.4.3 Record if any impacts were greater than three gravities (G). If impacts greater than three G's are discovered on the impact recorder, then the owner may require more acceptance testing. Contact substation technical services for determination of additional acceptance tests.

7.4.4 Stop work and contact the owner immediately if impacts of greater than five G's are noted. If the transformer is still on the rail car or truck, do not unload until a complete internal inspection is performed unless express permission from the owner has been received to proceed with offloading.

7.4.5 Impact recorder data (tapes, recordings or electronic data) must be included with the installation and testing documentation. The transformer serial number and equipment identification number shall be noted on the records.

7.5 Core ground test

7.5.1 If ship, rail car and/or trailer are used for transportation, a core ground test of each individual core ground connection shall be performed on the transformer before it is unloaded from all modes of transportation.

7.5.2 Perform the test per the "Core Ground Test" section located in procedure SP-INSRES. Record values on form SF-TRF-INST.

7.5.3 Contact owner's substation technical services representative immediately if the reading is below 1,000 megohms for new equipment or below 100 megohms for existing equipment. The test voltage shall be 1,000 VDC, unless the transformer manufacturer specifies a different test voltage.

7.6 Internal inspection

An internal inspection shall be performed on all transformers shipped without oil unless waived by the owner. Contact owner's substation technical services at least five business days before performing an internal inspection to verify whether a PacifiCorp representative will witness the internal inspection.

7.6.1 Precautions

7.6.1.1 Refer to the confined space entry procedure for requirements regarding breathing atmosphere monitoring and fall protection and retrieval equipment.

7.6.1.2 Keep all loose items (bolts, nuts, tools, etc.) on top of the transformer tank away from any open manhole lid.

7.6.1.3 Always apply a constant dry air purge when working internally to prevent atmospheric air from entering the transformer tank.

7.6.1.4 Never allow rain or snow to enter the transformer.

7.6.2 Visually inspect the inside of the transformer for any foreign materials such as metal filings, dirt or other abnormal conditions.

7.6.3 Visually inspect all accessible internal components for damage incurred during loading and shipping of the transformer.

7.6.4 If a PacifiCorp representative is not present for the inspection, notify the project manager and owner's substation technical services immediately if any abnormal conditions are found in the transformer.

7.6.5 If the transformer will be left overnight or for any period longer than 12 hours without oil inside, care should be taken to prevent moisture from entering the transformer. Fill the transformer with dry air or nitrogen to a minimum of two to three psig of pressure.

7.7 Sweep Frequency Response Analysis (SFRA) – Before removing the transformer from the rail car of trailer.

Note: This is only required if the transformer was shipped equipped with special test bushings for this purpose.

For large or critical transformers the owner may require the manufacturer to install special test bushings to elect to have a secondary set of SFRA tests performed on critical units. This set of tests shall typically be performed with the transformer still on the rail car or trailer, and the transformer will have special dummy test bushings installed for this purpose.

7.7.1 For transformers with dummy test bushings, a SFRA test must be performed in accordance with Doble Engineering's guide titled "Power Transformer – Test Specification Transformer Sweep Frequency Response Analysis Test" (version 5.2 dated October 2006).

7.7.2 The tests shall be performed using exactly the same test configurations and tap positions as those performed at the factory. The field test configuration and setup will be logged in the notes section in the SFRA setup. The following items shall be recorded in the test configuration, if applicable:

7.7.2.1 DETC position;

7.7.2.2 Neutral point grounded or ungrounded;

7.7.2.3 Tertiary windings open or closed or closed delta, grounded or ungrounded; and

7.7.2.4 LTC position.

7.7.3 Test results shall be compared to the equivalent tests performed by the manufacturer before the transformer was shipped from the factory. If any discrepancies are found, contact owner's substation technical services representative immediately.

7.7.4 Test results shall be labeled and identified for their purpose, date of test and location of test. The results shall be included with the final field test report and submitted to PacifiCorp documentation department on a CD-ROM in raw electronic data format (e.g. file.sfra) in addition to any other paper or scanned test reports.

7.8 Oil test - bulk oil

7.8.1 Draw an oil quality sample for laboratory analysis on bulk oil prior to filling the transformer, per owner's procedures SP-OIL-QUAL and SP-OIL-DGA.

7.8.2 Use form SF-OIL-DGA for logging the samples and submit the samples and form to a PacifiCorp-approved laboratory for analysis. A copy of the completed sample form shall be included with the documentation to be submitted to owner.

7.9 Assembly

7.9.1 Follow the manufacturer's assembly instructions with particular emphasis on the steps outline below.

7.9.2 Inspect the load tap changer for shipping damage, and follow manufacturer guidelines to complete any model specific installation tasks.

7.9.3 Verify that the bushings are not damaged or leaking and have correct oil levels.

7.9.4 Clean the top and bottom insulator surfaces and draw-lead tubes on all bushings prior to testing or installing in the transformer.

7.9.5 Perform power factor tests on all bushings prior to their installation. Measure C1 and C2 capacitances and power factor on bushings where test or voltage taps are available. Compare results to nameplate details and factory test report and contact owner's substation technical services for any anomalies.

7.9.6 Submit test equipment-generated report for bushing power-factor tests with installation forms. The original electronic data file generated by the test set shall be included on a CD-ROM in the "file.xml" format, in addition to any other scanned or paper documents. Label the test files to clearly indicate the purpose of the tests, date of tests and location of bushings.

7.9.7 Install components (bushings, radiators, radiator fans, surge arresters, oil pumps, device supports and braces, grounding materials, temperature and monitoring devices, etc.) in accordance with manufacturer instructions and layout diagrams.

7.9.8 If applicable, note the draw lead condition and length. Draw lead slack should not be greater than two inches.

7.9.9 Surge arresters that are made up of stacked units shall be checked to ensure the correct serial numbers are used in each phase stack and that they are properly assembled with each unit in the correct location relative to other units in the stack.

7.9.9.1 Verify that proper grounding connections are applied to all surge arresters.

7.9.9.2 Verify that surge arrester expulsion vents face away from bushings.

7.9.10 Do not re-use radiator, bushing or manhole cover gaskets used for shipping. Use new gaskets at all times.

7.9.11 Verify that all radiator valves are functional and the packing nuts are tight.

7.10 Oil processing and filling

7.10.1 The contractor is required to follow the owner's procedure for oil processing of transformers, procedure SPC-TRF- OILPROC. The transformer shall be dried out using the "Hot Oil Circulation Dry-out with Vacuum Fill" process, which shall include the use of a moisture trap (also known as a cold trap). Taking a dew point measurement to determine dryness in lieu of this dry-out method is not acceptable. Any substantial deviation from the owner's procedure shall be pre-approved prior to the contractor's mobilization to the work site.

7.10.2 Before filling the transformer with oil, the contractor shall perform a dielectric test of the oil, in addition to the oil quality sample described in section 7.8. If the oil dielectric test results differ by more than 15 percent from the manufacturer specification, the owner shall be contacted immediately before the oil is introduced into the transformer. Filling shall not proceed until owner approval has been obtained.

7.10.3 Fill the transformer with oil referencing the "Field Oil Filling Procedure" nameplate and using the procedure for oil processing of transformer – SPC-TRF-OILPROC. Use form SFC-TRF-OILPROC to record all pertinent data as described in the procedure.

7.10.4 After filling the transformer with oil, check that all valves are in their normal operating position (radiators, conservator, nitrogen, etc.).

7.11 Oil tests - baseline

Draw an oil quality sample and dissolved gas analysis sample from the transformer per procedures SP-OIL-QUAL and SP-OIL-DGA. Use form SF-OIL-DGA for both samples and submit samples to a PacifiCorp-approved laboratory for analysis. The results of these oil samples shall be included in the final field installation documentation package.

7.12 Core ground test – after assembly

7.12.1 Perform an additional core ground test for each separate core ground connection after the transformer is fully assembled and placed on the pad, per the core ground test procedure located in procedure SP-INSRES. Record the values on form SF-TRF-INST.

Note: **Contact owner's substation technical services representative immediately if the reading is below 1,000 megohms for new transformers or below 100 megohms for existing transformers. The test voltage shall be 1,000 VDC.**

7.12.2 All core ground straps must be reconnected to the end frame after tests, and external bushing or ground connections made up for normal operation according to manufacturer instructions.

7.13 Transformer turns ratio (TTR) test

7.13.1 Testing of transformers without Load Tap Changers (LTC) shall include measuring the ratios on all five de-energized tap changer (DETC) positions.

7.13.2 For transformers with LTCs, measurements of the ratios on LTC positions 16 Lower through 16 Raise shall be completed with the DETC in the position that it will be in during normal operation of the transformer. Contact the project manager to determine the final operational position of the DETC before performing the tests.

7.13.3 Testing results shall be recorded on form SF-TTR. If an electronic TTR test set is used, the test set generated data file together with a printout of the electronic test results (in PDF format) shall be attached to form SF-TTR. Filling out of the calculated and measured results on form SF-TTR is not required if electronic test results are attached.

7.13.4 Any test values that are not within the acceptable criteria outlined in section 9 of this document or as specified in the procedure SP-TTR shall be brought to the attention of owner's substation technical services representative immediately.

7.14 Power factor/exciting current test

7.14.1 Power factor tests

7.14.1.1 Power factor testing shall be done in accordance with the test equipment manufacturer's published data.

7.14.1.2 Perform a overall power factor test on all windings and the oil.

7.14.1.3 Repeat C1 and C2 power factor tests on all bushings that have potential taps after bushing installation.

7.14.1.4 Any test results that deviate from acceptable industry standards or the manufacturer's published acceptable values shall be brought to the attention of owner's substation technical services representative.

7.14.1.5 In addition to a printed or PDF report, the original electronic test file in original Doble software raw data format (file.xml) will be included on a CD-ROM or in the email message together with the rest of the documentation package for owner review.

7.14.2 Excitation tests

7.14.2.1 Exciting current testing shall be done in accordance with the test equipment manufacturer's published data.

7.14.2.2 Perform exciting current tests on all de-energized tap positions. If the transformer has an LTC and a DETC, place the LTC in neutral while testing all the DETC positions.

7.14.2.3 Perform exciting current tests on all LTC positions from 16L-16R with the de-energized tap changer on the final de-energized tap position per protection and control relay settings sheet.

7.14.2.4 Any test results that deviate from the manufacturer's published acceptable values shall be brought to the attention of owner's substation technical services representative.

7.14.2.5 In addition to any printed reports, the original electronic test file in original Doble software raw data format (file.xml) will be included on a CD-ROM together with the rest of the documentation package for owner review.

7.15 Sweep Frequency Response Analysis (SFRA)

7.15.1 A sweep frequency test is required once the transformer is installed in its final position.

7.15.2 Perform Sweep Frequency Analysis Test in accordance with Doble Engineering's guide titled "Power Transformer – Test Specification Transformer Sweep Frequency Response Analysis Test" (version 5.2, dated October 2006).

7.15.3 This guide is available from Doble Engineering, or a copy can be obtained from owner's substation technical services.

7.15.4 The tests shall be performed using exactly the same test configurations and tap positions as those performed at the factory. The field test configuration and setup will be logged in the notes section in the SFRA setup. The following items shall be recorded in the test configuration, if applicable:

7.15.4.1 DETC position;

7.15.4.2 Neutral point grounded or ungrounded;

7.15.4.3 Tertiary windings: open; closed delta; buried; accessible; grounded or ungrounded; and

7.15.4.4 LTC position.

7.15.5 These test results shall be compared to the equivalent tests performed by the manufacturer prior to shipping the transformer. If any discrepancies are found, contact owner's substation technical services representative immediately.

7.15.6 If the standard configuration tests for the specific winding layout are different from the tests performed at the factory, repeat a full set of tests in the recommended test positions as described in the Doble Engineering test specification listed in 7.15.2 to obtain a set of standardized baseline tests for future reference.

7.15.7 All test results shall be submitted to the PacifiCorp documentation department on a CD-ROM in original electronic Doble software raw data format (file.sfra), in addition to any other paper or scanned test reports. If more than one set of tests were performed, each shall be clearly identified for the exact purpose both in the software comments and in the documentation submittals.

7.16 Insulation resistance test

Caution: Any DC test may magnetize the core.

7.16.1 Perform an insulation resistance test as per procedure SP-INSRES.

7.16.2 Use form SF-INSRES-XXX Insulation Resistance (where XXX represents the letters used for the specific configuration of transformer) to record the test results.

7.17 Test and calibrate all auxiliary devices.

Perform operational and calibration checks on all applicable auxiliary devices listed below. This list may not include all transformer auxiliary devices installed on the transformer. Additional devices not listed in this document may also need testing.

7.17.1 Fans

Each fan shall be checked for proper operation. Test shall include a check for correct fan rotation.

7.17.2 Pumps, if applicable

Each pump shall be bump tested for proper operation. Check each oil pump flow indicator to ensure proper operation and pump rotation.

7.17.3 Temperature gauges, if applicable

7.17.3.1 Each temperature gauge and its micro-switch contacts (for fans, alarming and tripping) shall be checked for proper operation.

7.17.3.2 Contact temperature set points shall be set per PacifiCorp's transformer specification.

7.17.3.3 The alarm and trip logic shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.3.4 Record the transformer oil temperature as indicated on each gauge on form SF-TRF-INST.

7.17.4 Liquid level gauges

7.17.4.1 Each liquid level gauge and its micro-switch contacts (alarming and tripping) shall be checked for proper operation.

7.17.4.2 The alarm and trip logic shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.4.3 Record the liquid level as indicated on each gauge on form SF-TRF-INST.

7.17.5 Pressure relief device

7.17.5.1 Inspect the pressure relief device(s) and assemble the yellow operate flag.

7.17.5.2 Each pressure relief device shall be inspected and its alarm contacts shall be checked for proper operation.

7.17.5.3 The alarm contacts shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.6 Sudden pressure relay

7.17.6.1 Each sudden pressure relay and associated seal-in auxiliary relay shall be tested for proper operation.

7.17.6.2 The sudden pressure relay shall be mechanically tested per the testing procedures outlined in the Qualitrol device manual.

7.17.6.3 All auxiliary seal-in relay contacts shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.7 Current transformers

7.17.7.1 Current transformers shall be tested per procedure PCP-CT-INST – Current Transformer Installation.

7.17.7.2 Use form PCF-CT-INST – Current Transformer Installation to record the test results.

7.17.8 Temperature monitor/controller

7.17.8.1 Test and set the Qualitrol 509 electronic temperature control device per procedure PCP-RLY-INST-Q509 – Qualitrol 509 Installation.

7.17.8.2 Use form PCF –RLY-INST-Q509 – Qualitrol 509-100 Installation to record the test results.

7.17.9 LTC position indicator

7.17.9.1 Test and set the LTC position indicator and accessories per procedure PCP-MTR-INST-INCON – Incon 1250 Installation.

7.17.9.2 Use form PCF –RLY-INST-INCON – Incon 1250 Installation to record the test results.

7.17.10 LTC controller

7.17.10.1 Test and set the LTC electronic controls per procedure PCP-RLY-M2001C - Beckwith M-2001B/C Installation.

7.17.10.2 Use form PCF-RLY-INST-M2001B – Beckwith M2001B/C Installation to record results.

7.17.11 Nitrogen system, if applicable

7.17.11.1 The nitrogen system shall be tested to ensure the system regulates correctly and that there are no leaks.

7.17.11.2 Testing shall be done per the manufacturer’s testing procedures.

7.17.11.3 All micro-switch alarm contacts (empty cylinder, high pressure, low pressure, etc.) shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.11.4 Record the pressure indicated on gauge on form SF-TRF-INST.

7.17.12 Cooling loss of power

7.17.12.1 Each under-voltage alarm relay shall be tested for proper operation.

7.17.12.2 Relay contacts will be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.13 LTC failure, if applicable

7.17.13.1 The LTC failure indication alarm shall be tested for proper operation in accordance with the manufacturer’s specifications.

7.17.13.2 The alarm contact shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.14 LTC vacuum interrupter protection circuit

7.17.14.1 Verify correct operation of the LTC vacuum interrupter protection circuit in accordance with manufacturer instructions.

7.17.15 LTC filter, if applicable

7.17.15.1 The LTC filter indication alarm shall be tested for proper operation in accordance with the manufacturer’s specifications.

7.17.15.2 The alarm contact shall be consistent with the transformer wiring diagrams and schematics, and verified at the transformer output terminal blocks.

7.17.16 Desiccant/dehydrating breathers, if applicable

7.17.16.1 Verify that desiccant breathers for both the main tank and LTC compartment are assembled in accordance with the manufacturer’s instructions.

7.17.16.2 Verify that the breathing cups are properly filled with oil, and that the desiccant containers are properly filled with new desiccant.

8 Spare transformers or transformers installed in a temporary location

Transformers that are designated to be stored as spares or that will be installed in temporary location shall be handled in the same manner as transformers that are to be installed ready to be energized, with the following additional requirements:

8.1 On a case by case basis, and only with specific prior approval from owner's substation technical services: Transformers that are already earmarked for installation in a substation and that will be in temporary storage for less than three months may be exempted from oil filling, dress out and testing until they are moved to their final destination. Contact owner's substation technical services for approval and specific instructions before work is started.

8.2 Unless specific other instructions are provided by PacifiCorp, transformers shall be installed on suitable treated timbers. Timbers shall be of quality and size that they will withstand the weight of the transformer and they shall be treated to withstand years of outdoor exposure.

8.3 Unless specific other instructions were provided by PacifiCorp, radiators and radiator fans will not be installed.

8.3.1 Radiators shall be filled with nitrogen to keep moisture from coming in contact with the radiator internal walls.

8.4 Transformers that are filled with oil but without the radiators installed shall be overfilled to compensate for the oil that would normally be contained by the radiators. The purpose of this is to minimize or avoid the need for make-up oil once the radiators are installed at a later date.

Warning: Verify that sufficient expansion space remains in the overfilled transformer to prevent damage due to expansion of oil as a result of ambient temperature changes.

8.5 If make-up oil has to be added to a transformer it shall be added by following all the requirements of owner procedure SPC-TRF-OILPROC. Oil that is added shall be processed by degassing and heating first. A vacuum shall not be pulled on an oil-filled transformer before adding oil. Contact owner's substation technical services for specific arrangements.

8.6 All equipment and accessories shall be installed and tested as described in this document, with the exception of the radiators, cooling fans and surge arresters.

Note: If electrical power is not readily available for testing purposes, the installer shall make the necessary arrangements to provide power through the use of a portable generator.

8.7 After all testing has been completed, short all bushings together with suitable copper wire. The shorted bushings shall then be connected to the tank wall and ground, if possible.

8.8 If site AC power is available, connect the power source to the transformer to power the control cabinet heaters during storage.

8.9 Any miscellaneous parts associated with the transformer that are not installed on the transformer shall be clearly marked using a weather-resistant method and stored near the transformer.

8.9.1 This would include items such as radiators, fans, cooling pumps, surge arresters, arrester brackets, bushing cover plates, etc.

8.9.2 All such accessories shall be stored on pallets and covered with tarpaulins in a manner that will ensure they will not be damaged if stored for any length of time. The pallets shall be located to allow easy access so they can be ready for shipment in a short period of time.

9 Minimum acceptance criteria

In order for the owner to accept the transformer as being ready for service, the following acceptance criteria apply for new transformers. If the transformer fails to pass any of the tests below, corrective action will have to be negotiated with the owner before the transformer can be accepted.

9.1 TTR test

The TTR test shall test for correct ratio on all five DETC positions. For transformers with LTC the TTR test shall test for correct ratio on steps 16L through 16R.

9.1.1 No deviation greater than 0.5 percent from the manufacturer factory acceptance test results is accepted. Each tap position (16L through16R) must be tested with the de-energized tap changer in the nominal position.

9.2 Power factor test

9.2.1 Overall power factor and bushing tests should have no more than 0.5 percent deviation from nameplate or factory tests, with a maximum absolute power factor value of 0.5 percent. Perform C1 and C2 bushing power factor tests. All tests should have a pass rating assigned by the internal software analysis feature, if applicable.

9.3 Excitation test

9.3.1 No mismatch greater than 0.5 percent from the factory test results is accepted.

9.3.2 The core shall not be magnetized. If any test results indicate the core may be magnetized, the core shall be demagnetized and the excitation and SFRA tests shall be repeated.

9.3.3 Tests shall be performed with the de-energized tap changer in the final in-service tap position, and all load tap changer positions from 16L – 16R.

9.4 Insulation resistance tests (core ground and windings)

9.4.1 Minimum of 1,000 megohms for new transformers, and minimum 100 megohms for used transformers is required.

9.5 Accessories

9.5.1 All mechanical and electrical accessories must be installed and functioning as designed.

9.6 Documentation

9.6.1 All receiving and installation checks and tests must be documented and submitted as described in section 10.

10 Post-installation activities and documentation submittals

10.1 Once all installation activities have been completed, all pallets, scrap materials and other shipping or assembly materials that are no longer needed or used shall be properly disposed of. The work area around the transformer shall be left in similar condition as when the work started.

10.2 Failure to submit proper test reports as described below may lead to a delay of acceptance of the transformer by the owner. Equipment shall not be energized under any circumstances if all installation and test reports have not been reviewed and accepted by the owner. In addition, delays in submitting test reports may result in a delay of payment to the manufacturer or contractor. Field copies of installation tests and reports shall be submitted to owner for review during and no less than two days after completion of installation work. After all installation and testing is completed, a final field installation test report shall be submitted that shall include the following information:

10.2.1 A cover page listing the transformer test location, transformer serial number, transformer purchase order (PO) number, transformer equipment number (SAP number), date of tests, name of test company and their test personnel contact numbers.

10.2.2 An index page listing all test results included in the report.

10.2.3 Doble power factor and excitation electronic data test files (in "file.xml" format) and Doble SFRA electronic data test files (in "file.sfra" format) shall be included with the electronic test report as attachments in addition to any other printed results for those tests.

10.2.4 Final copies of all field installation forms used for recording accessory inspections, testing or verification and electrical test results such as transformer turns ratio, insulation resistance (e.g. Megger) and vacuum processing log sheets shall be included as attachments with the test report.

10.2.5 Copies of lab test results for oil samples (DGA and oil quality, corrosive sulfur, etc.) shall be included with the test report.

10.3 All test reports shall be signed and dated by the test personnel who performed the work. Contact details for test personnel shall be provided.

Substation:	Relay Equipment Memorandum	Today's Date:
Equipment Protected:	Power Delivery Form 006F Forward via email to Equipment Memorandums (equipmemo@pacificorp.com); or internal mail to 1500 LCT Form Rev Date: 6/10/2011 R8	Commissioning Testing Date:
Work Order #:	☐Main Grid ☐Local ☐Distribution ☐Power Supply / ☐ Direct Assigned Equipment Entity/Utility:__________________	Completed By:

Complete this form when <u>any</u> programmable/settable equipment utilized in protection systems or to interface with SCADA or other communication systems is installed or removed.

Examples Include: ▪ Annunciator ▪ HMI ▪ Interchange Meters ▪Jurisdictional Load Meters ▪Programmable Logic Controller ▪Sequence of Events or Digital Fault Recorder ▪Modems/Line Sharing Switches/Communications Processors ▪Automation Controllers ▪Digital/Analog Transducers ▪Satellite Clocks ▪Pilot Protection Equipment ▪Relays; major and all auxiliary relays such as lockout, breaker failure, thermal, trip indication, etc.

Relay Equipment INSTALLED:

☐ Update to Existing Relays in Package ☐ Installed New Relay Package ☐ Other Equipment Installed; Type__________________
(or circle above equipment type)

IEEE #	Mfg.	Mfg. Date	Type	Part #	Serial #	I.L. #	Supply Voltage	Internal Battery	Mstr Warrnty#	SAP # (if known)
								☐		
								☐		
								☐		
								☐		
								☐		
								☐		
								☐		

Relay Equipment REMOVED:

☐ Individual Relays Removed: ______________________________

____

____

☐ Relay Package Removed; SAP # ______________________
(including all individual relays in package)

☐ Other Equipment Removed; SAP # ______________________

For Asset Management Use ONLY:

WECC Priority ☐ YES ☐ NO
Type__________________

Completed By__________________; P#______________; Date______________; Area______________ PCM PKG#__________

Reviewed By__________________; P#______________; Date______________ PMP Type__________________

6B.5—Fence Application and Construction

1. Scope

This standard covers the construction requirements for permanent fencing around company substations or substation equipment. This standard shall also be used as an attachment to construction contracts for fence installation. The design considerations covered by this fencing application and construction standard are as follows:

1. Fence safety clearances
2. Curbed fence installations
3. Fence isolation sections
4. Removable fence section
5. Fence relocation
6. Cantilever gates

2. References

ANSI/IEEE C2, *National Electrical Safety Code (NESC)*

Company Substation and High-Voltage Equipment Engineering Handbook 6B.6, *Substation Grounding*

Company Construction Standard SG 001, *Substation High-Voltage Warning Signs*

PacifiCorp Standard Fence Drawings SR001, *Fence Plan & Details, Curbed*

PacifiCorp Standard Fence Drawings SR002, *Fence Plan & Details, Non-Curbed*

Company Standard Construction Specification 02810, *Chain Link Fencing and Gates*

Company Standard Construction Specification 02815, *Cantilever Slide Gate*

3. General

Fences are required to be installed around electrical equipment to minimize the possibility of entrance by unauthorized persons. This requirement includes platform mounted transformers and regulators that do not meet above ground equipment clearances.

3.1. Compliance with NESC

The construction of the fence must comply with NESC.

3.2. Grounding Requirements

Fences installed at electrical facilities typically must be grounded. All fence grounding shall be installed per 6B.6, *Substation Grounding*.

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3.3. Locked Entrance

Entrances through fences not under observation of an authorized attendant shall be kept locked.

3.4. Isolation of Fences

Company substation fences shall not be connected to any other fence. See Subsection 5, *Fence Isolation Sections*, for additional information.

3.5. Clearances from Structures

The minimum distance that the fence should be installed from any substation structure supporting a live part shall be based on Section 7 of this standard. Any objects inside or outside the substation should not be located within a restricted zone. The minimum restricted zone shall be ±5 feet wide and 16 feet high; see Figure 3. If the minimum five (5) feet distance cannot be met, measures should be taken to prevent the likelihood of a person using the object to gain access to the substation. The restricted zone outside the substation fence may be used for the planting of screening vegetation, as long as it is not climbable by a person.

3.6. Curbing at Fence Line

Curbing at the fence line should be installed around new substations that are being constructed in higher security areas as determined by operations management. The purpose of the curbed fences is to prevent entrance under substation fences. Curbing at the fence line can also be installed to provide oil containment. Details for curbed fences are indicated in drawing SR001.

4. Fence Construction

The fence shall be constructed of chain link, unless noted otherwise, and shall be installed in strict compliance with furnished plans and these standards. Installation shall use good workmanship by skilled craftsmen, experienced in erection of this type of fencing. The fence shall be erected on the lines and to the grade as provided by the company. Unless project specific construction drawings and specifications are provided, the following documents shall be used for installation of the fence:

PacifiCorp Standard Fence Drawings SR001, *Fence Plan & Details, Curbed*

PacifiCorp Standard Fence Drawings SR002, *Fence Plan & Details, Non-Curbed*

Company Standard Construction Specification 02810, *Chain Link Fencing and Gates*

Company Standard Construction Specification 02815, *Cantilever Slide Gate*

These documents provide information on the fence materials, details of construction for the fences with and without curbs, typical swing gates and cantilevered gates, man gates and fence isolation sections. Unless indicated otherwise, the normal drive gate should be a 24-foot wide double swing gate.

4.1. Warning Signs

Warning signs shall be placed on all gates and on each straight fence run. Signs shall be placed on each fence run starting five (5) feet from the corner and at 65-foot maximum spacing. The “Warning! Hazardous Voltage Inside Keep Out” signs shall be placed five (5) feet above grade level as measured from the bottom of the sign. The “No Trespassing” sign should be placed at the same five foot level and immediately to the left or right of the warning sign. Approved signs are listed below:

- Warning! Hazardous Voltage Inside Keep Out (RMP):

  SI# 7999852

- Warning! Hazardous Voltage Inside Keep Out (PP):

  SI# 7999851

Mounting Hardware: SI# 7999092

The mounting hardware is comprised of aluminum brackets with one-inch tamper-proof bolts and locking nuts. The bolts are installed through the sign’s front, and screw into the aluminum brackets located on the interior of the fence. Four sets of mounting hardware are needed for each sign.

Drawings SR001 and SR002 indicate the placement locations for fence signs.

4.2. Inward-Opening Gate

In substations where there is limited property, such that the ground grid cannot be extended four (4) feet out from the gate swing radius, the gate shall be limited to opening inward only, with gate catches installed as shown in Figure 1. Gates so designated shall be equipped with 180° hinges to restrict gate opening.

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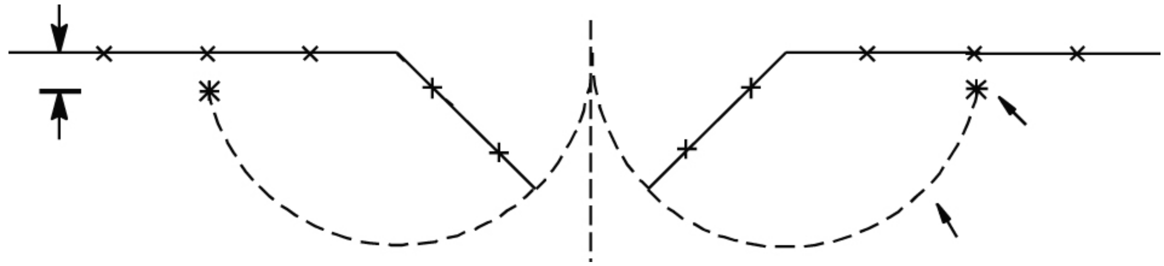

Figure 1—Inward Gate Swing

In substations where the ground grid has been extended outside the gate swing radius, gate catches shall be installed as shown in Figure 2.

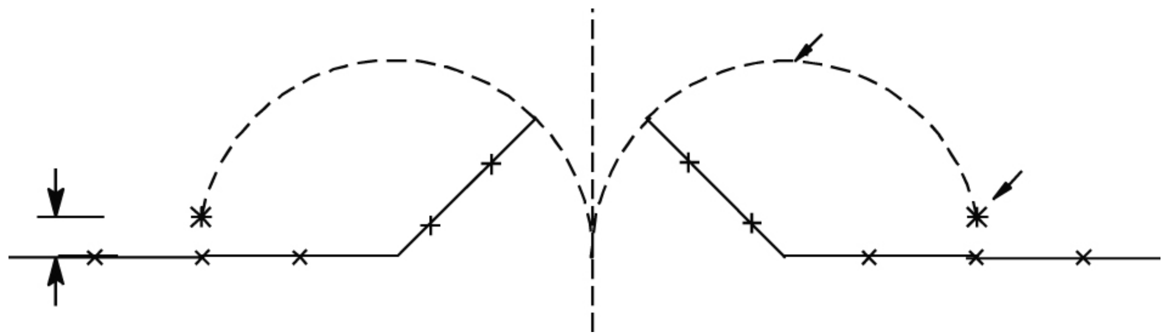

Figure 2—Outward Gate Swing

5. Fence Isolation Sections

When a company substation fence is to be adjacent to any other fence, an intermediate section of fence must isolate the two sections of fences. Details for construction of fence isolation panels are indicated in Drawings SR001 and SR002 for curbed and non-curbed fences respectively.

6. Removable Fence Section

A removable fence section may be required in substations with limited property to facilitate the removal of station equipment. Where feasible, a gate should be installed instead of a removal fence section. When a gate cannot be provided, the civil engineering department should be contacted for a custom designed removable fence section.

7. Fence Safety Clearances

Safety and operating clearance zones that are illustrated in Table 1 and Table 2 respectively shall be maintained when designing the substation fence location. These safety zones are designed to prevent contact with live parts by a person inserting an object through the substation fence. The fence should be located such that all live parts are outside the safety zone. The operating clearance zone is designed to allow adequate space between the fence and equipment for operation and maintenance purposes. The more stringent of the two requirements shall govern when designing the fence location. See Figure 3 for an example of a 12.5 kV substation.

Table 1—Fence Safety Clearances
(Dimensions for use with Figure 3)

Nominal Voltage (Between Phases)	Dimensions "A" (Vertical)		Dimension "B" (Horizontal)	
(volts)	(feet)	(meters)	(feet)	(meters)
151–34500	15.0	4.6	11.0	3.4
46000– 69000	16.0	4.9	12.0	3.7
115000	17.0	5.2	13.0	4.0
138000	17.0	5.2	14.0	4.3
161000	18.0	5.5	15.0	4.6
230000	19.0	5.8	16.0	4.9
345000	21.0	6.4	20.0	6.1
500000	25.0	7.6	23.0	7.0

Table 2—Fence Operating Clearances
(Dimensions for use with Figure 3)

Equipment Type	Dimension "B" (Horizontal)
Fuse Structure of Disconnect Switches	20 feet
Operation Handles of Airbreak Switches	15 feet
Structures where there is no equipment	10 feet

Notes:

1. Dimension A is equal to the vertical clearance of wires, conductors, and cables above spaces and ways subject to pedestrians or restricted traffic only (ANSI C2 [1], rules 232A and 232B, and table 232−1, 5) for the voltage considered. All vertical clearances are rounded up.
2. The B dimension is the horizontal clearance to unguarded live parts in electric-supply stations (ANSI C2(1), Rule 110A.2 and table 110-1). The clearance dimensions are rounded up and increased for 345 and 500 kV voltages to match the recommended values used in the company Engineering Handbook Section 6B.10, *Minimum Clearances for Substation Electrical Conductors*.
3. The values shown for dimension A for nominal voltages between phases of 115 kV and above should be increased 3% for each 1000 feet (300 m.) elevation in excess of 3300 feet (1000 m.) above mean sea level.

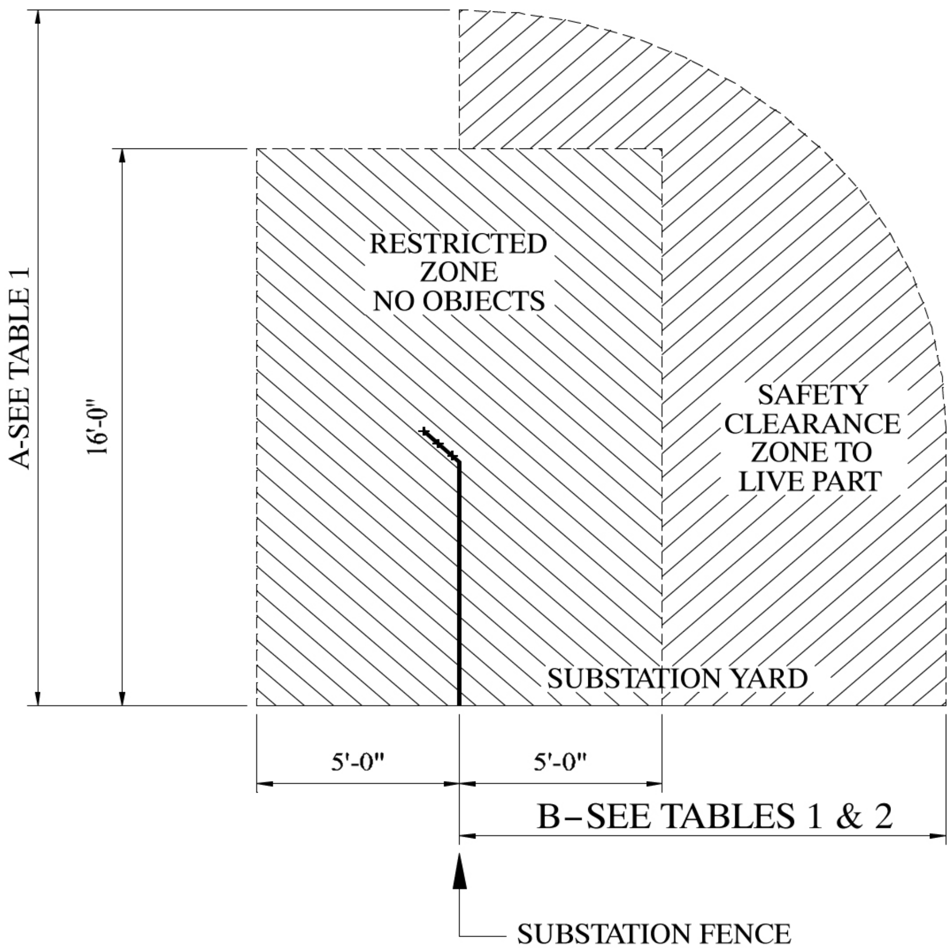

Figure 3—Safety Clearance for Substation Fence

8. Fence Relocation

8.1. Expansion of Substations

When specified in the contract documents, portions of an existing fence shall be removed and relocated (only if existing fence fabric and overall height meets current 8'- 0" height requirements), in accordance with these specifications and drawings furnished. The following fence materials may be reused if in good condition: Fabric, brace, rail and top rail, stretcher bars, truss rods, truss bands, security wire, gate frames and gate hardware. Reused fence materials shall be removed and handled with care so as not to damage them. New bottom tension wire and hog ties must be installed, and fence posts shall not be reused. All fence materials which are not reinstalled shall be returned to the nearest company warehouse unless stated differently in the contract.

When relocating an existing fence, the contractor shall coordinate the work so that security is maintained at all times.

Fence signs installed must be compliant with this standard.

8.2. New Fence to Existing Fence

When enlarging a substation by installing a new fence to an existing substation, the new fence shall meet the current fence height standard of eight (8) feet zero (0) inches (including barb wire). Details for joining unequal height fences are indicated in drawings SR001 and SR002.

9. Cantilever Gates

Cantilever gates may be required in substations with limited property to facilitate the removal of station equipment, or to accommodate a wider gate for mobiles and large equipment. If a cantilever gate is deemed necessary, the civil engineering department shall be consulted.

10. Handbook Issuing Department

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history, and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to Iuda Morar (503) 813-6937 or Perumal Radhakrishnan, (503) 813-5699, substation standards engineering. This handbook document shall be used and duplicated only in support of company projects.

6B.6—Substation Grounding

1. Scope

This standard covers the general requirements for the construction of company substation grounding systems. It outlines ground mat construction and required grounding connections. The methods outlined herein are nationally-recognized grounding procedures.

2. References

The latest revisions of the following documents apply to the extent specified herein:

IEEE 80, *Guide for Safety in AC Substation Grounding*

IEEE 81, *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System*

IEEE 1036, *Guide for the Application of Shunt Power Capacitors*

AASHTO T 27, *Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates*

AASHTO T 335, *Standard Method of Test for Determining the Percentage of Fracture in Coarse Aggregate*

ASTM D5821, *Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate*

Should a conflict arise between the reference documents and parts of this document, the more stringent requirement as determined by the company will prevail.

3. General

3.1. Primary Functions

The primary function of the substation grounding system is to increase safety, both to persons and property. Secondarily, it aids in system operation. Adequate ground systems are essential to attain low ground resistance and safe ground voltage gradients within and adjacent to substations yards. The specifications set forth herein shall be followed as closely as possible to ensure the safety of company personnel and the general public.

3.2. Requirements and Philosophy

The company requires its substations, and substations of other ownership connected to its system to have grounding systems which limit "touch-" and "step-voltages" to safe levels during ground fault events.

Touch-voltages are voltages, developed during ground fault events across a person in contact with any piece of equipment connected to the substation ground mat and the earth on which they are standing. Step-voltages are voltages developed between the feet of a person walking in (or near) the substation, during ground fault events.

Permitted touch- and step-voltages are based on industry standards, specifically the recommendations in IEEE 80. This guide shall also be used as a basis for the calculations associated with company standards contained herein. Safe grounding designs in substations are used to meet the following objectives:

- to provide a means to carry electric currents to ground under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service
- to ensure that any person in the immediate area of the grounding facilities is not exposed to any danger of critical shock.

The general philosophy regarding resistance of substation grounding is, "the lower the better," with considerations for economics. The resistance from the ground mat to earth shall be one ohm, or less, for transmission substations and other large electrical facilities. In smaller distribution substations the acceptable range is usually from one to five ohms, depending on the local conditions. Resistance values of more than one ohm shall be brought to the immediate attention of substation engineering.

A ground mat resistance to earth of one ohm generally is adequate to:

1. protect personnel from injury and property from damage by high-voltage surges resulting from lightning, switching, or other causes
2. handle discharge currents from lightning arresters, spark gaps, and other similar devices
3. provide a ground return path for grounded-wye generators and transformers
4. provide stable ground conditions for protective relays
5. improve the reliability of electric process controls, computers, and communication circuits by making low-resistance ground connections accessible

4. Grounding Design

Substation grounding design shall provide a continuous grounding system consisting of a buried main ground grid with ground rods. All equipment, structures, fencing, gates, and buildings shall be connected to the main ground grid. All ground grid conductors which are below the surface shall be bonded at each joint, and at each ground rod, by Cadweld exothermic connections.

4.1. Wire Sizes and Requirements

All ground wires shall be bare and free of any insulation, except as otherwise specified herein.

4.1.1. Main Ground Grid

The main ground grid shall be constructed of 4/0 copper wire, soft-drawn, 19-strand copper wire for substations with a maximum available fault current of 30 kA or less (for one second) and 500 kcmil, soft-drawn, 37-strand copper wire for substations with a maximum available fault current above 30 kA. When expanding existing substations that were built with ground grid wire of 250 kcmil copper, the same ground wire shall be used. The main ground grid shall never be constructed with wire smaller than 4/0 copper.

4.1.2. Equipment

The minimum conductor size used for grounding major substation equipment such as power transformers, circuit breakers, regulators, and capacitor frames, shall be 4/0 soft-drawn copper wire.

Other substation equipment shall be grounded with copper wire as specified in Table 1.

Ground wire sizes shall be indicated on the grounding plan, grounding details, and other drawings as necessary to ensure the installation of ground conductors as specified in Table 1. Where wire is liable to be damaged, larger sizes shall be substituted or protection shall be provided.

Table 1—Wire Size for Grounding of Substation Equipment

Equipment	Copper Wire Size
Steel structures	4/0
Coupling capacitors, instrument transformers, and station service transformers	4/0
Surge arresters	4/0
Distribution-class surge arresters	#2 or larger
Grounding switches	4/0
Switch and fuse bases on wood poles	4/0
Switch-operating mechanism	4/0
Independent yard light supports, steel buildings, metal enclosures, and fencing	#4 or larger
Steel switchboard panels	#6
Meters, relays, and similar equipment on insulating panels	#10

4.2. Main Ground Grid

The main ground grid design shall provide a continuous ground system consisting of copper wire as specified in section 4.1.1, buried 18″ below subgrade and spaced in a grid pattern designed to meet the IEEE-80 requirement for safe “touch-” and “step-voltages.” The ground grid shall be designed for site-specific conditions using the CDEGS software program. When the frost level in the given area is deeper than 18″, a calculation to account for the frozen-soil effect should be performed using Soil Model Manager (a CDEGS module) to determine the worst case soil condition that the grounding grid should be designed for. All ground rods, grids, and structures within the substation shall be connected to the main ground grid.

When solid rock or other poor ground conditions are encountered, substation engineering shall be advised, so that a special grounding system can be designed and installed.

4.2.1. Peripheral Ground Conductors

Peripheral ground conductors shall be installed 4′ inside and outside the fence, parallel to the fence. The peripheral ground conductor shall be constructed of the same copper wire as the main ground grid, buried 18″ below subgrade and connected to the main ground grid at intervals equal to the pattern of the main ground grid. No building, metallic fence, or conductive structure of any kind shall be located between the fence and the property line.

4.2.2. Gate Grounding

A ground grid shall be installed at gates in such a way that a person in contact with the gate during opening and closing will always be standing over the grid. Gate grounding grids shall be connected directly to the peripheral ground conductors and to the main ground grid.

4.2.3. Ground Rods

Ground rod requirements shall be as specified in this subsection. Ground rods shall be ⅝″ diameter copperweld, and 8′ long. Ground rods shall be fully driven below the surface of the earth.

Ground rods shall be connected to the ground grid with approximately equal spacing within the yard, and along the fence. The normal maximum spacing shall be 50′.

One ground rod shall be installed for every grid connection at power transformers. One ground rod shall be located within 2′ of the point where major equipment neutrals connect with the main ground grid. If there are large areas within the substation fence that are not immediately used, rod spacing may be increased to approximately double the spacing in other areas.

4.3. Structure Grounding

All steel structures and all miscellaneous steel, including light framework, steel support structures, and metal buildings, shall be solidly connected to the main ground grid with 4/0 copper wire.

All line and bus support structures shall be connected to the ground grid at each column. Each switch structure, or other similar structures, shall be connected to the ground grid at two columns, preferably at two diagonally opposite columns. One grounded column will suffice on small structures supporting a single instrument transformer, surge arrester, or other similar equipment.

The substation ground system shall be bonded at one point to each water system present within the substation.

4.4. Equipment Grounding

All system neutrals, surge arresters, grounding devices, transformers, reactors, circuit breakers and similar equipment bases shall be connected to the main ground grid with 4/0 copper wire.

Surge arresters, spill gaps, grounding switches, metal housings, equipment guards, and all metallic non-current-carrying parts of current-carrying devices shall be solidly tied with grounding conductors to the main ground grid system except as follows:

1. In cases where system requirements dictate that transmission line overhead shield wires (located in substations) shall be isolated from the substation ground grid, the shield wires shall be terminated using insulated deadends.
2. In cases where it is desirable to ground overhead shield wires to substation ground grids, grounding steel support structures to the main grid shall be considered adequate for the overhead shield wires.
3. Switch and fuse bases attached to steel structures shall be considered adequately grounded through the steel and the main ground connection.

Grounding requirements for overhead transmission lines shall be dictated by overall system requirements and shall be addressed on a per-project basis.

Operating handles of group-operated switches shall be grounded directly to the main ground grid. A protective, galvanized, steel switch ground plate shall be provided for installations above 25 kV. The switch handle shall be connected directly to the main grid with a single run of 4/0 copper wire and a flexible copper strap. The switch handle shall be directly bonded to a switch ground plate. Two diagonally opposite corners of the switch ground plate shall be connected to the ground grid. The switch ground plate shall be located on top of the finish crushed rock layer and shall be of an adequate size and be positioned such that the switch operator’s feet will never be outside the perimeter of the ground plate during switching operation.

4.5. Transformer Grounding

Transformer tanks shall be connected to the main grid at two points located at diagonally opposite corners of the tank.

Neutrals of grounded-wye-connected power transformers shall be connected to the main ground grid using two parallel 4/0 copper wires. These grounding copper wires shall be connected to the main ground grid through a PVC pipe attached to the transformer tank by the transformer manufacturer.

Lightning arresters shall be grounded to the main ground grid with 4/0 copper wire.

One ground rod shall be installed within 2′ of the point where the transformer neutral interconnects with the main ground grid. One ground rod shall be installed for each neutral and each lightning arrester ground connection to the main ground grid.

ROCKY MOUNTAIN POWER
PACIFIC POWER

The neutrals, or grounded side, of wye-connected instrument and station service transformer primaries shall be solidly connected to the main ground system with 4/0 copper wire.

Neutrals of instrument transformer secondaries, whether that of a single transformer or a set of interconnected transformers, shall be grounded at one point only. This also applies to certain types of secondary circuit interconnections, such as differential relaying or current totalizing, and any auxiliary transformers that may be required in the circuit. The location for the connection to the main ground system shall be at the switchboard and be connected such that it will not be removed unintentionally during testing or other work on the circuit.

The neutrals of unrelated secondaries shall be connected to the ground individually with one connection under a single screw (and not, for example, through the use of a single conductor jumpered from point-to-point on the terminal boards).

Neutrals of station service transformer secondaries shall be grounded at the transformer and at the main switch under the lug provided in the switch enclosure, thence to the main ground system.

4.6. Conduit and Cable Grounding

4.6.1. General

All metallic conduit shall be effectively connected to the ground grid, either by direct connection or by attachment to metal enclosures which are adequately connected to the ground grid.

Neutral conductor placed outside metallic conduit that carries feeder cables shall be bonded to the metallic conduit at both ends.

4.6.2. Distribution Substations

Metallic sheaths of control cable in distribution substations shall be grounded at one end only, unless specified otherwise. Control cable sheaths shall be grounded at the control house end of the cable. The control cable sheath at the equipment end shall be covered with electrical tape.

4.6.3. Transmission Substations

4.6.3.1. Below 230 kV

The method for grounding control cable sheaths in transmission substations below 230 kV shall be the same as specified for distribution substations
(see 4.6.2).

4.6.3.2. 230 kV and Above

Metallic sheaths of all control cable in transmission substations 230 kV and above shall be grounded at both ends of the cable at a minimum. A parallel 4/0 copper ground wire shall be installed with the control cable and other low-voltage circuits from the equipment to the control house or to the circuit's point of termination. The control cable sheath and parallel ground wire shall be connected together and grounded at the equipment, in the control house or the point of circuit termination, and at any intermediate junction boxes or manholes through which the circuits run.

CCVTs and free-standing current transformers at a voltage greater than or equal to 230 kV shall be grounded using the following method in order to minimize electrostatic and magnetic coupling of control wire connected to such equipment:

1. Install only shielded control cable in the substation yard. Install a parallel 4/0 copper ground wire with the control cable from the equipment to the control house or to the circuit's point of termination. It is not necessary to install extra parallel ground wires where multiple control cables share the same cable trench. Where control cables branch away from the main cable trench en route to the specific piece of equipment, the parallel ground wire shall be tapped using 4/0 copper wire and extended with the control cable to the equipment.
2. Install galvanized steel conduit from the equipment to the junction box and from the junction box to a point located 18″ below grade. The steel conduit helps attenuate high-frequency transients.
3. Connect the parallel 4/0 copper wire to the ground grid at the equipment and at the control house or the circuit's point of termination.
4. Install a #4 copper parallel ground wire inside the conduit from the equipment cabinet to the junction box or pull box. Connect the #4 copper ground wire to the equipment cabinet, junction box, and parallel 4/0 copper ground wire.
5. Connect the control cable sheath to the ground wire in the equipment cabinet, junction box, control house, or the circuit's point of termination. Grounding two or more locations on the metallic sheaths of control cable shall not be done without installing a parallel 4/0 copper ground wire over the entire length of the control cable. In addition, all ground connections made to the control cable metallic sheaths shall be bonded connections to the parallel 4/0 copper ground wire, either by direct connection or through some other copper wire connection.

A parallel ground wire shall be installed along with the control cable where multiple sheath grounds are required for the following reasons:

- it provides electrostatic shielding from overhead buses
- it minimizes magnetic coupling by reducing the loop area between the ground grid and the control cable sheath
- it prevents large magnitude currents from flowing in the control cable sheath during faults and other transient events
- it equalizes ground grid potential differences over the entire length of the cable

4.6.3.3. Multiple-Voltage Substations

For multiple-voltage substations (or for a single-voltage substation that may change to a multiple-voltage substation in the future) the type of conduit used (PVC or steel), and the method for grounding the conduits and cables in each yard shall be determined by a company standards engineer.

Taking into consideration the substation's ultimate layout and transmission line placements, the standards engineer may require the grounding methods specified in Section 4.6.3.2 (230 kV and Above) of this document, even though the initial design would have called for grounding according to Section 4.6.3.1 (Below 230 kV).

4.7. Switchboard Grounding

All metallic switchboards, bases, supports, and braces shall be connected to the ground grid with a minimum size of #6 copper wire. All meter, relay, and instrument cases and all instrument and control switches that are mounted on insulating panels shall be grounded with #10 copper wire.

4.8. Fence Grounding

All metallic fencing shall be securely tied to the main ground system inside the substation at each gate post, corner post (omit corner tie if 30′ or closer to the grounded gate post), and line posts at intervals of no more than 50′. The main ground grid shall ground to the gate posts, corner posts, and line posts, and fabric shall be grounded on both sides of any line crossing. The peripheral conductor of the main ground grid shall be located both 4′ inside and outside of, and parallel to, the fence and shall be buried 18″ below subgrade. The fence shall be grounded to the main ground grid at intervals of no more than 50′. Ground rods shall be driven along the conductor, and bonded at each fence corner, and at intermediate intervals of no more than 40′.

Fence posts shall be grounded by extending #4 copper wire from the main ground grid to the fence post and connecting the #4 copper wire to the fence post, using a bolted ground connector. The #4 copper wire connected to the fence post shall be extended and connected to the fence fabric using a bronze vise-type connector for #4 copper to #4 Al conductors. The #4 Al or #4 copper ground wire shall be extended toward the top of the barbed wire with connections made to the fabric and each barbed wire strand using bronze vise-type connectors.

Gates shall be grounded by extending #4 copper wire to the gate posts and connecting it to the gate post using a bronze vise type connector. The gate shall be grounded by connecting a flexible braided copper strap, with tin-plated ferrule at each end, between the gate post and gate frame. The #4 copper or #4 Al wire connecting the gate post to the ground grid shall be extended from the gate post to the gate fabric and connected using a bronze vise-type connector. The #4 wire shall then be extended toward the top of the barbed wire with connections made to the fabric and each barbed wire strand using bronze vise-type connectors.

On gates which may be opened outward, an additional ground conductor shall be laid 4i beyond the extreme reach of the gate as it is swung out. Each end of this conductor shall be bonded to the main grid, making it an integral part thereof.

4.9. Control House Grounding

The control house shall be grounded to the main grid at two diagonally opposite corners using 4/0 copper wire. Metal buildings with panel sections which are bonded together by brazed or bolted connections shall be considered adequately grounded. Metal buildings with panel sections which are not bonded together in this manner shall not be considered effectively grounded and shall require an externally placed #4 copper wire along the entire wall length with connections made to each panel section. If the inner and outer walls of the building are isolated from each other and from each panel section, a #4 copper wire shall be placed along the entire wall length of both the interior and exterior walls with connections made to each panel section.

Control buildings or houses with cable trenches shall have a 4/0 copper wire looped through the trench with attachments made to the trench wall using bronze vise-type connectors. Switchboard panels shall be grounded by tapping #6 copper wire off the 4/0 copper loop, terminating at the switchboard panel using a bolted-ground connector.

Control buildings or houses with overhead cable trays shall have a 4/0 copper wire looped through the tray with connections to the tray wall using bronze vise-type connectors. Switchboard panels shall be grounded in a manner similar to the method presented in the previous paragraph.

Cable entrance vaults shall be used for both the cable trench and overhead cable tray designs. In both cases, the looped 4/0 copper wire shall be brought into the control house through the cable entrance vault. In cases where cable termination cabinets are used, the cabinets shall be grounded by tapping #4 copper wire off the 4/0 copper looped wire and connecting to the ground bus bar of the cabinet.

4.10. Multiple Shunt Capacitors Grounding

Where two or more grounded-wye shunt capacitors are located in the same substation, the neutrals of these capacitor banks should be grounded using the “single-point” or “peninsula” grounding methods underlined in IEEE Standard 1036, Section 9.1.2. These grounding methods are intended to protect control cables, relays, and current and voltage transformers from the damage caused by the transients associated with capacitor back-to-back switching.

When using the single-point grounding method, the neutrals of all capacitor banks of a given voltage are connected together with insulated cable and tied to the substation ground grid at only one point. This arrangement prevents high-frequency currents that flow between capacitor banks during back-to-back switching from flowing in the ground grid. IEEE 1036, Figure 25 details this method. IEEE recommends the use of shielded cable between the capacitor bank’s neutral and the single-point ground, with the shields grounded at both ends of the cable to reduce voltage buildup at the end of the capacitor bank neutrals during switching. IEEE 1036 also recommends that voltage transformers used with shunt capacitor banks should have two bushings with the primary connected to the capacitor bank neutral and to the station ground grid.

With peninsula grounding, one or more ground grid conductor(s) are carried underneath the capacitor rack of each phase of each group and tied to the main station ground grid at one point at the edge of the capacitor area. All capacitor bank neutral connections are made to the isolated peninsula ground grid conductor(s) only. This method allows the rise of potential at the capacitor bank neutrals and associated current and voltage transformers, but it reduces these transients in the rest of the substation. This method is detailed in IEEE 1036, Figure 26.

4.11. Yard Finish Rock Requirements

Yard Finish rock covering is an integral part of the safety system. The substation shall not be energized until the rock covering is installed. If it is absolutely necessary to energize the substation before the covering is completed, all uncovered areas shall be clearly marked with barriers and warning signs. Entry into those areas shall be avoided.

The substation yard, with the exception of roadways, shall be covered with a minimum depth of 4″ of Yard Finish crushed rock. The Yard Finish rock shall be placed under each electrical bus and at least five feet beyond the bus perimeter, five feet beyond any steel structure, five feet on both sides of the exterior substation metallic fence, and five feet on either side of any internal metallic fence. Yard Finish rock shall be placed at least five feet from the perimeter of any steel building.

Security walls constructed of concrete, concrete block, or earthen brick need not have Yard Finish rock placed within five feet.

4.11.1. Gradation (Sieve Analysis According to AASHTO T27)

The size of the crushed rock shall be 1½″ to ¼″ crushed rock. The crushed rock shall meet the sieve requirements specified in Table 2.

Table 2—Yard Finish Rock Sieve Requirements

Sieve Size	Percent Passing
1-½″	100
¾ or ⅝″	0-30
¼″	0-5

4.11.2. Fractured Face

There shall be at least one mechanically-fractured face on 95% of all particles retained on each sieve ¼-inch and above. In addition, there shall be at least three mechanically-fractured faces on 70% ofr the same particles (per AASHTO T 335 or ASTM D5821).

4.11.3. Resistivity

Yard Finish rock shall have a minimum electrical resistivity of 3,000 ohm meters when tested in accordance with industry standards in the saturated wet condition adjusted for the resistivity of the water to 100 ohm meters.

5. Grounding Tests

All grounding systems shall be tested to remote-ground as soon as possible after installation. The results shall be reported promptly to substation engineering. Resistance values of more than one ohm shall be brought to the immediate attention of substation engineering. A second test shall be performed during the dry season, after the earth has settled.

6. Dissimilar Metal Requirements

To prevent galvanic action between dissimilar metals, buried copper ground wire shall not be buried adjacent to buried steel pipe or structural steel. If this is unavoidable, both metals shall be painted with a heavy coating of bitumastic paint, or the ground wire shall be enclosed in lengths of nonmetallic conduit at points where dissimilar metals are in close proximity. An exception to this requirement is the substation ground system, which shall be bonded at one point to each water system that may be present within the substation.

When making connections to painted metal, all paint shall be removed prior to making connections to ensure sufficient electrical contact.

7. Issuing Department and Approvals

The engineering standards and technical services department of the company published this document. Questions regarding editing, revision history, and document output may be directed to the lead editor at eampub@pacificorp.com. Technical questions and comments may be directed to Iuda Morar, substation standards engineering, (503) 813-6937. This handbook document shall be used and duplicated only in support of company projects.

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PACIFICORP ENERGY
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Generation Engineering

Document Type	**New Generation Plant Construction Standard**			Document Number	**GEN-ENG-RELAY-0001**
				Revision Number	0
SUBJECT:	**Protective Relaying Standard**				
Written By:	Mike Collins	Date:	4/14/08	Review Date:	
Approved By:	Mike Collins			Reviewed By:	
Title of Approver	Relay Department Manager	Date:	4/14/08		

THERMAL PLANT PROTIVE RELAYING REQUIREMENTS

Protection design, settings and hardware for electrical equipment must be approved by the PacifiCorp Protective Relaying Department and will meet all recommendations contained within the PacifiCorp FACILITY CONNECTION REQUIREMENTS FOR TRANSMISSION SYSTEMS, IEEE Std 666-1991 IEEE Design Guide for Electric Power Service Systems for Generating Stations, IEEE Std C37.102 IEEE Guide for AC Generator Protection and IEEE Std C37.110 IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes.

Protection drawing packages shall conform to PacifiCorp drawing standards. Separate 1-lines, 3-lines, DC control schematics, and wiring diagrams are required. All protection drawings must be provided with the standard PacifiCorp drawing boarder.

Part numbers for relays, test switches, lockout relays must be approved by the PacifiCorp Relay Department.

All voltage, current and digital inputs and outputs for each relay must be connected to a test switch. Protective relays and lockout relays must be electrically isolated via test switches for testing purposes.

Relay settings reports are required and must contain all data required to review the settings including 1-lines, narrative philosophy, relay set points, calculations, coordination curves, protected equipment data, and system data. The relay settings report must cover all the protective relays in the plant. A paper copy and an electronic copy must be provided to the PacifiCorp Relay Department.

All protective relaying DC control circuits must be 125 VDC.

Remote communication via modem must be provided to all generator, generator step-up, and auxiliary transformer protective relays. All plant relays must support the IEC 61850 communication protocol.

The final protective relaying drawing package and report must be submitted to the PacifiCorp Relay Department for approval at least two months prior to ordering equipment.

Plant protection systems must meet the PacifiCorp Standard 139 – Facility Interconnection Requirements for Xmsn Systems. The most current version of this document is posted at http://idoc.pacificorp.us/Article/Article23187.html.

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Generation Engineering

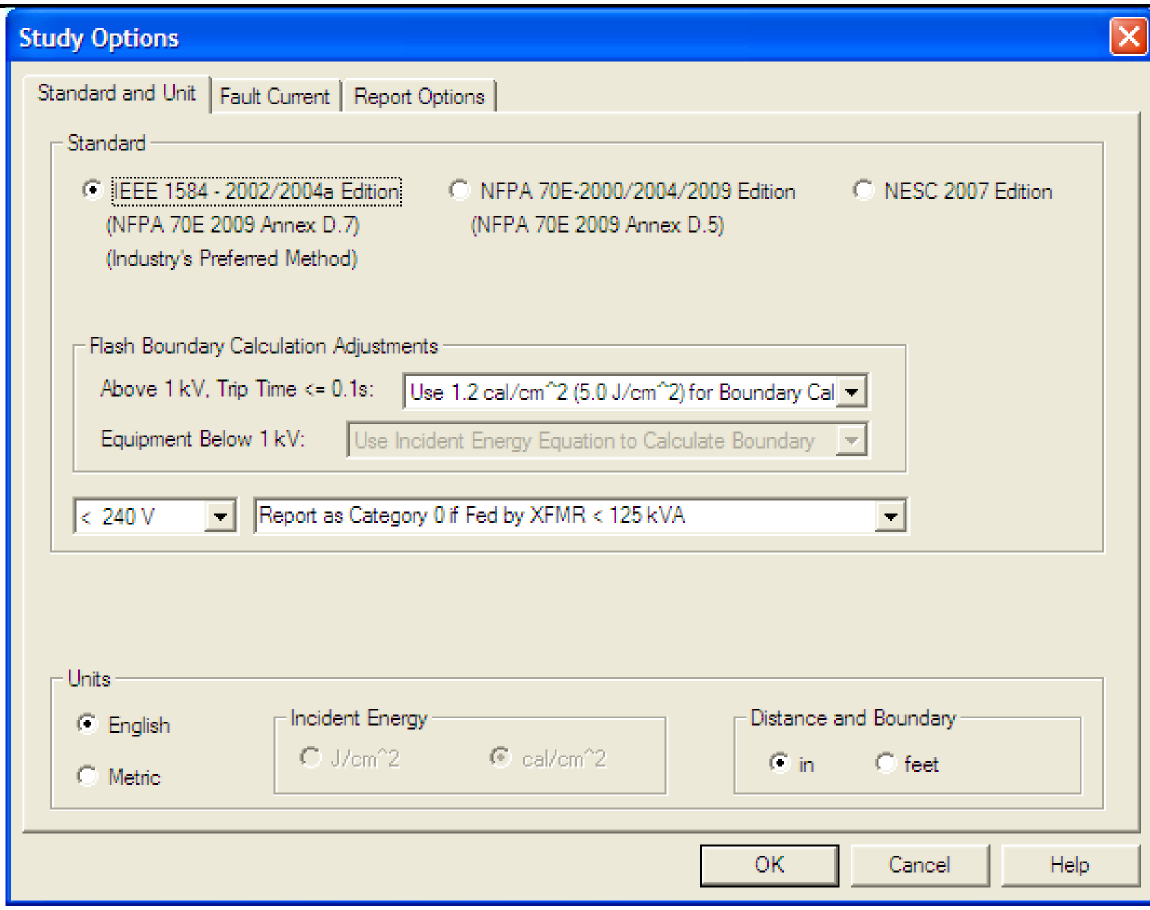
Document Type	**New Generation Plant Construction Standard**			Document Number	**GEN-ENG-RELAY-0002**
				Revision Number	5
SUBJECT:	**Arc Flash Hazard Standard**				
Written By:	Justin Rosenkrantz	Date:	5/10/2010	Review Date:	**5/10/2010**
Approved By:	Mike Collins			Reviewed By:	Mike Collins
Title of Approver	Relay Department Manager	Date:	5/10/2010		

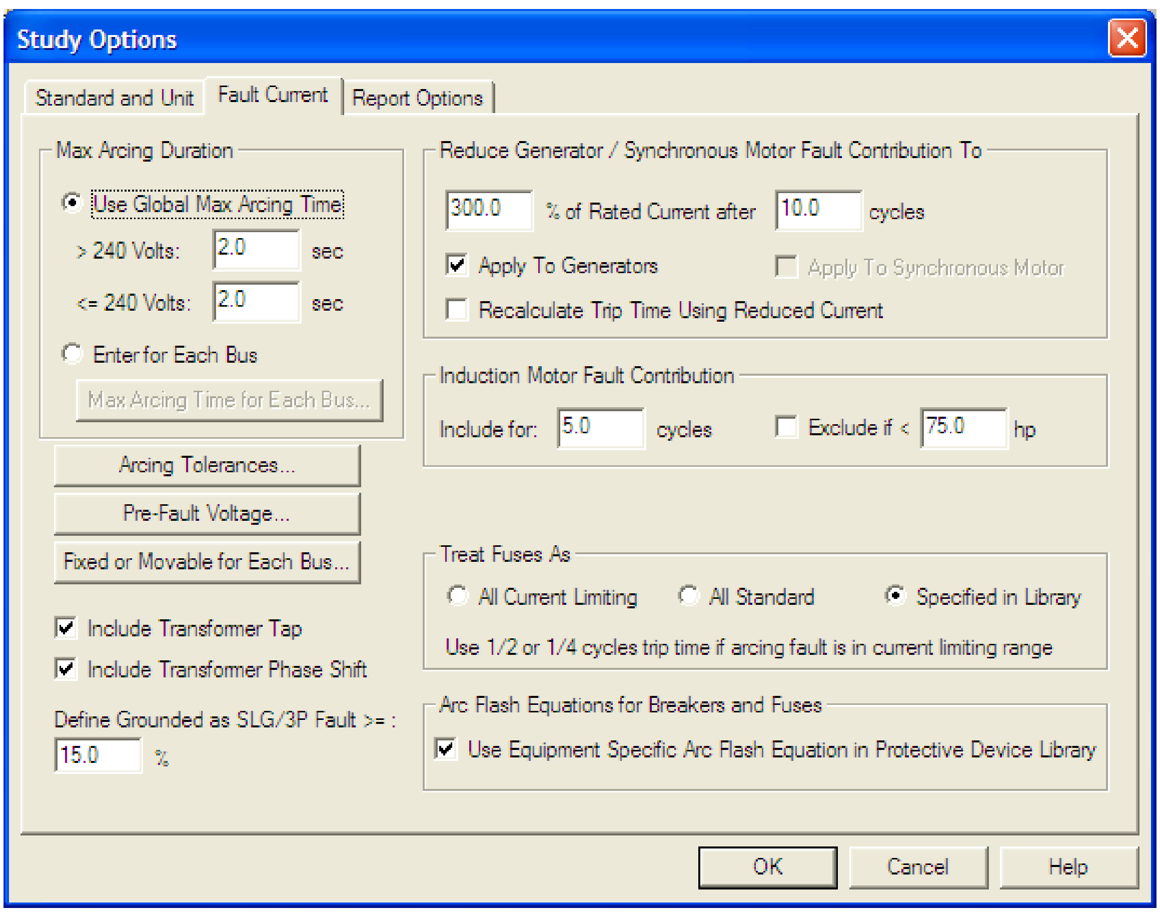
SCOPE and DEFINITION

This standard covers the arc flash safety requirements for new generation plant construction. This standard is designed to protect personnel from serious injury or death in the event of an arcing fault.

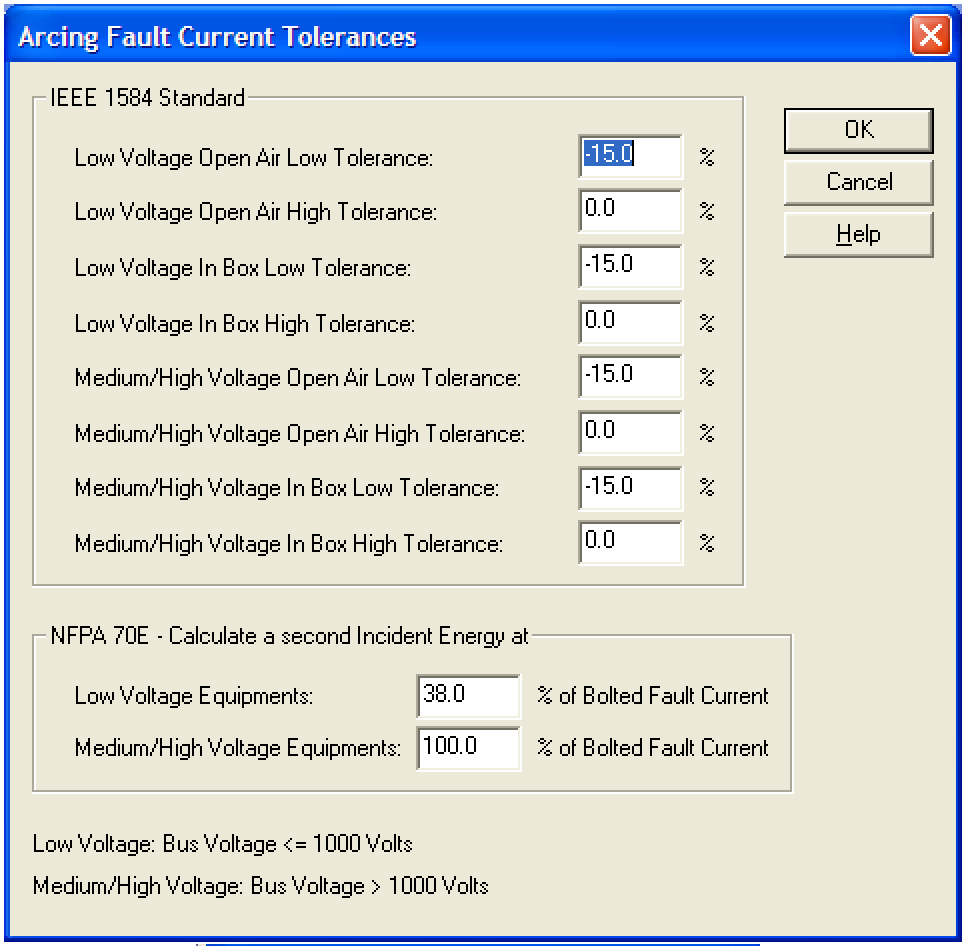
CONSTRUCTION REQUIREMENTS

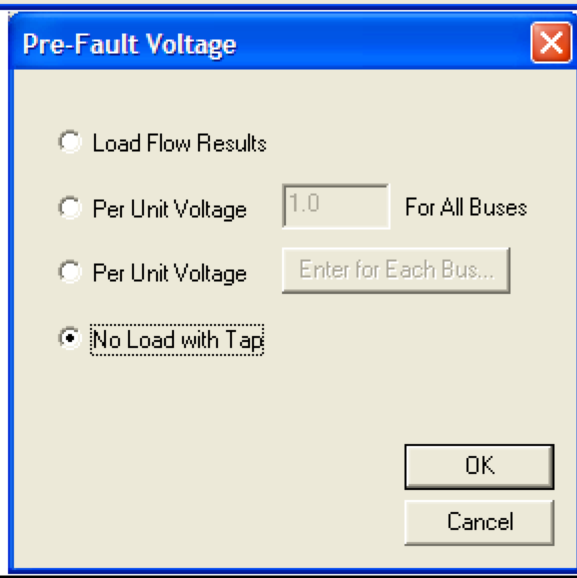
1. An arc flash study shall be performed based on the current version of IEEE standard 1584 and using SKM Power*Tools for Windows (PTW) software.
2. All electrical equipment shall be designed such that the incident energy levels from arc flash events shall be limited to 25 cal/cm^2 (a hazard category of 3). Where this is deemed infeasible, PacifiCorp Energy's protective relaying group shall be consulted.
3. Type 2B medium voltage arc resistant switchgear tested per the latest revision of IEEE Std C37.20.7 shall be installed for all applicable medium voltage locations.
4. The PTW model shall be based on the following (PacifiCorp Energy's protective relaying group should be consulted when any questions arise):
    a. A two second arc flash duration shall be assumed for all locations where deemed feasible. Where location constraints or other concerns make this assumption invalid, the arc flash calculations shall be appropriately modified.
    b. For 4160 VAC and above, the working distance shall be 36 inches. For all other voltages the working distance shall be 36 inches for drawout type breakers and 18 inches for all other equipment.
    c. SKM Parameters should be consistent with the following screenshots:

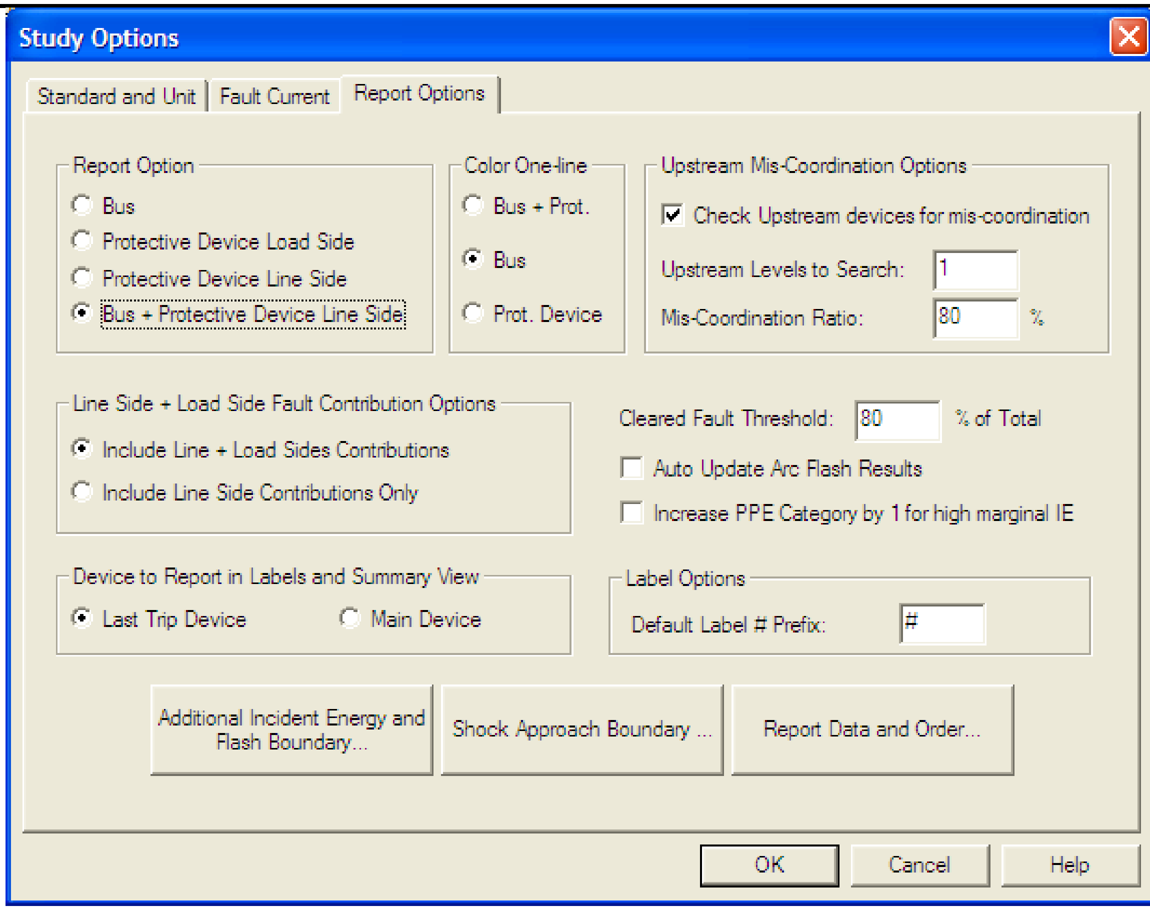

Study Options
Standard and Unit
Fault Current
Report Options
Standard
IEEE 1584 - 2002/2004a Edition
(NFPA 70E 2009 Annex D.7)
(Industry's Preferred Method)
NFPA 70E-2000/2004/2009 Edition
(NFPA 70E 2009 Annex D.5)
NESC 2007 Edition
Flash Boundary Calculation Adjustments
Above 1 kV, Trip Time <= 0.1s:
Use 1.2 cal/cm^2 (5.0 J/cm^2) for Boundary Cal
Equipment Below 1 kV:
Use Incident Energy Equation to Calculate Boundary
< 240 V
Report as Category 0 if Fed by XFMR < 125 kVA
Units
English
Metric
Incident Energy
J/cm^2
cal/cm^2
Distance and Boundary
in
feet
OK
Cancel
Help


Study Options
Standard and Unit
Fault Current
Report Options
Max Arcing Duration
Use Global Max Arcing Time
> 240 Volts: 2.0 sec
<= 240 Volts: 2.0 sec
Enter for Each Bus
Max Arcing Time for Each Bus...
Arcing Tolerances...
Pre-Fault Voltage...
Fixed or Movable for Each Bus...
Include Transformer Tap
Include Transformer Phase Shift
Define Grounded as SLG/3P Fault >= :
15.0 %
Reduce Generator / Synchronous Motor Fault Contribution To
300.0 % of Rated Current after 10.0 cycles
Apply To Generators
Apply To Synchronous Motor
Recalculate Trip Time Using Reduced Current
Induction Motor Fault Contribution
Include for: 5.0 cycles
Exclude if < 75.0 hp
Treat Fuses As
All Current Limiting
All Standard
Specified in Library
Use 1/2 or 1/4 cycles trip time if arcing fault is in current limiting range
Arc Flash Equations for Breakers and Fuses
Use Equipment Specific Arc Flash Equation in Protective Device Library
OK
Cancel
Help

*Although grounded is defined as 15% as shown in the options above, that is mainly to help SKM complete the calculations. Field verification should be made and anything that is resistively grounded or ungrounded should be marked as ungrounded in the study, per IEEE 1584.







The PPE Table for SKM should be requested by Consultant from Company and the latest revision will be provided for loading into SKM.

5. Create a detailed report to include the topics in order as listed below. Two printed copies in three ring binders with section dividers shall be provided, along with a CD in each binder which should include electronic copies of report documentation and the SKM model project files (including PTW library file used for the study). Before the report is printed and any labels are created, the study results shall be discussed with Company. Any changes discussed shall be included in the final report.
    a. Title Page (should include name of Consultant responsible for the arc flash review and the date the review was completed)
    b. Table of Contents
    c. Report summary (include a copy of the AF Summary results from SKM)
    d. Description of different system operating configurations used for SKM scenarios
    e. List of any assumptions
    f. Screenshots of SKM options and Help -> About screen showing SKM version used.
    g. SKM one-line diagram
    h. List of all data used in the arc flash study (i.e. transformer, motor, and generator data, cable information, and protective device settings)
    i. Any other documentation the Consultant deems appropriate to include
6. All applicable equipment shall be labeled with weather-resistant (and UV resistant where exposed to sunlight) arc flash labels using the following design as an example:

WARNING

Arc Flash and Shock Hazard

Appropriate PPE Required

36 inches	Flash Hazard Boundary
3.6 cal/cm^2	Flash Hazard at 18 inches
Category 1	Cotton Underwear + FR Shirt & Pants + Face Shield + Std PPE(inc. hearing)
480 VAC	Shock Hazard when cover is removed
00	Glove Class
42 inches	Limited Approach
12 inches	Restricted Approach
1 inches	Prohibited Approach

Location: MCC-A1-3

10-28-09 UPDATE

PACIFICORP ENERGY
A DIVISION OF PACIFICORP

Generation Engineering

Document Type	Relay Testing Procedure		Document Number	**GEN-ENG-RELAY-0003**
			Revision Number	
SUBJECT:	**Relay Current Transformer (CT) and Potential Transformer (PT) Insulation Integrity Test**			

Written By:	CW Franz	Date:	09/15/11		Review Date:	9/20/11
Approved By:					Reviewed By:	CW Franz
Engineering Manager	Mike Collins	Date:	9/20/11			
Generation Support						

Revision Number	Reason for Revision	Date	MOC #

SCOPE and DEFINITION

To comply with current NERC Reliability Standards, each PacifiCorp generation facility shall perform a DC ground test to all protective relay CT and PT input circuits during the testing of the relay.

PROCEDURE ADDENDUM

Current Transformer (CT) Circuits

1.) **The CT circuit must be de-energized**. Conform to all PacifiCorp energy isolation procedures that apply.

2.) Isolate all devices that may be damaged from the insulation integrity test voltage such as relays and meters. Always check prints to determine all of the devices in the circuit prior to performing the insulation integrity test.

3.) Isolate the single point ground and verify that there is only one single point ground. If a second ground point is found it must be reported and corrected.

4.) Insulation test voltage for CT circuits is 500 Vdc. Values less than 1 megohm must be reported to Generation Engineering.

Potential Transformer (PT) Circuits

1.) **The PT circuit must be de-energized**. Conform to all PacifiCorp energy isolation procedures that apply.

2.) Isolate all devices that may be damaged from the insulation integrity test voltage such as relays and meters. Always check prints to determine all of the devices in the circuit prior to performing the insulation integrity test.

3.) Isolate the single point ground and verify that there is only one single point ground. If a second ground point is found it must be reported and corrected.

4.) Insulation test voltage for PT circuits is 500 Vdc. Values less than 1 megohm must be reported to Generation Engineering.

PACIFICORP ENERGY
A DIVISION OF PACIFICORP

Generation Engineering

Document Type	**POLICY and PROCEDURE**		Document ID Number	**GEN-ENG-RELAY - 1003 rev 1**
			Review Date:	**6/2/2011**
SUBJECT:	**Thermal Plant Protective Relay Maintenance and Testing – PRC-005**		Reviewed By:	**Irv Moore**

Written By:	Mike Collins	**Date:**	5/18/2011		**Approved By:**	Rod Roberts	**Date:**	6/2/2011

Revision Number	Reason for Revision	Date	MOC #

SCOPE and DEFINITION

This document defines and details the roles and responsibilities of key personnel who are responsible for the documentation of WECC designated relay maintenance and testing and station battery testing as defined in NERC Reliability Standard PRC-005.

PROCEDURE

Section 1 - Relay maintenance to be performed during plant outages:

1. The plant planning department is responsible to initiate the "call" for the preventive maintenance plan and the release of the work orders required to perform protective relay maintenance and notifying the appropriate relay technician managers that work will be required.
    a. Substation operations would prefer to have PM's requiring relay technicians support for the entire year submitted in January of the same year.
2. The following SAP Work Management codes and transactions will apply:
    a. All WECC preventive maintenance plan items have been identified using the ABC indicator of "F" on the equipment master record.
    b. SAP transaction IP17 should be used to identify WECC maintenance items by using the following selection criteria:
        i. ABC indicator = "F"
        ii. Function location and equipment group for a specific plant
        iii. Planning plant
3. The plant planning department is responsible to provide the relay technician with the following documents:
    a. Work order numbers for each group of relays to be tested.
    b. One relay testing checklist for each group (functional location) of relays being tested. The latest checklist can be found in P8 under the Generation – Thermal and Wind Docs – Relay Testing Checklist.
4. The relay technician must return all relay testing checklists and Doble testing summary sheets to the plant planning department within 14 days after the end of the outage. Each relay testing check list and Doble Test summary shall have the appropriate work order number for the relay or relay

group tested on the document and will be attached to the appropriate work order.

5. The plant planning department is responsible to enter the following into the SAP database by attaching to the services for object, in the order, the following documents:
    a. Relay testing results
    b. Relay testing checklist
6. The plant planning department is also responsible to ensure that the relay technician has appropriately charged time to all applicable work orders.

Section 2 - New protective relay installations:

1. The project manager is ultimately responsible to ensure all the steps in Section 1 above are initiated and completed for new protective relay upgrades and installations.
2. The plant planning department is responsible to:
    a. Retire the old equipment in SAP
    b. Create new equipment and install in the functional location structure in SAP
    c. Move and modify as necessary preventive maintenance plans and records from old equipment to new equipment.
        i. Note the closed PM's on the capital work order used for new equipment installation.
        ii. The plant planning department will need to make sure that the capital orders receive the labor charges to install the new equipment.

Section 3 - Batteries

1. The plant planning department is responsible for initiating work orders for all one year and four year battery tests and entering the battery test reports into SAP.

Relay Testing & Commissioning Checklist

Plant______________________________ Unit_______ Order #____

Relay Description____

- ☐ Hard copies of all forms and all test results (Pro Test pass/fail summary, CT screen shots, etc.) must be scanned into a single pdf document and forwarded to the plant representative and emailed to Generation Engineering at: genrelspprt@pacificorp.com.
- ☐ All connections are tight and equipment is mounted properly.
- ☐ Relay and wiring is not visibly physically damaged.
- ☐ Relay outputs trip all intended equipment including breakers and lockouts. If trip check to a circuit breaker is not possible during this scheduled maintenance, note here when it will be possible.

  ____
- ☐ Visually verify that CT shorting block connections correspond to relay CT ratio settings.
- ☐ DC voltage on the relay is within limits.
- ☐ Each element found in the relay trip or output equations has been tested and operates as designed.
- ☐ Transfer trip communications equipment has been tested and ensured to be operating correctly. Transfer trips from the relay operate all intended equipment such as breakers and lockouts. If trip check to a circuit breaker is not possible during this scheduled maintenance, note here when it will be possible. ____
- ☐ After testing is complete, ensure in-service magnitude and phase measurements as seen by the relay for both current and voltage are correct. Measurements shall begin at 10 % to at least 50% of the equipment full load value. Verify the above measured values against another relay, meter or other measurement device.
- ☐ Screen shots of the above mentioned phasors and saturation curves have been attached to this document.
- ☐ Relay is back in service and all equipment is in the normal operating position and in working order such as any test switches or other equipment modified during the tests.
- ☐ Any equipment found to be damaged or working incorrectly has been reported to protection engineering.
- ☐ Verify relay settings are correct by comparing to the settings database or having the settings reviewed by a protection engineer.
- ☐ Alarm paths and systems have been verified. Alarms to control room, or other monitored area, are verified to be in working order.

Sign and date below indicating that the above work is complete and correct to the best of your knowledge. **All boxes above must be checked.** If you think a box cannot be checked, you must contact the Generation Engineering Electrical Department to discuss.

____

Name Date

Last Modified By: Jacob Hatch Revision # 11 Revision Date 6/18/2015

PROCEDURE

GENERATION
PROTECTION AND CONTROL EQUIPMENT
INSTALLATION PROCEDURE

GPCP-EQPMNT-INST

Version number:	1
Approval date:	10/03/2012
Authoring department:	Generation Protection & Relay Support
Approved location:	P8
File name:	GPCP-EQPMNT-INST

Revision Log		
0	10/03/2012	Original procedure file "GPCP-EQPMNT-INST" created from *Protection and Control Services* department document PCP-EQPMNT-INST.
1		

PROCEDURE

PacifiCorp
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PROTECTION AND CONTROL EQUIPMENT INSTALLATION PROCEDURE

1 Scope

This document provides the general guidelines and procedures required to test and verify the protection and control equipment associated with equipment installation.

2 References

2.1 Utilize manufactures manuals and reference material.

2.2 Relay settings issued by the protection and control engineer.

3 Precautions

3.1 Follow PacifiCorp's safe work practices.

3.2 Before measuring resistance with a multimeter, always check for standing voltage across open contacts.

3.3 Contact the appropriate PacifiCorp Company representative if any equipment fails to perform as designed or any equipment is inconsistent with the issued substation construction drawings.

4 Equipment Used

4.1 Current and voltage inservice test meters are needed if current or voltage quantities are included in this installation.

4.2 Current transformer excitation, ratio and polarity test set or equivalent is needed if current transformer(s) are included with this installation.

5 Required Documentation

All forms and any test set generated reports shall be forwarded to the company representative and to genrelspprt@pacificorp.com. Test results shall be submitted in electronic format as well as part of the pdf document. A single pdf document will be created that contains the pass/fail test summary from Pro Test and all the applicable forms from the list below. The current revisions of the relay maintenance and installation procedures, forms and policies are primarily available in P8.

5.1 Completed current transformer test form, GPCF-CT-INST, Current Transformer Installation. Required if current transformers are included in this installation.

5.2 Relay Commissioning Checklist GPCF-RLY-INST.

5.3 All final plant and/or substation as-constructed drawings must be clearly marked-up and modified to reflect the exact equipment installed details.

6 Procedure

Perform the following sections that apply to this application.

6.1 Visual Inspection

Visually inspect all relays, board instruments, transducers, meters, equipment control cabinet, and any modified or new relay control panels for damage that may have occurred during shipping and installation.

6.2 Relay and Control Panel

Perform the following relay and control panel inspections and tests.

6.2.1 Panel Equipment Installation

Verify relays, equipment, and nameplates are installed on the panel as documented in the panel layout and connection diagram.

6.2.2 Wiring Verification

On all new or modified panels count the number of wires on each terminal and verify the number of wires conforms to the connection diagram. Perform point-to-point wire checks on all new or modified panels. Point-to-point verification may be performed by a manufacturer, contractor, or PacifiCorp technician, and need only be performed once. Verify modified wiring matches the connection diagram and control schematics.

6.2.3 Panel Wire Lugs

Verify that all new and modified panel wiring lugs are adequately crimped.

6.2.4 Panel Terminal Blocks

Verify that all new and modified panel wiring terminal block connections are checked for tightness.

6.2.5 Panel Current Transformer Circuit Tests

For each new or modified relay control panel, measure the DC resistance of each CT (current transformer) circuit from the panel input terminal blocks. Open associated current test switches and manipulate any rotary switches used in the associated CT circuit, so long as manipulating the switch does not introduce connectivity to an energized CT circuit. This test is to ensure that the CT circuits are not open-circuited. The measured DC resistance of each circuit should be less than 5 ohms.

6.2.6 Panel Voltage Transformer Circuit Tests

For each new or modified relay control panel, measure the DC resistance of each VT (voltage transformer) circuit from the panel input terminal blocks. Measurements should take place between phase-to-ground and phase-to-phase. This test is to ensure that the VT circuits are not short-circuited. The measured DC resistance of this circuit should be greater than 1000 ohms.

6.2.7 Panel DC Circuit Tests

Measure the DC resistance of the DC control power circuit from the panel input (DC positive and DC negative) terminal blocks. This test is to ensure that the DC circuit is not short-circuited. The measured DC resistance of this circuit should be greater than 10 ohms.

6.3 Current Transformer Testing

Test all new current transformer installations that are included with this circuit breaker. Follow installation test procedure PCP-CT-INST Current Transformer Installation, and complete test form PCF-CT-INST Current Transformer Installation.

6.4 Current Transformer Secondary Circuit Testing

Test all current transformer secondary wiring and devices that are included with this equipment installation.

6.4.1 Current Transformer Secondary Wiring

Verify all secondary CT wiring matches the substation connection diagrams and control schematics. Ensure correct CT ratio, polarity, and grounding.

6.4.2 Secondary Current Transformer Loading Test

Load each secondary CT circuit with five amps of AC current. Verify proper magnitude and direction of current at each relay and metering device in the CT circuit. Spot-check the other unloaded phases to verify that the current is zero. For circuits with electromechanical relays only, calculate burden on each CT circuit. See figure 1 below.

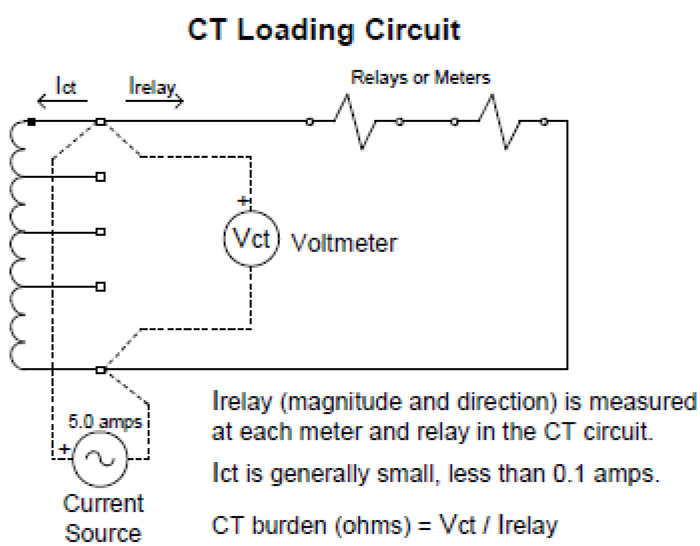

Figure 1

6.5 Voltage Transformer Secondary Testing

Verify all voltage transformer secondary equipment and wiring that is included with this equipment installation.

6.5.1 Voltage Transformer Secondary Wiring

Verify all secondary VT wiring matches the substation connection diagrams and control schematics. Ensure correct VT ratio, polarity, and grounding.

6.5.2 Voltage Transformer Secondary Resistance Test

At the voltage transformer, measure the secondary circuit DC resistance for each phase-to-phase and phase-to-ground circuit. This test is to verify that a circuit-short does not exist.

6.6 Control Logic

The control logic operation must match the equipment control schematic and relay settings.

6.6.1 Using the issued control schematics verify all remote and local control, indication, alarms and logic inputs/outputs. Use a highlighter to mark the control schematic as they are verified. The highlighted control schematic should be included in the installation documentation.

6.7 Dispatch Metering, Indication, and Control

Verify the dispatch metering, indication, and control for this equipment.

6.7.1 Required Checkouts for Modified Equipment

SCADA checkout of affected points must occur under the following circumstances that may cause a change in SCADA functionality.

- New points are added;
- Existing points are reused for new functions; or
- Analog full-scale value changes due to hardware or setting change such as a modification of a CT or PT ratio.

Coordinate with BSAs (Business System Analysts) to test affected SCADA points. The BSA can provide a list of all new points which are to be tested. To find BSA, search intranet directory and in title box enter "Sr BusSys/EMS" for a complete list of BSAs.

6.7.2 Control and Indication

Verify with the BSAs the functionality of all modified or added SCADA control points up through their respective devices. This includes trip and close, tag on and off, reclose on and off, and reset functions.

Verify with the BSAs the functionality of all indication/status points. Include equipment opened and closed, tag on or off, recloser on or off, relay failure normal or alarm, etc. The breaker stored energy alarm should be blocked when the 01 control switch is in the turn-to-latch position.

6.7.3 Dispatch Metering

Verify metering quantities to dispatch for proper function and accuracy associated with the installed equipment. Remote metering quantities should operate with no more than ±5.0% error at 0 and 25-100% of full scale. If test switches are not available to inject test quantities prior to energization, mark as "N/A", make a note in the comments section, and complete verification after energization.

6.8 Complete the Relay Package Maintenance Procedure PCP-RLY-MAINT-GENERAL or PCP-RLY-MAINT-XFMR and their associated forms, PCF-RLY-MAINT-GENERAL or PCF-RLY-MAINT-XFMR for the installed equipment.

6.9 Drawings and Equipment Memorandums

Complete the as-built drawings and submit any Equipment Memorandums for this equipment installation. Drawings must be clearly marked up and modified to reflect the exact substation equipment installation details. If complete as-built drawings are not available until after energization, mark as "N/A", make a note in the comments section, and submit drawings after energization.

6.10 Retired Critical Relays

As per NERC CIPS standards**,** if any critical relays are removed from service during this equipment installation, the relay settings shall be removed or the relay destroyed.

7 Commissioning Records Retention

Submit all required test reports and installation forms by email to the "Commissioning" mailbox. If this commissioning work has an associated project notebook, determine the proper file and email subject naming convention, either from 1) the Project Notebook spreadsheet associated with the project, or 2) the "Commissioning Documents Naming Convention" document found in the Project Notebook Sharepoint site by clicking the "Home Page" tab at the top of the Project Notebook screen, or by following this link. This includes all ProTest records and forms referred to in this procedure.

PROCEDURE

GENERATION CURRENT TRANSFORMER INSTALLATION PROCEDURE

GPCP-CT-INST

Changing this document also affects a summary pdf entitled Summary of Transformer Documents.

Version number:	1
Approval date:	10/10/2012
Authoring department:	Generation Protection & Relay Support
Approved location:	P8
File name:	GPCP-CT-INST

Revision Log		
0	10/10/2012	Original procedure file "GPCP-CT-INST" created from *Protection and Control Services* department document PCP-CT-INST.
1		

PROCEDURE

CURRENT TRANSFORMER INSTALLATION PROCEDURE

1 Scope

The following is required to test and verify a current transformer (CT).

2 References

2.1 Utilize manufactures manuals and reference material.

3 Required documentation

3.1 Follow PacifiCorp's safe work practices.

3.2 Contact the appropriate PacifiCorp Company representative if any equipment fails to perform as designed or test results deviate from manufacturers published acceptable specifications.

3.3 Perform all AC powered tests before DC powered tests.

4 Equipment Used

4.1 Current transformer excitation, ratio and polarity test set or equivalent.

4.2 500 VDC insulation tester.

5 Required Documentation

This form and any test set generated reports shall be forwarded to the plant representative and to genrelspprt@pacificorp.com.

5.1 GPCF-CT-INST Current Transformer Installation Form

6 Testing

6.1 Equipment Sketch

Sketch the equipment and CT location(s). Include phase, CT number, bushing designation, and polarity marking. This should include a depiction of the physical location of the CTs on the transformer, breaker, or other device. Alternatively, a combination of current schematics and onelines that depict this same information may be submitted with this form in lieu of a hand sketch. Indicate the attached drawing numbers in the space provided.

6.2 Visual Inspection

Visually inspect the CT wiring, lugs, and shorting-type terminal blocks for tight connections, and any damage that may have occurred during shipping. The physical installation should be consistent with the equipment wiring diagrams and schematics.

6.3 Ratio Test

Verify the ratio between the secondary and the primary windings. For multi-ratio CT's, verify the ratio for each winding section. Measured ratio values should be consistent with the manufactures CT test data, and the equipment wiring diagrams and schematics.

Saturation Test

Perform a saturation test on the full winding (maximum ratio) of the CT. Graph the Secondary Exciting Volts verses Secondary Exciting Amps for the winding. In addition, determine the saturation value for the full winding. Saturation is defined as the point where the curve is tangent (at 45 degrees) to the secondary exciting amperes. Measured saturation curve characteristics and saturation value should be consistent with the CT excitation curves and data provide by the manufacture.

Note that ratio and saturation data may be manually entered into the CT Installation Form or a printout from an approved CT tester may be included instead of manually entering the data.

6.4 Polarity Test

Verify the polarity of the CT primary to the secondary windings. Correct polarity is when the current entering the positive primary terminal is in phase with the current leaving the positive secondary terminal. Verify that measured polarity is consistent with the equipment, wiring diagrams, and schematics.

6.5 Insulation Resistance Test

Measure the CT insulation resistance to ground on each output terminal using a 500 VDC insulation tester. Values greater than 1 megohm are acceptable.

6.6 Power Factor Freestanding CTs.

Perform power factor test on all 115kV and above free standing CT's. Power-factor testing shall be done in accordance with test equipment manufacturer's published data.

7 Commissioning Records Retention

Submit all required test reports and installation forms by email to the "Commissioning" mailbox. If this commissioning work has an associated project notebook, determine the proper file and email subject naming convention, either from 1) the Project Notebook spreadsheet associated with the project, or 2) the "Commissioning Documents Naming Convention" document found in the Project Notebook Sharepoint site by clicking the "Home Page" tab at the top of the Project Notebook screen, or by following this link. This includes all ProTest records and forms referred to in this procedure.

1 # CURRENT TRANSFORMER INSTALLATION FORM

2 ***Version 4***

3 **PacifiCorp Protection and Control Technical Services Form PCF-CT-INST**

4 **The person(s) responsible for the job shall print their name(s) below as verification that the work has been performed correctly and the form filled out accurately. Each responsible person shall list their identifying number (1, 2, 3, 4, or 5) in the "signed by" columns next to the results of each of the tasks they perform.**

5 **Responsible person 1:** **Phone number:** **Date:**

6 **Responsible person 2:** **Phone number:** **Date:**

7 **Responsible person 3:** **Phone number:** **Date:**

8 **Responsible person 4:** **Phone number:** **Date:**

9 **Responsible person 5:** **Phone number:** **Date:**

10 Crew:

11 Substation: Work order:

12 Purpose: Scheduled Trouble New install Other:

13 Equipment Identification

14	PacifiCorp Equipment or SAP number:	Equipment Type:
15	Operating #:	

16 ***For results use A = acceptable, C = corrected, U = unacceptable, NA = not applicable to this equipment***

17 ***For items marked 'C' or 'U' provide a detailed explanation in the comments section***

18 Section 6.1 Equipment Sketch

		Signed by	Results
20	Sketch the equipment and CT locations(s) by hand or insert a photo below. Include phase, CT number, bushing designation, and polarity marking. Alternatively, current schematics that depict this same information may be submitted with this form in lieu of this sketch. Indicate the attached drawing numbers here:		

21

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22	6.2 Visual Inspection	
23	Signed by	Results
24 Visual Inspection Completed.		

25 | 6.3 Ratio & Saturation |
|---|
| 26 |

27 CT Number:	Phase:	CT Type:

28 Ratio Type: Multi Ratio Single Ratio	Test Method: Current Injection Voltage Injection

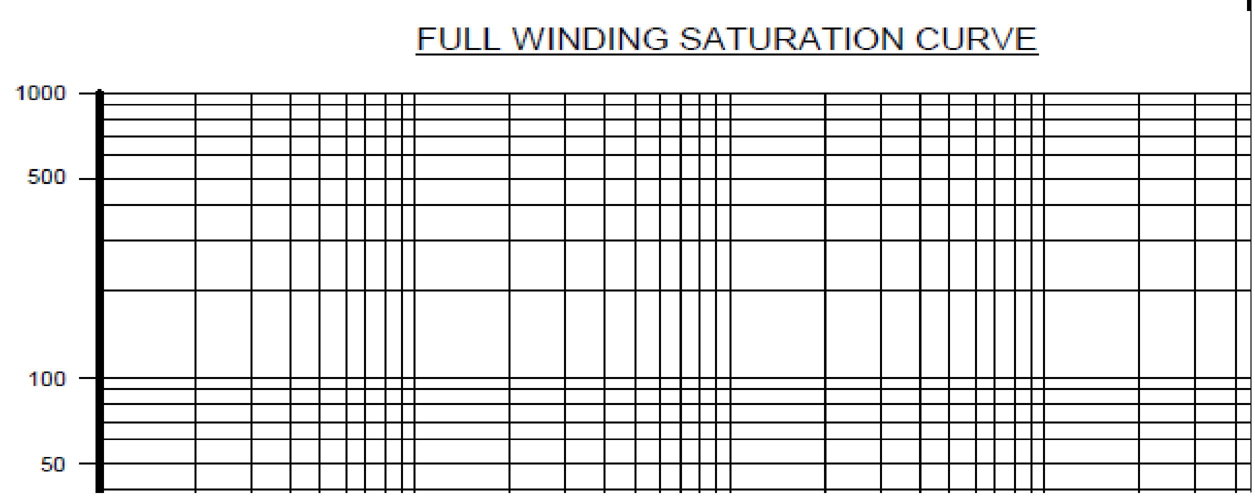
29 **Note:** Ratio and saturation data may be manually entered into this form or a printout from an approved CT tester may be included instead of manually entering the data.

30 **Ratio Test Data**

31 CT Terminals	Name Plate Ratio	Tested Ratio	Percent Error
32 1-2			
33 2-3			
34 3-4			
35 4-5			

36 Graph below or attach the full winding saturation test results.

37



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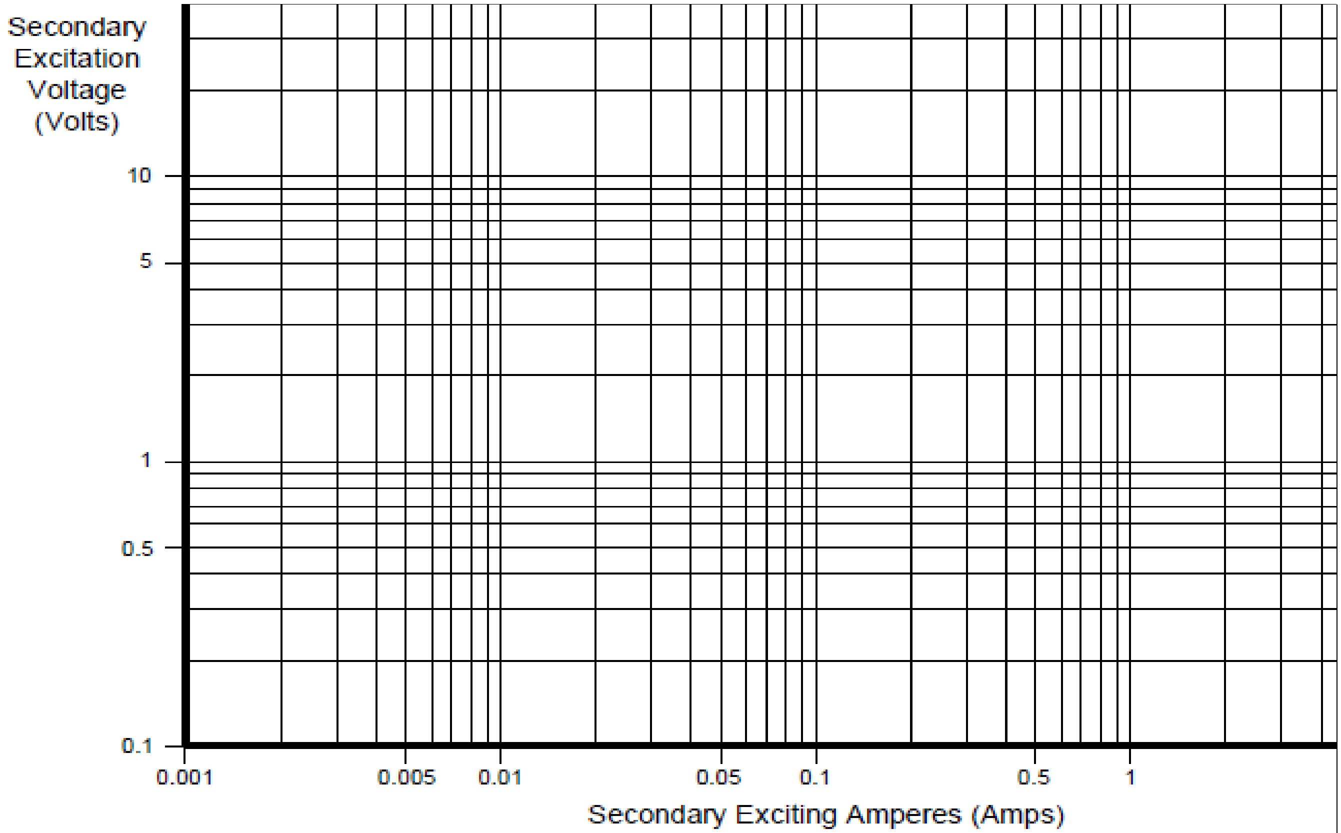

53

SG 001 Substation High-Voltage Warning Signs

Scope

This standard specifies the details of, and installation procedures for high-voltage warning signs. These signs shall be placed on all fenced enclosures containing high-voltage electrical equipment.

References

The following publications also pertain to substation high-voltage warning signs:

ANSI Z535.1-2006 (R2011), Safety Colors

ANSI Z535.2-2011, Environmental and Facility Safety Signs

ANSI Z535.3-2011, Criteria for Safety Symbols

ANSI Z535.5-2011, Safety Tags and Barricade Tapes (For Temporary Hazards)

NESC 2017 Handbook, Appendix B, Safety Signs

PacifiCorp Substation Engineering Handbook Document 6B.5, *Fence Application and Construction*

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Figure 1—High-Voltage Warning Sign for Pacific Power (SI# 7999851)

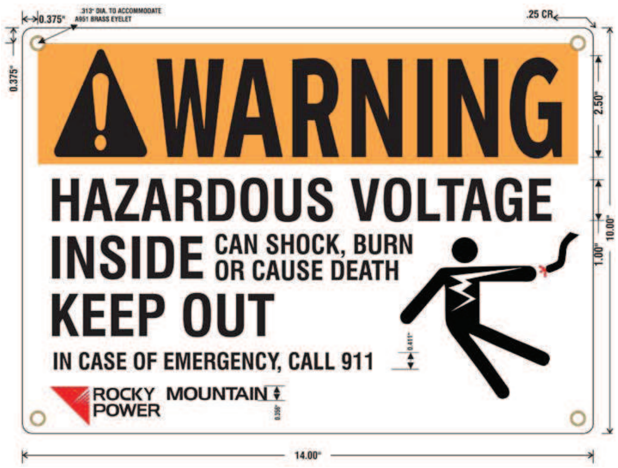

Figure 2—High-Voltage Warning Sign for Rocky Mountain Power (SI# 7999852)

Sign Description and Layout

1. Substation high-voltage warning signs are 10″ × 14″ in size, of an Everlast material, with a white background. A black signal word 2.5″ high is placed in a safety-orange colored rectangular box across the top of the sign. A safety alert symbol 2.5″ tall (the symbol is triangular and contains an exclamation point) precedes the signal word.
2. A warning message in black letters 1″ tall follows the signal word and safety alert symbol. The warning message is printed in black, on the sign's white background.
3. An electrical "person with wire" safety symbol follows the warning message (it may also precede the warning message). This symbol is printed in black, on the sign's white background.
4. Signal and message wording is printed in a sans-serif font. Signal wording is always in uppercase. Message wording may be a combination of upper and lowercase letters, with the first word in the sentence capitalized. Message wording in uppercase is acceptable for short messages or emphasis of individual words.
5. Text justification is left-aligned for the word messages. Signal words are centered.
6. On the sign, the signal word reads, "WARNING." The warning message reads, "HAZARDOUS VOLTAGE INSIDE KEEP OUT." Additional wording includes, "CAN SHOCK, BURN OR CAUSE DEATH" and "IN CASE OF EMERGENCY, CALL 911." The Pacific Power or Rocky Mountain Power logo follows as shown in Figure 1 and Figure 2.

Placement and Spacing

1. Signs shall be placed on each fence run starting five (5) feet from the corner and then at 65-foot maximum spacing.
2. Signs shall also be placed on each gate, and shall be placed on the left-hand leaf of double gate.
3. Signs shall be placed on the outside of the fence (not the inside) at an approximate height of 5′-6″ from the bottom of the sign to grade. Sign location and height may be adjusted as needed to ensure maximum visibility. (For example, signs should not be obstructed by bushes, trees, berms, etc.)

Ordering, Installation, and Inspection

1. On existing installations, Technical Operations will inspect signs, verify placement, address conditions, and secure or order signs where and if needed.
2. Order high voltage warning signs with internal stock item number:

   Pacific Power sign: SI# 7999851

   Rocky Mountain Power sign: SI# 7999852
3. Order mounting hardware for mounting the sign on the substation fence, with internal Stock Item Number 7999092.

Description: The mounting hardware is comprised of aluminum brackets with 1″ temper-proof bolts and locking nuts. The bolts are installed through the sign's front, and screw into the aluminum brackets located on the interior of the fence. Four sets of mounting hardware are needed for each sign.

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EXHIBIT X

Specification for Substation
Equipment Installation, Testing and Commissioning

TABLE OF CONTENTS

Substation

Testing and Commissioning

1 Substation Testing and Commissioning

1.1 Scope of specification

Capitalized terms shall have the same meaning as defined in the Contract unless the context requires otherwise. This specification covers the testing of substation Equipment, auxiliary Equipment, relays, circuits and controls associated with the installation of new Equipment at Owner substations.

In general, all Equipment, switches, wiring, relays, controls, grounding systems, batteries, generators, buildings and associated systems, and all other devices shall be tested and verified by Contractor to meet the manufacturer's recommendations and Industry Standards and to be fully functional. In addition, the specific testing and commissioning criteria as stated in this document must be completed by Contractor. Testing is to be complete and as extensive as necessary to ensure the proper operation and functionality of the entire Project. If there is a conflict between the manufacturer testing requirements and Owner installation and/or testing procedures, Owner procedures shall prevail, unless specifically agreed to in writing by both parties. Any such conflicts or potential conflicts of procedures shall be highlighted and included in Contractor's pre-commissioning and test plan that must be submitted at least sixty (60) days before the Work starts, as described in Section 1.5. The primary purpose of these procedures is to: (a) ensure that the Equipment has been properly installed in accordance with the Equipment manufacturer and Owner procedures, and (b) to describe or provide the proper format for the documentation of all commissioning Work and test results obtained by Contractor so that Owner can review Contractor's Work.

1.2 Testing and commissioning responsibilities

Contractor shall be responsible for all aspects of installation, testing, pre-commissioning and commissioning, post-energization failures and corrections, except as noted below. The definitions of installation, testing, pre-commissioning and commissioning as used in this document are defined in Section 1.5. Contractor shall not install final protective relay settings or perform in-service verifications. However, Contractor shall dispatch personnel familiar with the Work to be on-site within twenty-four (24) hours after notification by Owner to correct any deficiencies due to Contractor performance of the Work. Review and acceptance by Owner of Contractor's test results and data shall not release Contractor of responsibility for any workmanship or Equipment deficiencies. Contractor shall be responsible to correct deficiencies due to Contractor performance of the Work in the manner described above until the Equipment has been placed in service, after which normal warranty procedures shall apply. Specific breakdown of Work responsibilities between Contractor and Owner can be found in PacifiCorp Testing and Commissioning Responsibility Matrix, Attachment X.1.2.

Contractor is responsible for confirming that all Equipment meets voltage, current, and other applicable ratings for the engineered design and application of the device.

Examples of typical Equipment and systems to be tested and verified for proper operation are listed below. This list is not all-inclusive and may include items not applicable:

- Circuit breakers
- Switches
- Transrupters
- Capacitor banks
- Power transformers and reactors

- Instrument transformers
- Bushings
- Arresters
- Protective relays and devices
- Monitoring devices
- Fault recording devices
- Meters and instruments
- Cables, wiring terminations and auxiliary controls
- AC and DC control systems
- Batteries and chargers
- Grounding systems and grids
- Lighting and AC service systems
- Building systems
- HVAC

1.3 Applicable standards

Contractor shall complete the testing and commissioning Work set out in this specification in full compliance of the following standards:

1.3.1 International Electrical Testing Association, Inc.

1.3.2 Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems

1.3.3 American National Standards Institute (ANSI):

- C12.1 - Code for Electricity Metering
- C12.10 - Physical Aspects of Watt-hour Meters - Safety Standard
- C12.11 - Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL
- C12.20 - Electricity Meters 0.2 and 0.5 Accuracy Classes
- C63.2 - Electromagnetic Noise and Field-Strength Instrumentation, 10 kHz to 40GHz
- C63.4 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz - Revision of ANSI C63.4-2001

1.3.4 American Society for Testing and Materials (ASTM):

- D 117 - Standard Guide for Sampling, Test Methods, Specifications, and Guide for Electrical Insulating Oils of Petroleum Origin
- D877 - Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
- D1816 - Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes

1.3.5 Institute of Electrical and Electronics Engineers (IEEE):

- C37.20.1 - Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
- C37.20.2 - Metalclad and Station-Type Cubicle Switchgear
- C37.20.3 - Metal-Enclosed Interrupter Switchgear
- C57.13 - Requirements for Instrument Transformers
- C57.13.1 - Guide for Field Testing of Relaying Current Transformers
- C57.13.2 - Conformance Test Procedures for Instrument Transformers
- C57.13.3 - Guide for Grounding of Instrument Transformer Secondary Circuits and Cases
- C57.106 - Guide for Acceptance and Maintenance of Insulating Oil in Equipment
- IEEE 450 - Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations

1.3.6 National Electrical Manufacturers Association (NEMA) and Insulated Cable Engineers Association (ICEA):

- NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables
- NEMA WC 70/ICEA S-95-658 - Non-shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
- NEMA WC 71/ICEA S-96-659 - Non-shielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy
- NEMA WC 74/ICEA S-93-639 - 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

1.3.7 National Fire Protection Association (NFPA):

- 70 - National Electrical Code

1.4 Safety

Test procedures, Equipment, temporary circuits, etc., shall be designed and used in a safe manner to minimize danger to testing technicians and other personnel. For example, current transformer temporary test circuits utilizing alligator clips shall not be permitted. Contractor shall furnish and utilize safety devices such as personal protective Equipment, personal grounds, rubber gloves and blankets, protective screens and barriers, yellow tape, danger signs, warning tags, and other items as appropriate to adequately protect and warn all personnel in the vicinity of the tests. Contractor shall keep Owner personnel informed of potential hazards associated with their Work when and as it could impact Owner's employees. Contractor shall participate in joint safety meetings with Owner personnel when they are on-site together. Contractor shall take all precautions necessary to ensure that Owner personnel are not exposed to safety hazards that may exist due to Contractor Work.

1.5 Definition of Equipment installation, testing and the commissioning process

The Contractor shall perform all typical industry accepted installation practices, manufacturer recommended installation and commissioning tests and Owner's required tests.

The overall commissioning process typically includes all activities from when the equipment is installed until it is placed in operational service. In order to facilitate work assignments and responsibilities, and for purposes of clarification the commissioning process will typically follow the sequence of events listed below:

1.5.1 Commissioning consists of:

1.5.1.1 Pre-commissioning

1.5.1.1.1 Installation of equipment

1.5.1.1.2 Acceptance testing of equipment.

1.5.1.2 Final commissioning

1.5.1.2.1 Functional testing of equipment.

1.5.1.2.2 Energization of equipment.

1.5.2 Definitions:

The different terms as used in this process are intended to have the following meanings:

1.5.2.1 Installation (of Equipment):

To place, position, or fit into a position or location and then to assemble sub-components and connect control and power cables, conductors, and other accessories and fittings to the Equipment as required to make it ready to be operational.

1.5.2.2 Testing:

To perform appropriate electrical, mechanical, thermal, pressure, operational and functional testing and verification of Equipment such as transformers, circuit breakers, switches, bus Work and ground mats. Testing of equipment takes place during pre-commissioning and final commissioning and can be sub-divided as follows:

1.5.2.2.1 Acceptance testing: Are those testing activities performed to verify that the equipment has been properly assembled and installed. For control cables and relay panels it means to perform insulation resistance (Megger), continuity, and point to point wiring verification tests. These activities will typically be performed by the Contractor.

1.5.2.2.2 Functional testing: Are those testing activities that are performed immediately prior and during initial energization of the equipment to verify correct operation under energized conditions. For protection and control systems, it implies applying final settings and performing functional tests to verify correct operation of the Equipment. These activities will typically be performed by the Owner.

1.5.3 Pre-commissioning:

To perform all installation (as defined in Section 16.5.2.1), acceptance testing (as defined in Section 16.5.2.2.1) and verification activities of substation Equipment, cables and relay panels in order to prepare it for placing it in service. For Equipment such as batteries, circuit breakers, switches, reactors and transformers, it includes all installation activities such as assembly, oil or gas processing, functional testing of accessories and sub-components, timing tests, and any electrical and mechanical acceptance tests needed to verify that the Equipment has been installed and connected according to the manufacturer and Owner's specifications. The purpose of these activities is to ensure that the Equipment is able to perform its intended function. These activities will be performed by Contractor with the exception of Equipment, cables and relay panels that are installed in existing and energized control buildings. Installation and testing activities on these items will be performed by Owner.

1.5.4 Final Commissioning:

The process of energizing the Equipment with control power followed by all final functional testing (as defined in Section 16.5.2.2.2) and verification required to verify that the equipment can be energized at rated voltage and power. Functional testing of the Equipment will be followed by energizing the Equipment at rated voltage and power to perform all post energization testing and verification of proper power flows through the Equipment before it can be placed in operational service. Final commissioning requires that pre-commissioning (as defined in Section 16.5.3) of the Equipment has been completed. This activity includes doing. These activities will be performed by Owner unless expressly delegated to Contractor.

1.6 Documentation

1.6.1 General

No installation and testing forms with failed test results should be submitted to PacifiCorp. The technician shall contact PacifiCorp to determine an appropriate course of action when acceptable test results cannot be achieved.

1.6.2 Pre-commissioning schedule and test plan

Contractor shall provide a written pre-commissioning schedule and test plan for all pre-commissioning activities to be completed for this Project no later than sixty (60) calendar days prior to the start of those activities. An individual plan is required for each substation in the Project. This plan and schedule shall include Equipment to be tested, testing Equipment to be used, test forms used for each Equipment type, and schemes used to test. The test plan shall include a detailed description of the test procedures that will be followed and the sequence in which they will be followed for each type of Equipment. The overall sequence in which the Equipment will be installed and tested shall be described. Owner shall approve this plan in writing before any test or pre-commissioning Work may commence.

1.6.3 Installation and Testing documentation required – field copies

Contractor shall supply Owner with field copies of all test results no later than two (2) days after completion of the tests for each piece of Equipment as it is installed and tested. These test results shall be dated and signed by the lead on-site tester.

1.6.4 Installation and Test documentation required – final copies

Contractor shall supply Owner with the final completed test data and reports within ten (10) days after completion of the tests for each piece of Equipment as it is installed and no later than five (5) days prior to energization of that Equipment. These test results shall be dated and signed by the lead on-site tester and the lead Project test engineer, when applicable.

1.6.5 Use of Owner-provided installation procedures and forms

Equipment-specific procedures and forms are provided by Owner and shall be utilized during the installation and testing of substation Equipment. Each required installation and testing form must be completed in full before it is submitted.

Equipment-specific procedures and forms are listed under each Equipment type in section 2. These documents are also listed in the attachment index at the end of this document; however, this list does not include all of the required procedures and forms. See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of Owner-provided required documentation.

Where Owner procedures and forms are not available for a specific type of Equipment, Contractor shall submit his own procedures and suitable forms for documenting the test data for Owner review and approval. All Contractor procedures and forms that are to be used shall be included with the pre-commissioning and test plan for Owner review and approval.

1.6.6 Electronic test set-generated data

Test set-generated electronic data results shall be submitted in two formats: This will typically apply for any power factor; transformer turns ratio; battery; and transformer sweep frequency analysis test results.

1.6.6.1 Adobe Acrobat copies or print-outs of all test set generated reports.

1.6.6.2 Test set generated data files shall be submitted as attachments in the OEM test equipment software format.

1.6.7 Installation reports and test data format and file naming convention

All test reports and documentation packages shall be e-mailed to the following e-mail address: Commissioning@PacifiCorp.com.

All equipment that is listed and tracked in the Commissioning Notebook shall have equipment memorandum forms submitted in addition to all test reports. These forms are listed Substation Apparatus and Line Equipment Memorandum, Form 001F, Attachment A-X1.6.7A, and Relay and Interchange Meter Equipment Memorandum, Form 006F, Attachment X1.6.7B

Test data and forms pertaining to any one piece of Equipment shall be submitted together in one e-mail. If the e-mail message size will exceed ten megabytes, the data shall be divided into separate e-mails and clearly labeled with subpart numbers, for example: Part 1 of 3; Part 2 of 3; etc.

- Type of test report (e.g. Field copy or Final Test Report)
- The subject line of the e-mail shall list the following information:
- Installed location of Equipment (e.g. substation name)
- Equipment description (e.g. 345kV circuit breaker CB123)
- Company identification number if the Equipment has one (e.g. SAP#: 123456)
- Subpart number of e-mail. Single e-mail submittals will be listed as Part 1 of 1.
    - e.g. Ashley_CB123_SAP123456_part 1 of 1

When several different forms are submitted for a particular piece of Equipment, these forms may not be combined or scanned into one electronic Adobe Acrobat file. Each form or data set shall be included as a separate attachment contained in the one e-mail submittal. The body of the e-mail shall list all the attachments contained in the e-mail by form or document name.

All test forms shall be delivered to Owner electronically in the original Adobe Acrobat format as provided and using marked up design or installation drawings (when required). Testing and verification data not specifically addressed in this specification shall be formally documented and submitted in Adobe Acrobat format, unless otherwise agreed to by Owner.

All information fields on all Owner-provided forms shall be completed in full by Contractor. Where more than one subcontractor performs parts of the Work for any particular type of Equipment, their respective Work shall be combined on one form for Owner review. Partially completed forms from each subcontractor are unacceptable. Each documentation package submitted shall be arranged as described below.

In addition to the electronic submittals, an official copy of the field and final test reports shall be submitted in duplicate on CD-ROM. Paper copies of the reports are optional.

All test reports on paper or CD-ROM shall include the minimum subsections and subparts in the format as listed below:

a. A title page listing:

- **i.** Report title/purpose: Field Installation/Test Report for "Equipment Type";
- **ii.** The installed location of the equipment;
- **iii.** The Owner project title or description;
- **iv.** The date the test reports were submitted to the Owner;

b. If test reports are submitted for more than one piece of equipment in one report, an index page shall follow the title page with the information as listed below for each separate piece or unit of equipment (i.e. circuit breaker, transformer, instrument transformer, switch, etc.) included in the report:

- **i.** The type of equipment – circuit breaker, transformer, etc.;
- **ii.** The Owner equipment number;
- **iii.** The equipment serial number provided by the manufacturer; and
- **iv.** Equipment location (substation) and Owner-provided position number.

c. For each separate unit or piece of equipment included in the report, a separate cover page shall be included preceding the test data for that equipment, listing the following information as it pertains to that piece of equipment:

- **i.** Type of equipment - circuit breaker, transformer, etc.;
- **ii.** The Owner equipment number (if applicable);
- **iii.** The equipment serial number;
- **iv.** The name and contact details of the manufacturer / factory representatives on site during the installation;
- **v.** The names and contact details of all subcontractors that performed the field installation and testing (if more than one subcontractor was used, please specify each and their responsibility);
- **vi.** The start and end dates of field installation and testing work;
- **vii.** All test reports and forms included in the report, in chronological order as they appear in the report; and
- **viii.** Miscellaneous test results as described in Section 1.6.8.

d. If test reports are submitted for more than one piece of equipment in one report, an index page shall follow the title page with the information as listed below for each separate piece or unit of equipment (i.e. circuit breaker, transformer, instrument transformer, switch, etc.) included in the report:

- **i.** The type of equipment – circuit breaker, transformer, etc.;

ii. The Owner equipment number;

iii. The equipment serial number provided by the manufacturer; and

iv. Equipment location (substation) and Owner-provided position number.

e. For each separate unit or piece of equipment included in the report, a separate cover page shall be included preceding the test data for that equipment, listing the following information as it pertains to that piece of equipment:

i. Type of equipment - circuit breaker, transformer, etc.;

ii. The Owner equipment number (if applicable);

iii. The equipment serial number;

iv. The name and contact details of the manufacturer / factory representatives on site during the installation;

v. The names and contact details of all subcontractors that performed the field installation and testing (if more than one subcontractor was used, please specify each and their responsibility);

vi. The start and end dates of field installation and testing work;

vii. All test reports and forms included in the report, in chronological order as they appear in the report; and

viii. Miscellaneous test results as described in Section 1.6.8.

1.6.8 Miscellaneous Equipment and Equipment without company identification numbers

Control cable tests, wiring verifications, alarm verifications and all other required testing that does not have a specific associated check sheet or computer generated test result shall be highlighted (yellow for wire verification and pink for devices), initialed by the tester, and dated on the appropriate clean construction drawing or print. The highlight will confirm that all verification and testing has been completed by Contractor.

Additions of Equipment, wiring, or any other modifications to the drawings shall be fully and professionally documented. Removals of Equipment or wiring shall be drawn in green and permanent corrections and additions shall be marked in red. All changes shall be reviewed and approved by Contractor design engineer.

Testing technician comments or notes pertaining to the marked changes that are not intended for permanent retention on the drawings shall be marked in standard pencil. Corrected drawings (“as-constructed”) shall be continually updated and completed prior to energization for Owner’s engineering review and technician’s use during energization commissioning.

1.6.9 Review and acceptance of test results

All test results, forms and data shall be approved by Owner before the Equipment may be energized or placed in service. Acceptance of test results by Owner does not relieve Contractor of his responsibility to perform the Work in accordance with the various procedures and forms or the terms of the contract.

1.7 Personnel qualifications

1.7.1 General

All technicians shall be pre-qualified by PacifiCorp for each project prior to any installation or testing work commencing. All technicians shall be experienced in installation and testing of substation equipment with similar voltage class and type as this project entails. All installation and testing of substation equipment must be carried out by qualified technicians.

1.7.2 Lead testing technician

The lead testing technician shall have a minimum of ten (10) years of relevant experience in electric utility high voltage substation testing, including being in charge of testing programs for substations of a similar size and nature to this project. The lead testing technician shall be present on-site during all testing activities. All testing of equipment shall be performed under the direct on-site supervision of the lead testing technician.

1.7.3 Testing Technician

The testing technician shall have a minimum of five (5) years of relevant experience in electric utility high voltage substation testing.

1.7.4 Installation technician

The installation technician shall have a minimum of five (5) years of relevant experience in electric utility high voltage substation equipment installation.

1.7.5 Proof of experience

Each technician shall submit detailed written documentation that describes the specific equipment type, models and manufacturers of relevant equipment previously installed and tested to support the technician's claims of relevant experience. The evidentiary documentation shall explain the specific responsibility and role that the person had for each type of equipment. Documentation shall include the company name for each project where work was performed. Owner may require all technicians to perform a practical skills and subject matter knowledge demonstration before being approved. The purpose of this process is to corroborate the technician's claims of specific and relevant experience. A general purpose resume style document is unacceptable.

All technicians may be interviewed by PacifiCorp representatives to determine if the technician is approved for installation and/or testing activities. All documentation for the technician shall be submitted one month before any installation or testing is to commence. Approvals may be limited to certain equipment types or by voltage class. Approvals will apply to both Rocky Mountain Power and Pacific Power.

1.8 Required test Equipment

Contractor shall furnish all required testing Equipment. All test Equipment shall have been tested, calibrated and certified to be in fully functional condition by the Equipment manufacturer (or other certified facility); in accordance with the Equipment manufacturer's recommended calibration intervals, prior to performing any testing. Copies of all certificates shall be provided to Owner prior to testing. Owner will field verify that only pre-qualified test Equipment is used during actual testing. Test technicians must be familiar with the use of this Equipment and have a thorough understanding of the devices that are being tested.

The following is a list of approved test Equipment. Deviations from this list shall require Owner approval. Complete details of Equipment that deviates from the approved list of Equipment, as well as any other Equipment that will be used and is not listed here shall be submitted with the pre-commissioning and test plan prior to the start of the Work as described in Section 1.5.

1.8.1 Power factor/exciting current (e.g. Doble M4000)

1.8.2 Relay test set for use as a power supply for functional testing, as required (e.g. Doble 6150 series or 3 each of the 2350 series)

NOTE: Contractor is not responsible for installation or verification of relay settings or in-services tests.

1.8.3 Voltmeter and ammeter

- Multi-meters may be used during the calibration of meters, transducers and relays. Any meter used must be high-accuracy digital and meet the following specifications:
- 4.5 digit or better resolution
- True RMS AC measurement
- Basic DC accuracy: 0.05 percent of scale used
- Basic AC accuracy: 0.2 percent of scale used

1.8.4 Current transformer test Equipment

1.8.5 A device specifically designed to test current transformers shall be used. Approved devices include:

- Model CTER-91 Vanguard EZ Current Transformer Tester (preferred)
- AVO Current Transformer Excitation Test Set
- Appropriate Vanguard current transformer excitation test set device

1.8.6 Test jack devices

- ABB FT-1 and FT-19R test switches shall be used extensively throughout the protective relay and control and metering systems to facilitate testing.
- Disconnection of internal wiring is discouraged and is to be performed only when absolutely necessary and with prior approval from the Owner.
- It shall be necessary to have sufficient quantities of ABB Test Plugs (duckbills) to enable the use of the test switches.

1.8.7 Computer and printer

- A computer and associated communications cables for communicating with the various types of testing Equipment is required and shall include special software to communicate with test Equipment, substation integration devices, and/or intelligent Equipment devices (i.e., relays, panel meters, transformer tap controllers, etc.). Contractor is responsible for providing the computer, printer, cables and any other associated hardware and software that may be needed.

1.8.8 Ohmmeters

- 5000-volt megohm meter with a minimum accuracy of 5 percent
- Digital Low Resistance Ohmmeter (DLRO)
- Direct current (DC) Micro ohmmeter, 100 ampere (A) true continuous DC current

1.8.9 Infrared (IR) scanning Equipment

- IR Equipment must be capable of recording thermal images and temperatures in full sunlight. Proper magnification lens must be used for distances of 75 feet or more.

1.8.10 Battery-powered wire identification test set

1.8.11 Standard insulating liquid test set

- The test set should include a test cell with one-inch disc electrodes and adjustable gap per ASTM D877 and a test cell with electrodes and spacing per ASTM D1816, Hipotronics Type OC or approved equivalent.

1.8.12 DC resistance load box, 100 A or greater

1.8.13 Alternate current (AC) high current test set, Multi-Amp MS-2, or approved equivalent

1.8.14 AC high-potential test set, adjustable up to 60 kV and 60 hertz

1.8.15 DC high-potential test set, adjustable up to 90 kV

1.8.16 Oscilloscope, capable of six traces, including three current traces

1.8.17 Contact resistance test set, 100 A or greater

1.8.18 Sweep frequency response analyzer (e.g. Doble M5000 series)

1.8.19 Circuit breaker timing test set (e.g. Vanguard CT7500)

2 Specific Equipment testing

2.1 Switches

2.1.1 Documentation:

2.1.1.1 Contractor shall complete and submit a separate PacifiCorp Substation Form SF-ABDISC-INST, Attachment X.2.1, for each switch that is installed.

2.1.1.2 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.1.2 Description:

2.1.2.1 All high-voltage switches shall be verified to meet manufacturer's standards for functionality, toggle accuracy, timing accuracy, open- and closed-position accuracy, proper operating torque, and required torque of bolted connections. Owner shall verify switch operation prior to setting of piercing bolts by Contractor.

2.2 Grounding grid

2.2.1 Documentation:

2.2.1.1 This testing and inspection shall be highlighted or marked off on the grounding plan drawing for Owner's review. All test results shall be documented on the appropriate forms and will include tabulated and graphed results as required in the prescribed industry type tests or test methods described in PacifiCorp Substation Procedure SP-GRND-CONTINUITY, Attachment X.2.2A. Submit PacifiCorp Substation Form SF-GRND-CONTINUITY, Attachment X.2.2B, and soil resistivity report, if required.

2.2.1.2 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.2.2 Description:

2.2.2.1 If required, a soil resistivity test shall be performed along at least two (2) sides of the site, as well as diagonally from one corner to another, using the four point

"Wenner" measurement method. Test results shall be used as part of the ground grid design.

2.2.2.2 All ground grids, grounding connections, Equipment and fence grounding shall be tested and inspected for proper torque value and/or Cad-Weld integrity.

2.2.2.3 For new ground grids or additions to existing ground grids, a ground grid resistance to earth test shall be performed. Contractor shall ensure that the new grid under test is disconnected from all external utility neutral or grounding connections, including static lines on overhead power lines entering the substation. The test shall be performed using the "Fall of Potential" or three-point measurement method. Contractor shall verify the ground resistance test results meets or exceeds the design requirements. If test results do not meet or exceed design requirements, Contractor shall submit a mitigation plan for approval to Owner.

2.2.2.4 The ground grid shall be tested for continuity between all connected parts of the grid using the current injection method described in procedure SP-GRND-CONTINUITY, Attachment X.2.2A. All exposed ground grid connections must be verified using a high-current injection test set rated at one hundred (100) amperes (A) or greater. Each Equipment and structure connection point must be injected (forced to flow) with minimum one hundred (100) A to verify proper continuity of the below-ground level grounding grid conductors and connections. Voltage and current flows at each exposed conductor shall be recorded on form SF-GRND-CONTINUITY, Attachment X.2.2B, and on the grounding plan drawing. The location of the power supply connections for the specific test area shall be recorded and marked on the forms and drawings as described.

2.3 Phasing

2.3.1 Documentation:

2.3.1.1 Protective circuitry phasing verification shall be highlighted on applicable potential schematic drawings.

2.3.1.2 High-voltage bus phasing verification shall be highlighted on applicable potential schematic drawings.

2.3.1.3 Phasing nomenclature will be provided by Owner for each substation.

2.3.1.4 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.3.2 Description:

2.3.2.1 Physically, electrically, and mechanically verify high-voltage bus Work and lines, low-voltage station service, transfer switches, generator, and all motors have proper rotation and phasing and meet engineering design and application. Owner will ensure phasing is performed during commissioning.

2.4 Control wiring

2.4.1 Documentation:

2.4.1.1 All final substation as-constructed drawings, including manufacturer drawings, must be clearly marked-up and modified to reflect the exact substation Equipment installed details.

2.4.1.2 Complete and submit PacifiCorp Substation Form SF-CABLE-INST, Attachment X.2.4A for all control cables that are installed to connect equipment to each other.

2.4.1.3 Wiring termination drawings shall be highlighted to indicate wiring and device testing and verification.

2.4.1.4 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5 for a complete list of required procedures and forms.

2.4.2 Description:

2.4.2.1 Visual inspection: Visually inspect all relays, meters, electrical Equipment control cabinets, and any modified or new relay control panels for damage that may have occurred during shipping and installation.

2.4.2.2 Panel Equipment installation: Verify relays, Equipment, and nameplates are installed on the panel as documented on the panel layout and connection diagram.

2.4.2.3 Panel point-to-point wiring: Perform point-to-point wire checks on all new and modified relay control panels. Verify wiring matches the connection diagram and control schematics.

2.4.2.4 Panel wire lugs: Verify all new and modified panel wiring lugs are adequately crimped. See Construction Specifications, Attachment X.2.4B, for cable lug installation specifications.

2.4.2.5 Panel terminal blocks: Verify all new and modified panel wiring terminal block connections are checked for tightness.

2.4.2.6 Panel current transformer (CT) circuits: For each new or modified relay control panel, measure the direct current (DC) resistance of each CT circuit from the panel input terminal blocks with no shorting screws installed. This test is to ensure that the CT circuits are not open-circuited. The measured DC resistance of each circuit should be less than five (5) ohms.

2.4.2.7 Panel voltage transformer (VT) circuits: For each new or modified relay control panel, measure the DC resistance of each VT circuit from the panel input terminal blocks. This test is to ensure that the VT circuits are not short-circuited. The measured DC resistance of this circuit should be greater than one thousand (1,000) ohms.

2.4.2.8 Panel DC circuits: Measure the DC resistance of the DC control power circuit from the panel input (DC positive and DC negative) terminal blocks. This test is to ensure that the DC circuit is not short-circuited. The measured DC resistance of this circuit should be greater than ten (10) ohms.

2.4.2.9 Cable insulation testing: Test the insulation on all new and modified control wires before the leads are laid down. Test each wire to shield insulation resistance with all the other wires bonded to the shield, using a fine hundred (500) volt DC insulation tester. Measured insulation levels should exceed one megohm at five hundred (500) volts DC.

2.4.2.10 Cable lugs: Verify all new and modified cable lugs are adequately crimped.

2.4.2.11 Cable terminal blocks: Verify all new and modified outdoor cable terminal block connections are checked for tightness.

2.5 Circuit breakers

2.5.1 Documentation:

2.5.1.1 Complete and submit manufacturer-specific installation forms in conjunction with Owner provided Adobe Acrobat forms, SF_6 gas analysis results and electronic test Equipment generated data files with timing information.

2.5.1.2 Use PacifiCorp Substation Form SF-CKB-SF6PUFF-INST, Attachment X.2.5A, for all generic circuit breakers without model specific forms.

2.5.1.3 Use PacifiCorp Substation Form SF-CKB-HVB362-INST, Attachment X.2.5B, for HVB-362 model circuit breakers.

2.5.1.4 Use PacifiCorp Substation Form SF-CKB-BOTTLE-INST, Attachment X.2.5C for all outdoor type distribution vacuum or SF6 bottle type circuit breakers.

2.5.1.5 Use PacifiCorp Substation Form SF-CKB-SWG-INST, Attachment X.2.5D for all metal clad distribution vacuum circuit breakers.

2.5.1.6 Use PacifiCorp Substation Form SF-SF6-SMPL, Attachment X.2.5E, for submitting SF_6 gas samples. Refer to PacifiCorp Substation Procedure SP-CKB-SF6PUFF-INST, Attachment X.2.5F, and PacifiCorp Substation Procedure SP-SF6-SMPL, Attachment X.2.5G, for instructions.

2.5.1.7 Refer to PacifiCorp Procedure MATP-SF6CYL-PROCESS, Attachment X.2.5H, for SF_6 gas procurement instructions and PacifiCorp Substation Procedure SP-SF6-FILL, Attachment X.2.5I, regarding introduction of SF_6 gas into the breakers.

2.5.1.8 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

Description:

2.5.1.9 Refer to procedure SP-CKB-SF6PUFF-INST, Attachment X.2.5F, and follow the process outlined in that procedure for the installation and testing of SF6 circuit breakers.

2.5.1.10 Refer to procedure SP-CKB-BOTTLE-INST, Attachment X.2.5J for installation and testing of all outdoor type distribution vacuum or SF6 bottle type circuit breakers.

2.5.1.11 Refer to procedure SP-CKB-SWG-INST, Attachment X.2.5K and follow the process outlined in that procedure to install and test metal clad distribution vacuum circuit breakers.

2.5.1.12 Perform all assembly and installation tasks and internal checks and adjustments in accordance with manufacturer instructions.

2.5.1.13 Refer to procedure MATP-SF6CYL-PROCESS, Attachment X.2.5H, to obtain SF_6 gas from the PacifiCorp technical operations warehouse for breaker filling. DO NOT use SF_6 gas from any other source.

2.5.1.14 Install SF_6 gas using manufacturer procedures in conjunction with procedures SP-SF6-FILL, Attachment X.2.5I, and SP-SF6-SMPL, Attachment X.2.5G. SF_6

gas samples shall be taken from all circuit breakers no less than twenty-four (24) hours after filling, and submitted to an Owner-approved laboratory for analysis. Unless the circuit breaker has a common gas manifold between the poles, a separate sample shall be taken from each pole. The laboratory analysis should include moisture content, dielectric and gas purity. The analysis results shall be included with the test reports.

2.6 Current and voltage transformers

2.6.1 Documentation:

2.6.1.1 PacifiCorp Protection and Control Form PCF-CT-INST, Attachment X.2.6A, for current transformer installation and testing.

2.6.1.2 PacifiCorp Substation Form SF-VT-INST, Attachment X.2.6B for voltage transformer installation and testing.

2.6.2 Description:

2.6.2.1 Current transformer (CT) secondary wiring:

2.6.2.1.1 Verify all secondary CT wiring matches the substation connection diagrams and control schematics. Ensure correct CT ratio, polarity, and grounding.

2.6.2.2 CT Testing and inspection:

2.6.2.2.1 Visually inspect the CT wiring, lugs, and shorting-type terminal blocks for tight connections, and any damage that may have occurred during shipping. The physical installation should be consistent with the Equipment wiring diagrams and schematics.

2.6.2.2.2 Ratio test: Verify the ratio between the secondary and the primary windings. For multi-ratio CT’s, verify the ratio for each ratio. Measured ratio values should be consistent with the manufacture’s CT test data, and the Equipment wiring diagrams and schematics.

2.6.2.2.3 Saturation test: Perform a saturation test on the full winding (maximum ratio) of the CT. Graph the secondary exciting volts verses secondary exciting amps for the winding. In addition, determine the saturation value for the full winding. Saturation is defined as the point where the curve is tangent, or forty-five (45) degrees, to the secondary exciting amperes. Measured saturation curve characteristics and saturation value should be consistent with the CT excitation curves and data provided by the manufacturer.

2.6.2.2.4 Polarity test: Verify the polarity of the CT primary to the secondary windings. Correct polarity is when the current entering the positive primary terminal is in phase with the current leaving the positive secondary terminal. Verify that measured polarity is consistent with the Equipment, wiring diagrams, and schematics.

2.6.2.2.5 Insulation resistance test: Measure the CT insulation resistance to ground on each output terminal using a five hundred (500) volt DC insulation tester. Values greater than one (1) megohm are acceptable.

2.6.2.3 Voltage transformer (VT) testing and inspection:

2.6.2.3.1 Perform all installation activities and tests as listed on procedure SP-VT-INST, Attachment X.2.6C.

2.6.2.3.2 For capacitive coupled voltage transformers (CCVTs), verify that the capacitor stacks are assembled per manufacturer assembly diagrams and that the nameplate data for each capacitor stack matches the manufacturer data for location, serial number and capacitance.

2.7 Oil-filled transformers and shunt reactors

2.7.1 Documentation:

2.7.1.1 Refer to PacifiCorp Substation Procedure, SP-TRF-INST, Attachment X.2.7A, for all required forms and referenced procedures.

2.7.1.2 Follow and complete PacifiCorp Substation Form SF-TRF-INST, Attachment X.2.7B, beginning at receipt of transformers from the shipper. Complete and submit all required forms listed in procedure SP-TRF-INST, Attachment X.2.7A.

2.7.1.3 PacifiCorp Substation Procedure SPC-TRF-OILPROC, Attachment X.2.7C, and PacifiCorp Substation Form SF-TRF-OILPROC, Attachment X.2.7D.

2.7.1.4 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.7.2 Description:

2.7.2.1 The installation and testing of the transformer shall be performed in accordance with procedure SP-TRF-INST, Attachment X.2.7A, and all sub-procedures referenced therein.

2.7.2.2 If the transformer is to be oil-filled on site, the dry-out and oil filling process described in procedure SPC-TRF-OILPROC, Attachment X.2.7C shall be followed. Complete vacuum processing log SF-TRF-OILPROC, Attachment X.2.7D.

2.8 Shunt capacitor banks

2.8.1 Documentation:

2.8.1.1 Refer to PacifiCorp Substation Procedure SP-CAP-INST, Attachment X.2.8, and submit documented test results as described in that procedure.

2.8.1.2 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.8.2 Description:

2.8.2.1 Perform all manufacturer-recommended mechanical assembly tests and verifications.

2.8.2.2 The capacitor bank’s capacitance value for each individual phase shall be measured and verified to be balanced within engineering design criteria.

2.8.2.3 Individual capacitor cans shall be measured using a capacitance bridge to measure the capacitance. Measurements must be logged on a drawing clearly indicating each capacitor can’s physical location in the bank.

2.8.2.4 For factory assembled racks, the rack location and capacitor can serial numbers shall be verified against the manufacturer design drawings to ensure correct rack and capacitor can placement.

2.8.2.5 Bank electrical layout must be verified according to design.

2.9 Series capacitor banks

2.9.1 Documentation:

2.9.1.1 Completed test reports of capacitor checks and tests recommended by the manufacturer, also to include manufacturer specifications with Equipment measurements.

2.9.1.2 Series capacitor bank bypass circuit breakers require completion of PacifiCorp Substation Form SF-CKB-SF6-INST, Attachment X.2.5A. Refer to Section 2.5 of this document for instructions specific to SF_6 circuit breaker installation.

2.9.1.3 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.9.2 Description:

2.9.2.1 Perform all manufacturer-recommended mechanical assembly and electrical commissioning tests.

2.9.2.2 The capacitor bank capacitance value for each individual phase shall be measured and verified to be balanced within engineering design criteria.

2.9.2.3 Individual capacitor cans shall be measured using a capacitance bridge to measure the capacitance. Measurements must be logged on a drawing that clearly identifies the physical location of each capacitor can in the bank.

2.9.2.4 For factory-assembled racks, the rack location and capacitor can serial numbers shall be verified against the manufacturer design drawings to ensure correct rack and capacitor can placement.

2.9.2.5 Bank electrical layout must be verified according to design.

2.10 Batteries

2.10.1 Documentation:

2.10.1.1 Refer to PacifiCorp Substation Procedure SP-BAT-CHGR-INST, Attachment X.2.10A. Complete and submit PacifiCorp Substation Form SF-BAT-CHGR-INST, Attachment X.2.10B.

2.10.1.2 Submit any battery or charger manufacturer-specific installation and test forms.

2.10.1.3 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.10.2 Description:

2.10.2.1 Perform all manufacturer installation and setup actions and other tests as specified in procedure SP-BAT-CHGR-INST, Attachment X.2.10A.

2.10.2.2 Perform a DLRO low-resistance micro ohm test across all cell interconnections.

2.10.2.3 An IR scan and image of all connections and the bank shall be performed during load testing. If abnormal heating of any cells or connections between cells are connected these shall be corrected and brought to Owner's immediate attention if corrections can not readily be made.

2.10.2.4 The charger shall be configured and tested for the specific application, including verification of all DC output voltages and all alarm points, in accordance with manufacturer procedures and Owner settings.

2.11 Circuit Switchers and Transrupters

2.11.1 Documentation:

2.11.1.1 PacifiCorp Substation Form SF-TRUPTER-S2000-INST, Attachment X.2.11A

2.11.2 Description:

2.11.2.1 Perform all installation and testing activities as described in procedure SP-TRUPTER-S2000-INST, Attachment X.2.11B

2.12 Emergency Generators

2.12.1 Documentation:

2.12.1.1 PacifiCorp Substation Form SF-EPU-INST, Attachment X.2.12A

2.12.2 Description:

2.12.2.1 Perform all installation and testing activities as described in procedure SP-EPU-INST, Attachment X.2.12B

2.13 Metal Clad Switchgear

2.13.1 Documentation

2.13.1.1 PacifiCorp Substation Form SF-SWG-INST, Attachment X.2.13A

2.13.2 Description

2.13.2.1 Perform all manufacturer recommended installation and testing activities, in addition to those described in procedure SP-SWG-INST, Attachment X.2.13B

2.14 Air Core Reactor

2.14.1 Documentation

2.14.1.1 PacifiCorp Substation Form SF-XRT-AIR-INST, Attachment X.2.14

2.14.2 Description

2.14.2.1 Follow manufacturer recommended installation procedures and testing, in addition to completing form SF-XRT-AIR-INST, Attachment X.2.14

2.15 Control Buildings and other miscellaneous equipment

2.15.1 Documentation

2.15.1.1 PacifiCorp Substation Form SF-HVAC-INST, Attachment X.2.15A for HVAC systems.

2.15.1.2 PacifiCorp Substation Form SF-REG-INST, Attachment X.2.15B for single phase voltage regulator installation.

2.15.1.3 PacifiCorp Substation Form SF-SS-INST, Attachment X.2.15C for station service transformers and associated switches and panels.

2.16 Infra-red Scans

2.16.1 Documentation

2.16.1.1 PacifiCorp Substation Form SF-INS, Attachment X.2.16

2.16.2 Description:

2.16.2.1 Follow the manufacturer recommended guidelines and perform in-service infra-red scans of all energized equipment including for which installation activities were performed, including bus bars and equipment connection jumpers.

2.17 Auxiliary settings and commissioning (other than protective relays)

2.17.1 Documentation:

2.17.1.1 Setting and verification of functional operation shall be noted on appropriate drawings or prints.

2.17.1.2 See PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents, Attachment X.1.6.5, for a complete list of required procedures and forms.

2.17.2 Required settings and testing:

2.17.2.1 All devices not specifically addressed in this document shall be tested in accordance with manufacturer specific procedures and requirements.

END OF SECTION

ATTACHMENTS

Exhibit X

Testing & Commissioning

X.1.2	PacifiCorp Testing and Commissioning Responsibility Matrix
X.1.6.5	PacifiCorp SubEquip-Comprehensive List of Installation and Testing Documents
X.1.6.7A	PacifiCorp Apparatus and Line Equipment Memorandum, Form 001F
X.1.6.7B	PacifiCorp Relay and Interchange Meter Equipment Memorandum, Form 006F
X.2.1	PacifiCorp Substation Form SF-ABDISC-INST Air Break Switch Installation
X.2.2A	PacifiCorp Substation Procedure SP-GRND-CONTINUITY Ground Grid Continuity Test
X.2.2B	PacifiCorp Substation Form SF-GRND-CONTINUITY Ground Grid Continuity Test
X2.4A	PacifiCorp Substation Form SF-CABLE-INST Cable Installation
X.2.4.B	PacifiCorp Construction Specification 16300
X.2.5A	PacifiCorp Substation Form SF-CKB-SF6PUFF-INST SF6 Circuit Breaker Installation
X.2.5B	PacifiCorp Substation Form SF-CKB-HVB362-INST HVB-362 Circuit Breaker Installation
X.2.5C	PacifiCorp Substation Form SF-CKB-BOTTLE-INST Outdoor Vacuum and SF6 Bottle Circuit Breaker Installation
X2.5D	PacifiCorp Substation Form CKB-SWG-INST Metal Clad Circuit Breaker Installation
X2.5E	PacifiCorp Substation Form SF-SF6-SMPL Gas Sampling
X.2.5F	PacifiCorp Substation Procedure SP-CKB-SF6PUFF-INST Puffer Style SF6 Circuit Breaker Installation
X.2.5G	PacifiCorp Substation Procedure SP-SF6-SMPL Gas Sampling
X.2.5H	PacifiCorp Procedure MATP-SF6-CYL-PROCESS Procedure to Obtain Sulfur Hexafluoride (SF_6) Gas Cylinders
X.2.5I	PacifiCorp Substation Procedure SP-SF6-FILL SF6 Filling
X2.5J	PacifiCorp Substation Procedure SP-CKB-SWG-INST Metal Clad Circuit Breaker Installation
X2.6A	PacifiCorp Protection and Control Form PCF-CT-INST Current Transformer Instalaltion
X.2.6B	PacifiCorp Substation Form SF-VT-INST Voltage Transformer Installation
X.2.6C	PacifiCorp Substation Procedure SP-VT-INST Voltage Transformer Installation
X.2.7A	PacifiCorp Substation Procedure SP-TRF-INST Transformer Installation
X.2.7B	PacifiCorp Substation Form SF-TRF-INST Transformer Installation

X.2.7C	PacifiCorp Contractor Procedure SPC-TRF-OILPROC Oil Processing of Transformers
X.2.7D	PacifiCorp Substation Form SF-TRF-OILPROC Vacuum Processing Log
X.2.8	PacifiCorp Substation Procedure SP-CAP-INST Capacitor Bank Installation
X.2.10A	PacifiCorp Substation Procedure SP-BAT-CHGR-INST Battery and Charger Installation
X.2.10B	PacifiCorp Substation Form SF-BAT-CHGR-INST Battery and Charger Installation
X2.11A	PacifiCorp Substation Form SF-TRUPTER-S2000 Transrupter and Series 2000 Circuit Switcher Installation
X2.11B	PacifiCorp Substation Procedure SP-TRUPTER-S2000 Transrupter and Series 2000 Circuit Switcher Installation
X2.12A	PacifiCorp Substation Form SF-EPU-INST Emergency Generator Installation
X2.12B	PacifiCorp Substation Procedure SP-EPU-INST Emergency Generator Installation
X2.13A	PacifiCorp Substation Form SF-SWG-INST Metal Clad Switchgear Installation
X2.13B	PacifiCorp Substation Procedure SP-SWG-INST Metal Clad Switchgear Installation
X2.14	PacifiCorp Substation Form SF-XRT-AIR-INST Air Core Reacto Installation
X2.15A	PacifiCorp Substation Form SF-HVAC-INST HVAC Installation
X2.15B	PacifiCorp Substation Form SF-REG-INST Single Phase Voltage Regulator Installation
X2.15C	PacifiCorp Substation Form SF-SS-INST Station Service Installation
X2.16	PacifiCorp Substation Form SF-INF Infra-red Scan

avian-safe design

SV 002 Bird and Animal Protection—General Installation Instructions

1. Scope

This standard provides information regarding the proper installation of bird and animal protection products to reduce the risk of protected bird electrocutions and bird and animal-caused outages within company substations.

2. Avian-Safe Design and Applicable Voltages

Bird and animal protection products are installed in substations at and near equipment and support structures when the horizontal/diagonal separation between potential points of contact is less than 46″ and/or when the vertical separation between potential points of contact is less than 30″. Phase-to-phase and phase-to-ground distances must be considered when determining the need for protection. Lower voltage substations up to and including 46 kV require the installation of cover-up products or barriers at and near equipment and support structures to reduce the risk of bird and animal electrocutions. Protection may include covers and/or barriers on bushings, arresters, jumpers, switches, bus support insulators, and station service.

69 kV substations should, by engineering design (where applicable), meet avian-safe separations without the use of cover-up materials. However, if avian-safe separations are not met in 69 kV substations, work with engineering and T&D environmental services to assess the risks and develop an appropriate solution.

3. Personnel-Protective Grounding Provisions

When bird and animal protection is installed on equipment, provisions must be made to allow proper grounding of substation equipment and bus work. Generally, a minimum length of six inches (6″) of non-covered, bare conductor should be maintained for grounding. Self-adhesive tape should be installed directly on the hose, adjacent to the grounding gap, to help secure the hose and eliminate sliding and shifting. When possible, these gaps in coverage on conductors should be staggered at alternating heights to minimize bird and animal electrocution risks.

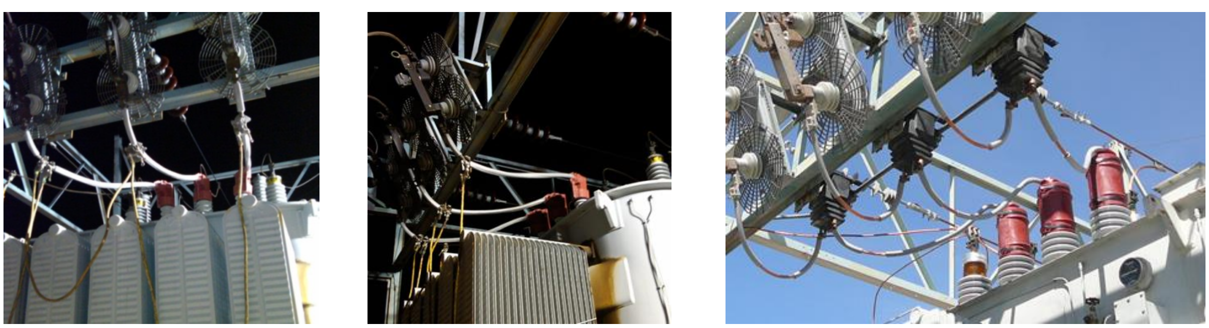


Figure 1—Gaps in Hose Coverage on Conductors for Proper Grounding

ROCKY MOUNTAIN POWER

PACIFIC POWER

4. Proper Installation of Bird and Animal Protection Products

The following section provides general guidance for the proper installation of various bird protection products. It is imperative that products be installed correctly to prevent future operational problems, equipment failures, or nesting issues:

- **Do NOT cover the entire length of bus or conductor**

  Bus and conductor covering should be installed at and near equipment and support structures where the horizontal/diagonal separation between potential points of contact is less than 46″ and/or when the vertical separation between potential points of contact is less than 30″. Hose or heat-shrink tape should not extend the entire length of the bus or cover the entire conductor, but rather, should be installed at, and adjacent to, equipment and support structures, where perching may occur.

Figure 2—Incorrect Installation of Hose on the Entire Length of Conductor

Figure 3—Incorrect Installation of Hose on the Entire Length of the Center Bus

Do not cover the entire length of the bus or conductor. Covering is required at and adjacent to equipment and support structures, but not for the entire length of the bus.

ROCKY MOUNTAIN POWER PACIFIC POWER

Figure 4—Correct Installation of Heat-Shrink Tape (or Hose) on the Bus

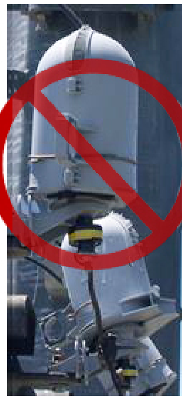
The entire length of the bus is not covered; covers and heat-shrink tape were installed at, and adjacent to, equipment and support structures. Heat-shrink tape should be installed with ⅔ overlap.

A propane torch is required for the proper installation of heat-shrink tape.

Figure 5—Propane Torch for the Installation of Heat-Shrink Tape

- **Do NOT completely cover bushings, arresters, or insulators**

  Bushing, arrester, and insulator covers should be installed near the top of the bushings, arresters, or insulators—between the first and second skirts or sheds. Bird and animal protection products should never cover the entire bushing, arrester, or insulator and should never make contact with the grounded equipment or support structure. Covering entire bushings, arresters, or insulators may prevent natural washing, compromise the BIL of the insulator, and can lead to tracking or flash-overs.



Incorrect Installation

Correct Installation

Figure 6—Incorrect and Correct Installation of Covers

- **DO cover the energized components of bushings, arresters, or insulators**

  Install covers so they do not tip or tilt, leaving energized components uncovered. Covers should be installed between the first and second skirts or sheds of bushings, arresters, and insulators. The incorrect installation of bushing covers can leave energized components exposed.

Figure 7—Incorrect Installation of Bushing Covers

- **Do NOT leave large gaps, holes, or openings in the covers**

  Covers should be trimmed in the field to fit snugly. To prevent bird and insect access, ensure no large openings or gaps exist.

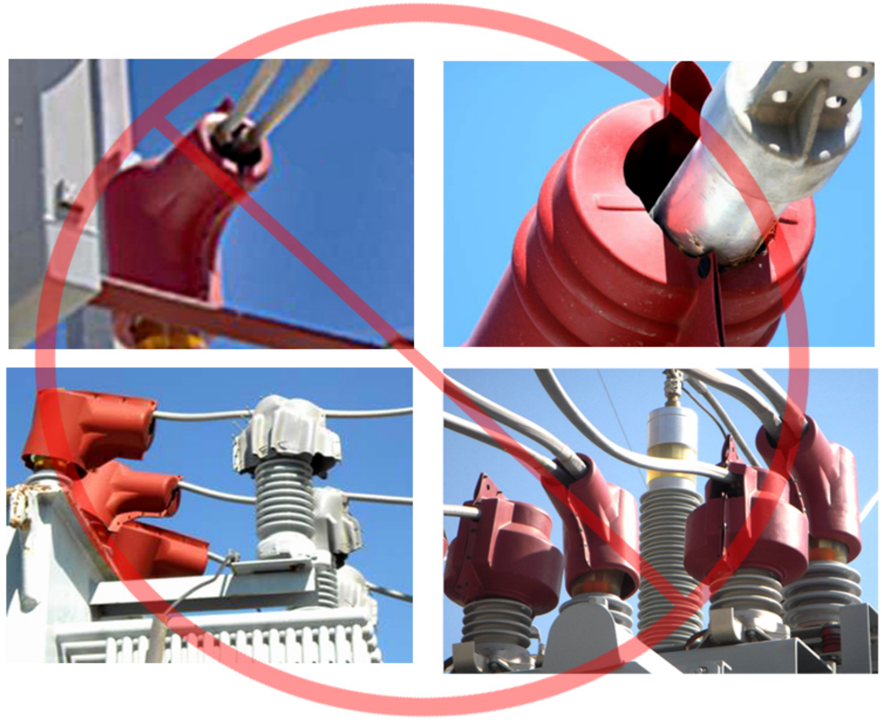


Figure 8—Incorrect Installation of Covers with Large Gaps and Openings

Use the following suggested practices and strategies to prevent and eliminate gaps and openings and reduce the chance of bird and insect use.

Precise holes can be cut in the covers to accommodate conductors (see Figure 9).

Figure 9—Precise Holes Cut Around Conductors to Prevent Gaps

Alternately, “finger-like” slits can be made in the covers to create a tight fit around conductors (see Figure 10).

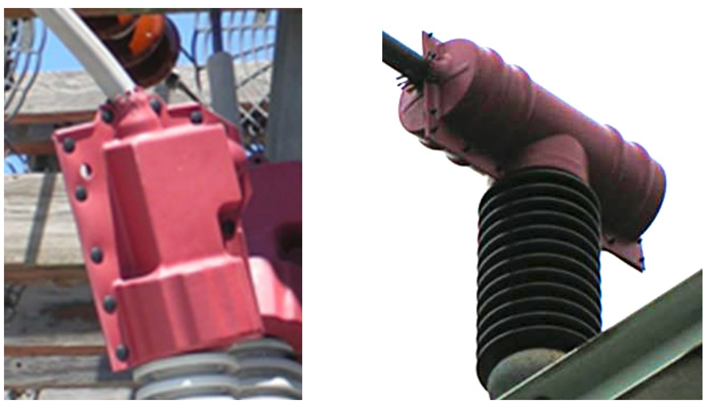


Figure 10—“Finger-Like” Slits Cut Around Conductors to Prevent Gaps

Surplus cut pieces can also be used to fill gaps and close holes by using a leather-punch to create additional pinning holes and piecing together materials. This practice is not a means to repair a bad cut and should only be used when conductors do not align with the cover seams or when there is no other means of eliminating gaps (see Figure 11).

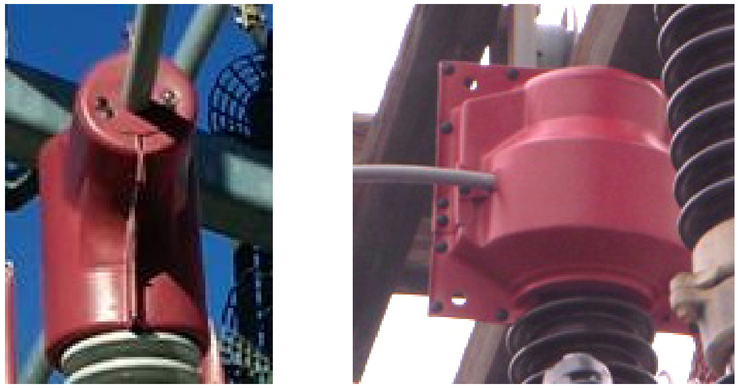


Figure 11—Surplus Cut Material Pieced Together to Prevent Gaps

Extra pins can also be added to prevent gaps adjacent to conductors (see Figure 12). When needed, additional holes should be created using a leather-punch (see Figure 13). Punch additional holes with a diameter to match the existing holes in the cover.

Figure 12—Extra Pins Added to Prevent Gaps Adjacent to Conductors

Figure 13—Two Styles of Leather-Punch Tools for Creating Additional Holes for Pinning

Note: These tools are available in local craft stores, or contact T&D environmental services department for guidance.

- **DO install ALL pins provided with the covers to ensure a secure fit**

  Black push pins are provided with non-silicone covers and silicone pins are provided with silicone covers. If additional pins are needed, they can be ordered using SI# 7889168 for black push pins and SI# 7889461 for silicone pins. See Figure 14 and SV 651. Pins can be ordered and installed when additional pins are required for securing covers or when pins are missing or lost.

SI# 7889168

SI# 7889461

Figure 14—Black Push Pins and Silicone Pins

- **Self-adhesive tape should only be used to keep bird and animal protection products in place, to prevent gapping in split hose installed on conductor or bus, or to gain the appropriate coverage associated with sight-glass bushings. It is not to be used to cover the bus.**

  Do NOT use self-adhesive tape, black electrical tape, or heat-shrink tape on bushings and bolted connections. The use of tape on bushings and bolted connections can trap water and cause corrosion and equipment failure. Covers, which allow water drainage and can be removed and re-installed as needed, should be installed on bushings and bolted connections.

Figure 15—Inappropriate Use of Self-Adhesive Tape

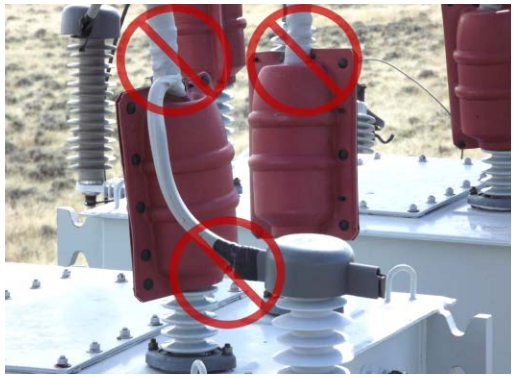


Figure 16—Inappropriate Use of Self-Adhesive Tape and Black Electrical Tape

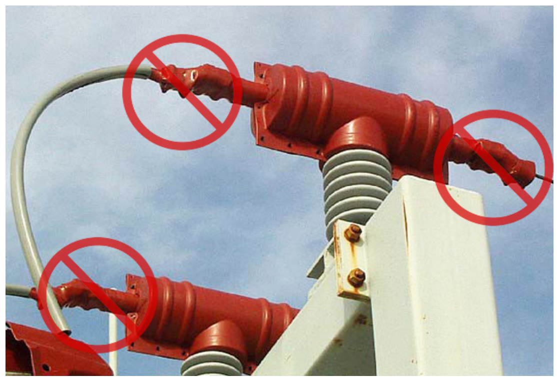


Figure 17—Inappropriate Use of Heat-Shrink Tape

Self-adhesive tape should be handled with care to avoid a loss of adhesion. Avoid touching the inner, adhesive side of the tape. If there is an end section of tape that is handled during installation, cut this "tail" off before securing the final section. When used to keep protection products in place and to prevent gapping in split hose, self-adhesive tape should be installed over the existing cover or hose. It should not be installed directly on the conductor or electrical equipment. Self-adhesive tape should be cut, never stretched and/or torn.

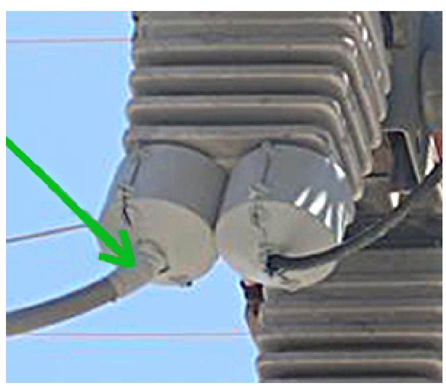


Figure 18—Appropriate Use of Self-Adhesive Tape

Figure 18 illustrates the appropriate use self-adhesive tape to hold bird and animal products in place.

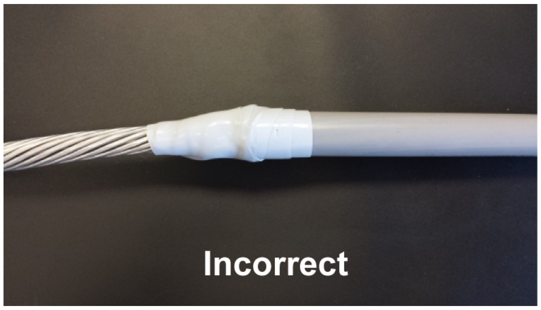


Figure 19—Incorrect and Correct Installation of Self-Adhesive Tape

Figure 19 illustrates the incorrect and correct installation of self-adhesive tape installed on conductor with hose. See Figure 26 for an example of how to use self-adhesive tape in association with sight-glass bushings.

Heat-shrink tape should only be installed on the bus to reduce the chance of bird and animal electrocutions at and near the support structure. See Figure 4 for examples of the correct use of heat-shrink tape.

- **DO encourage water to drain from covers by cutting drainage holes when covers are installed with seams upward**

  When water is trapped inside covers, freeze/thaw cycles can cause damage and equipment failure. Cut small drainage holes in covers when they are installed with natural seams upward.

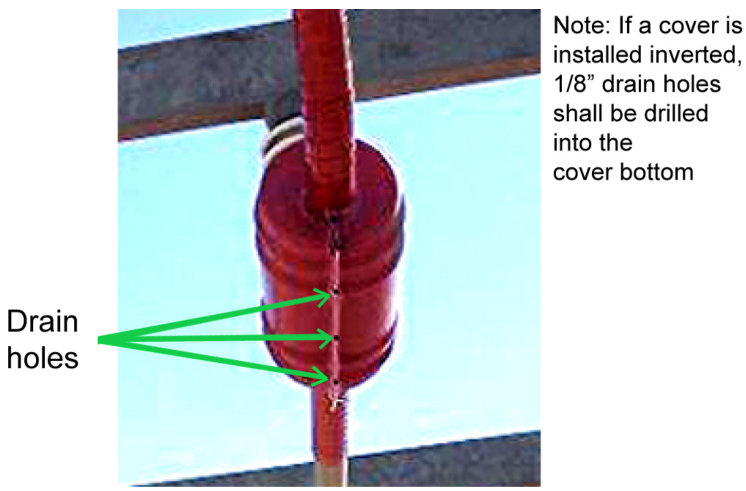


Figure 20—Drain Holes Cut in Covers Installed with Seams Upward

- **DO add weep holes in the bus and covering when the sections of the bus are covered with heat-shrink tape or hose**

  The installation of heat-shrink tape or hose on the bus may cover existing weep holes present in the bus. If, when installing heat-shrink tape or hose on sections of the bus, the existing weep holes are covered, additional weep holes should be drilled through both the heat-shrink tape or hose and the bus.

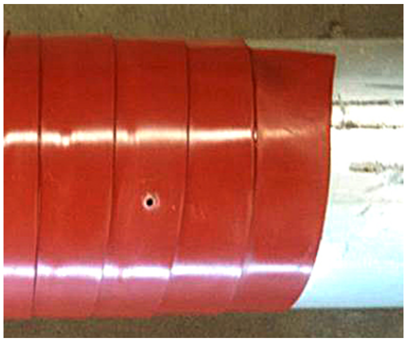


Figure 21—Weep Hole

- **DO install covers on expansion joints and connectors where there is less than 30″ vertical separation and 46″ horizontal/diagonal separation between potential points of contact**

  Box covers, SV 301, can be used to cover expansion joints. Tape should NOT be used for covering expansion joints.

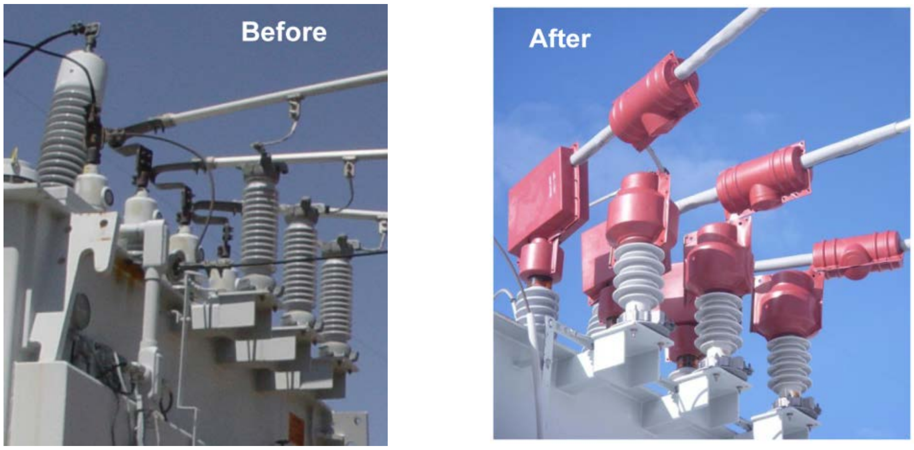


Figure 22—Box Covers

- **DO NOT allow covers to hinder the visibility of gauges or oil sight-glass on bushings**

  The installation of covers should not compromise the viewing of gauges or oil level indicator windows.

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Figure 23—Cover Installation, "Before" and "After"

Figure 23 illustrates views before and after the correct installation of a cover that allows gauge viewing.

If present, oil indicator windows must remain visible. This can be achieved by cutting an opening in the bushing cover to allow viewing of the oil indicator window (See Figure 24) or by using an “inspection” bushing cover (See Figure 25). Bushing covers can also be cut to expose the oil indicator window and supplemented with self-adhesive tape (See Figure 26).

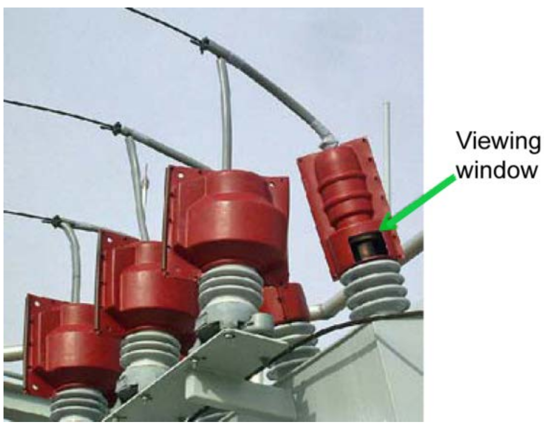

Figure 24—Cover Modification to View Oil Indicator Window

Figure 25—“Inspection” Bushing Cover to View Oil Indicator Window

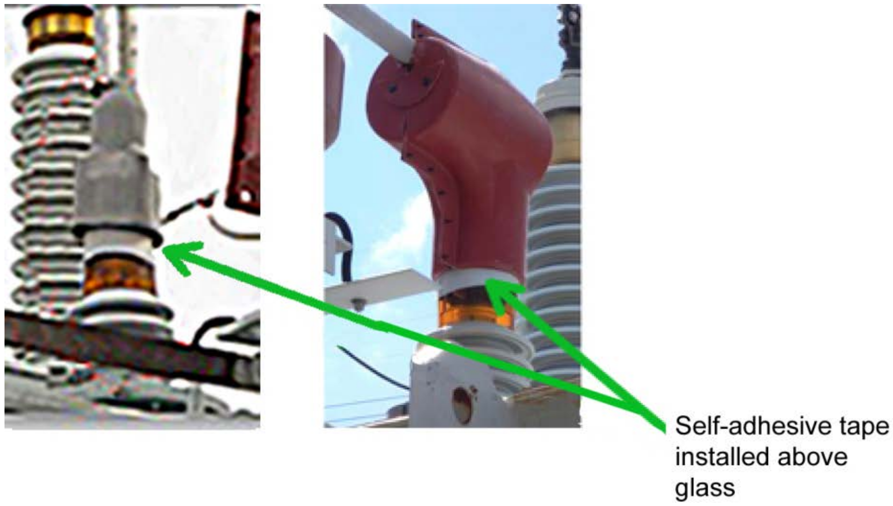

Figure 26—Self-Adhesive Tape Installed Above Glass*

* Heat-shrink tape cannot be used for this application.

Figure 26 illustrates a cover modification and the use of self-adhesive tape to view oil indictor window.

Silicone self-adhesive tape can be installed on the metal directly above the oil indicator window. At least two layers of self-adhesive tape should be installed to achieve the appropriate coverage. When using this strategy for viewing oil indicator windows, ensure the bushing cover overlaps the self-adhesive tape. Heat-shrink tape shall **not** be used as an alternative on the sight glass, as heating the glass could cause it to shatter.

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avian-safe design

SV 251 Bird and Animal Protection for Miscellaneous Equipment

1. Scope

This standard provides information on avian-safe design of station service transformers; feeder arresters; cutouts; voltage, potential, and current transformers; vacuum switches; and risers. The criteria in this standard is intended to reduce bird and animal electrocutions and outages. This standard applies to both retrofitted and newly-constructed substations.

2. Standard References

The following company construction standards are used in conjunction with this document:

EC 951, *Conductor, Overhead Primary, Leads and Jumpers*
EV 151, *Cutout Cover*
EV 985, *Guard, Bird, Arrester Cover*
SV 001, *Substation Bird and Animal Protection—General Information*
SV 002, *Bird and Animal Protection—General Installation Instructions*
SV 301, *Cover, Box*
SV 311, *Cover, Termination*
SV 315, *Cover, Vacuum Switch*
SV 401, *Cover, Arrester*
SV 421, *Cover, Current Transformer, Bushing*
SV 425, *Cover, Voltage/Potential Transformer, Bushing*
SV 451, *Cover, Bushing/Arrester*
SV 471, *Bushing Cover, Inspection*
SV 473, *Bushing Cover, Silicone*
SV 475, *Bushing Cover, Flared-Bottom*
SV 481, *Bushing Cover, Hard-Sided, Two-Piece*
SV 483, *Bushing Cover, Right-Angle*
SV 485, *Bushing Cover, Spring-Loaded*
SV 491, *Bushing Cover, Straight/Tall*
SV 601, *Split Hose, Silicone*
SV 602, *Tape, Self-Adhesive Silicone*
SV 611, *Jumper, Covered Wire*

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3. Application Information

Avian-Safe Design and Retrofitting

Covers and covered wire/hose should be installed to reduce the risk of bird and animal electrocution where there is less than 30″ of vertical separation and/or less than 46″ of horizontal/diagonal separation between potential points of contact at, and near, equipment. Phase-to-ground and phase-to-phase distances must be evaluated when determining the need for protection. Covered wire should be used for station service transformers, cutouts, and arrester jumpers. The installation of covered wire for these applications is preferred over hose.

4. Station Service Transformers

Actual station service transformer installations are shown in Figure 1. The service transformer is protected as shown in Figure 2. Energized bushings should be covered and bushing covers should be installed near the top of the bushing--between the first and second skirts or sheds. Bird and animal protection products should never cover the entire bushing and should never make contact with the transformer can. See SV 002, *Bird and Animal Protection—General Installation Instructions*, for additional information and photographs.Covered wire should be used for station service transformer leads. See EV 921, *Guard, Bird, Equipment Bushing* and SV 485, *Bushing Cover, Spring-Loaded*, for the preferred station service transformer bushing cover.

NOTES:

1. Covered wire should be used for arrester grounds when they are present with the cutout
2. When the transformer is mounted on the steel structure, there may be a phase-ground point of contact between the gapped jumper wire and the grounded structure if avian-safe separations are not met. Efforts should be made to minimize this risk of contact by moving the hose gap further from the structure or other appropriate methods.

Figure 1—Station Service Transformer and Arrester Bird and Animal Protection

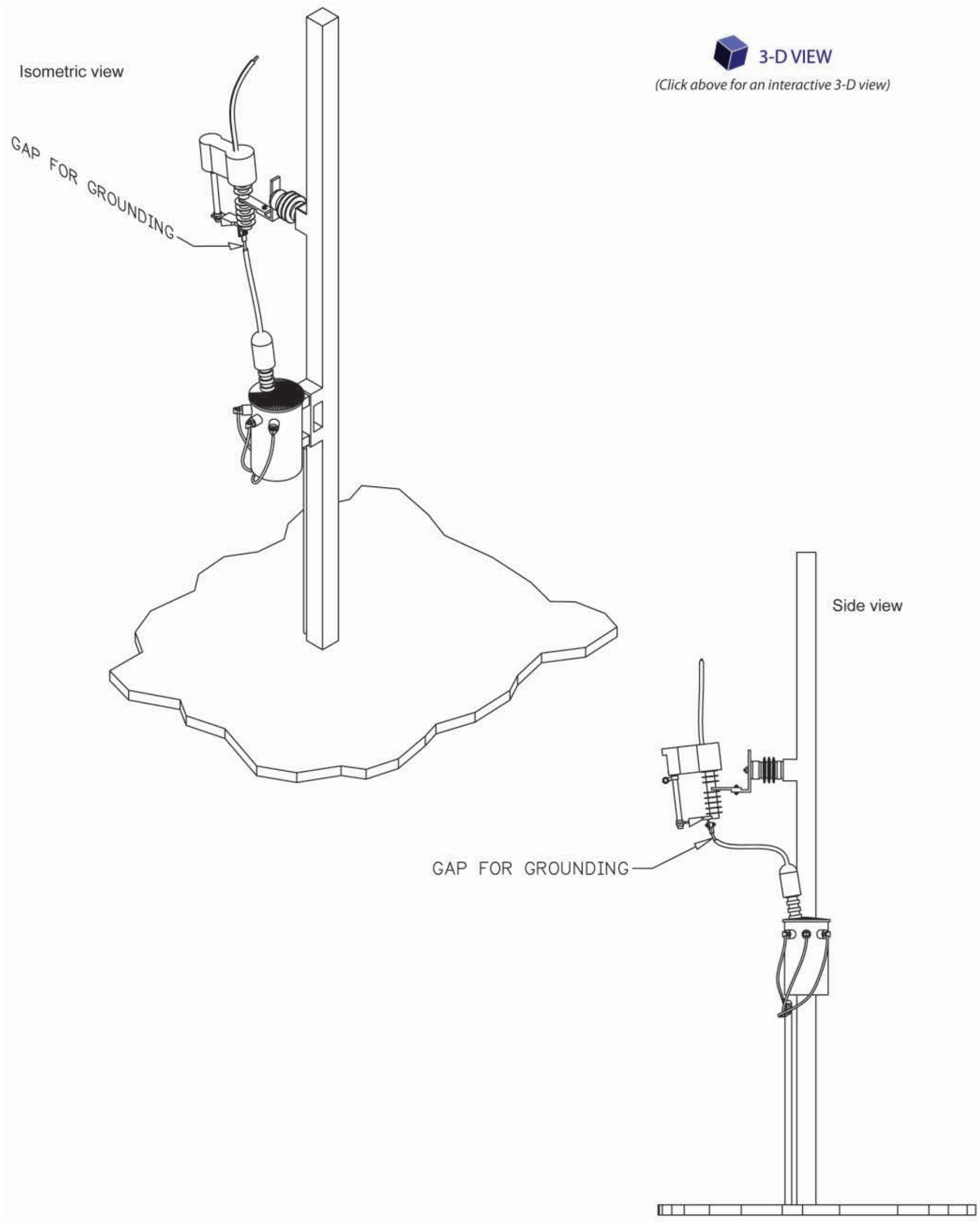

Figure 2—Station Service Transformer, with Bird and Animal Protection

5. Feeder Arresters

Actual feeder arrester installations are shown in Figure 3. The feeder arrester is protected as shown in Figure 4. Multiple cover options exist dependent on the size and manufacturer of the arrester. Factory-installed arrester covers should be evaluated and replaced if the covers have been compromised in any way. Arrester covers should sit on the top of the arrester above the second skirt and should never cover the entire arrester. Arrester jumper wire leads should be protected by covered wire (EC 951/SV 611). See EV 985, SV 401, or SV 451 for feeder arrester product options.

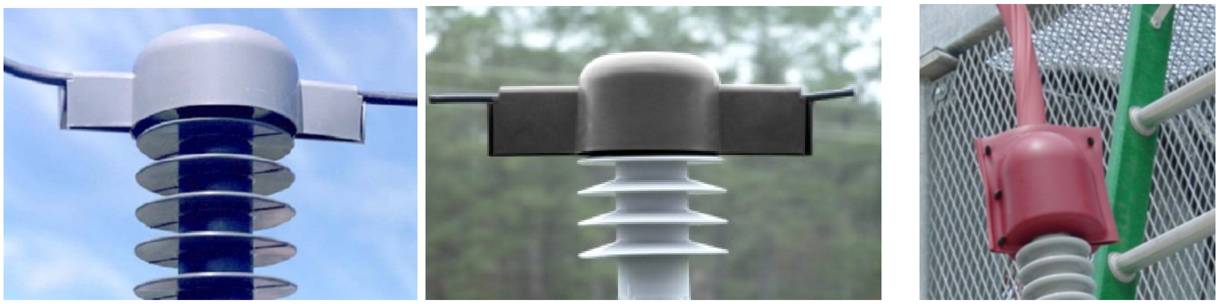

Figure 3—Station Service Transformer and Arrester Bird and Animal Protection

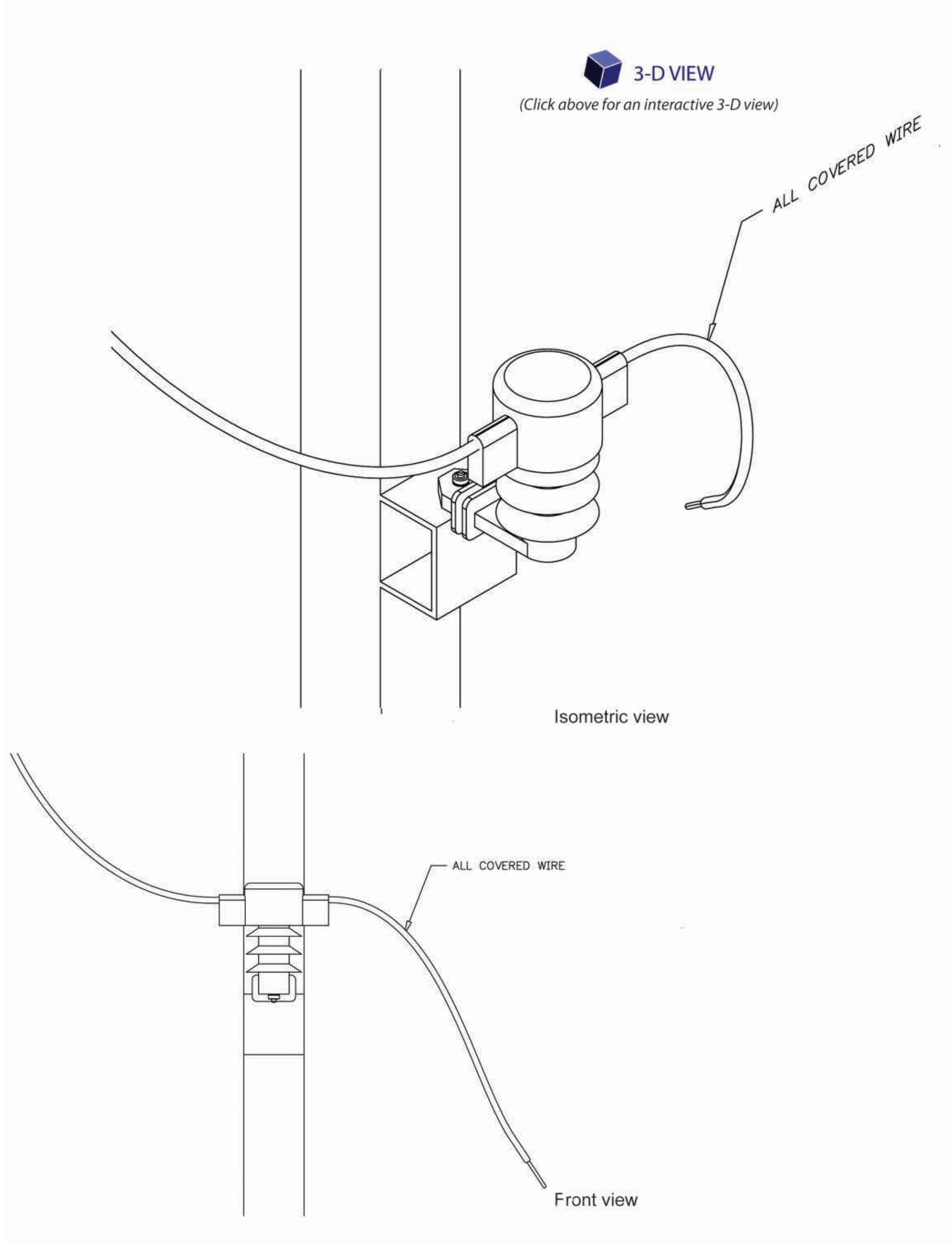

Figure 4—Feeder Arrester, with Bird and Animal Protection

6. Cutouts

An actual cutout installation is shown in Figure 5. Cutouts are protected as shown in Figure 6. Multiple cover options exist dependent on the style (porcelain versus polymer) and voltage of the cutout. Pins are required to keep the covers in place. Cutout jumper wire leads should be protected by covered wire (EC 951/SV 611). See EV 151 and SV 305 for cutout product options.

Figure 5—Cutout, With Bird and Animal Protection

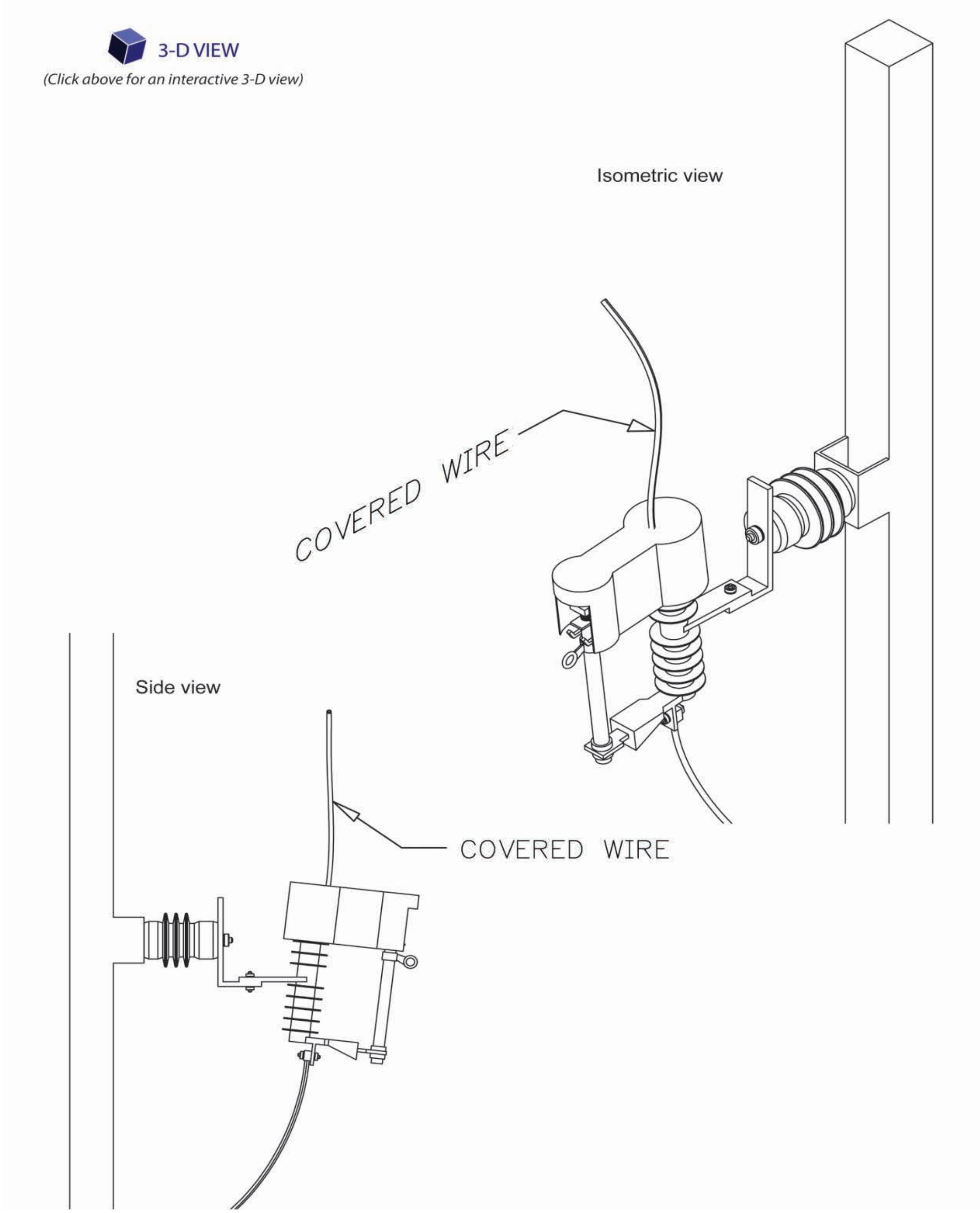

Figure 6—Cutout, with Bird and Animal Protection

7. Voltage/Potential and Current Transformers

Actual voltage/potential and current transformer installations are shown in Figure 7. A voltage transformer connection is protected as shown in Figure 8. Jumper wire leads should be protected by either covered wire (EC 951/SV 611) or hose (SV 601). Do not cover bolted connections with tape. Covers may be trimmed in the field if needed, to fit snuggly. To prevent bird and insect access, ensure no large openings exist. See SV 002, *Bird and Animal Protection—General Installation Instructions*, for additional information and photographs. See SV 421- 483, and SV 491 for VT/PT and CT product options.

Note: The hose or covered wire should be installed at and adjacent to equipment where there is less than 30″ of vertical separation and/or less than 46″ of horizontal/diagonal separation between potential points of contact.

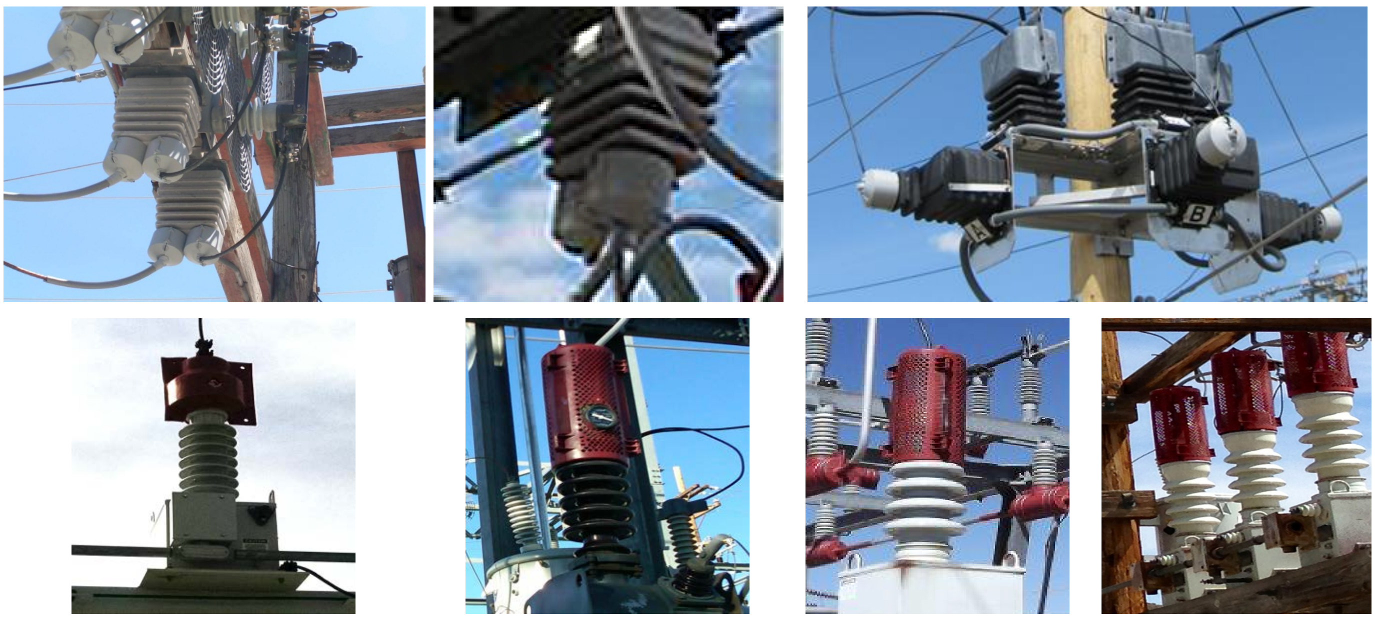

Figure 7—Current and Potential Transformers with Bird and Animal Protection

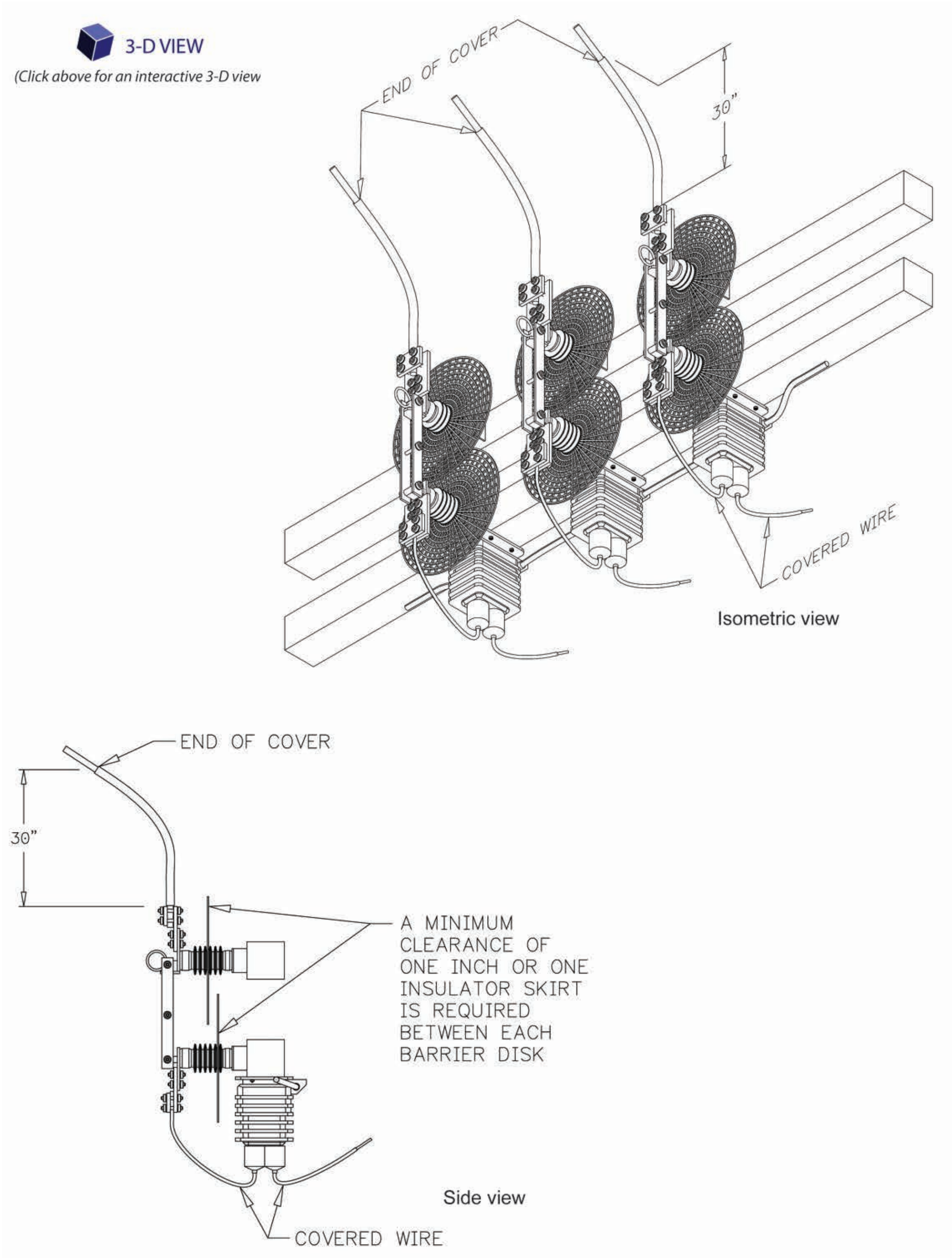

Figure 8—Voltage Transformers, with Bird and Animal Protection

3-D VIEW
(Click above for an interactive 3-D view)

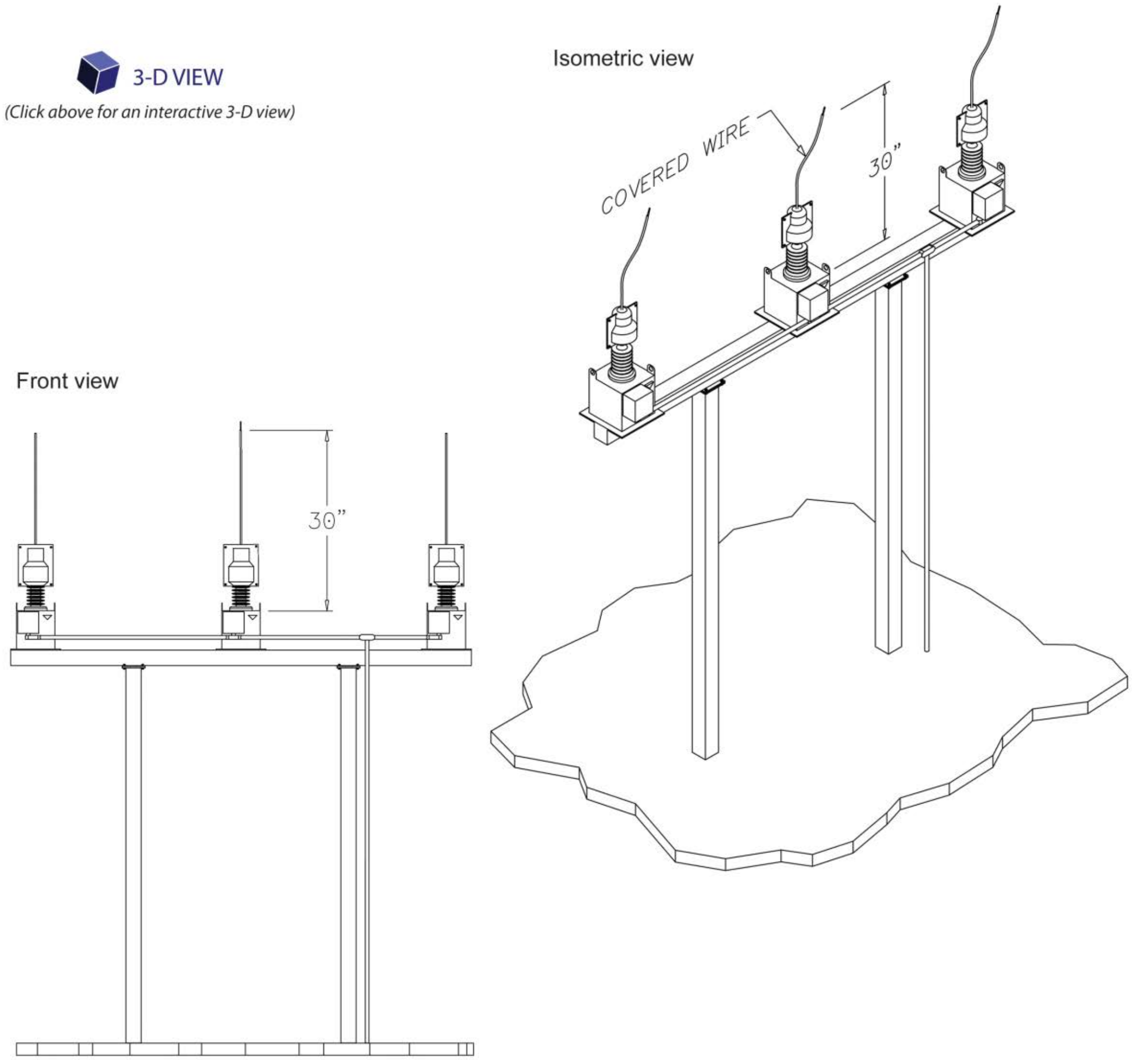

Figure 9—Voltage Transformers, with Bird and Animal Protection

8. Vacuum Switches

An actual vacuum switch installation is shown in Figure 10. A vacuum switch is protected as shown in Figure 11. Covers may be trimmed in the field to fit snuggly. To prevent bird and insect access, ensure no large openings exist. See SV002 for additional information and photographs. Jumper wire leads should be protected by either covered wire (EC 951/SV 611) or hose (SV 601). See SV 315 for vacuum switch product options.

Note: The hose or covered wire should be installed at and adjacent to the vacuum switch where there is less than 30″ of vertical separation and/or less than 46″ of horizontal/diagonal separation between potential points of contact.

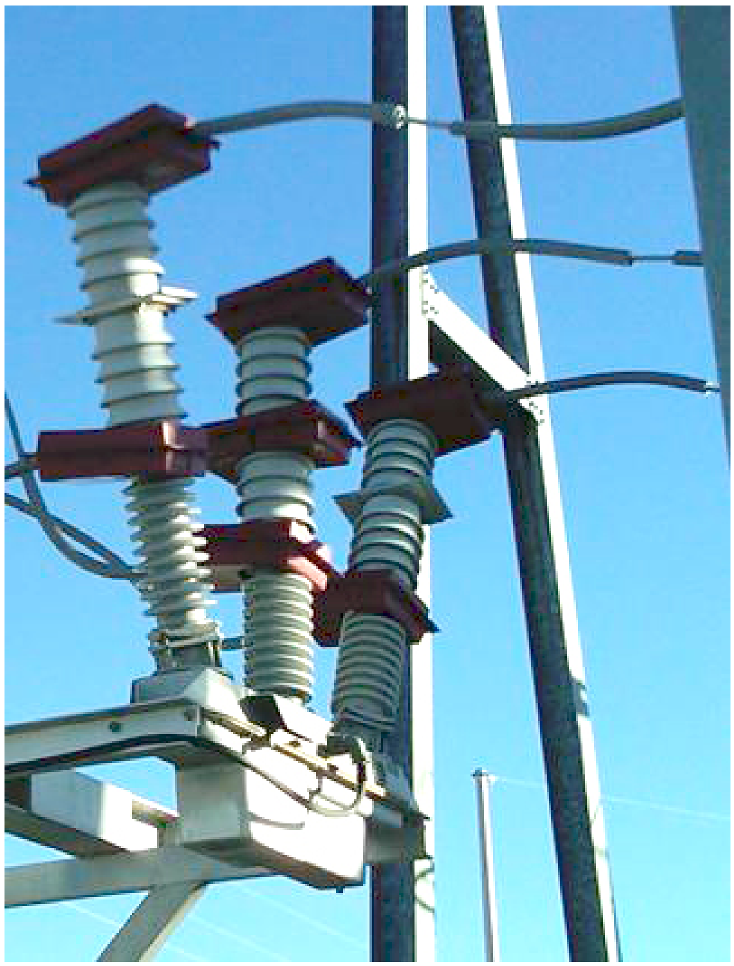

Figure 10—Vacuum Switch, with Bird and Animal Protection

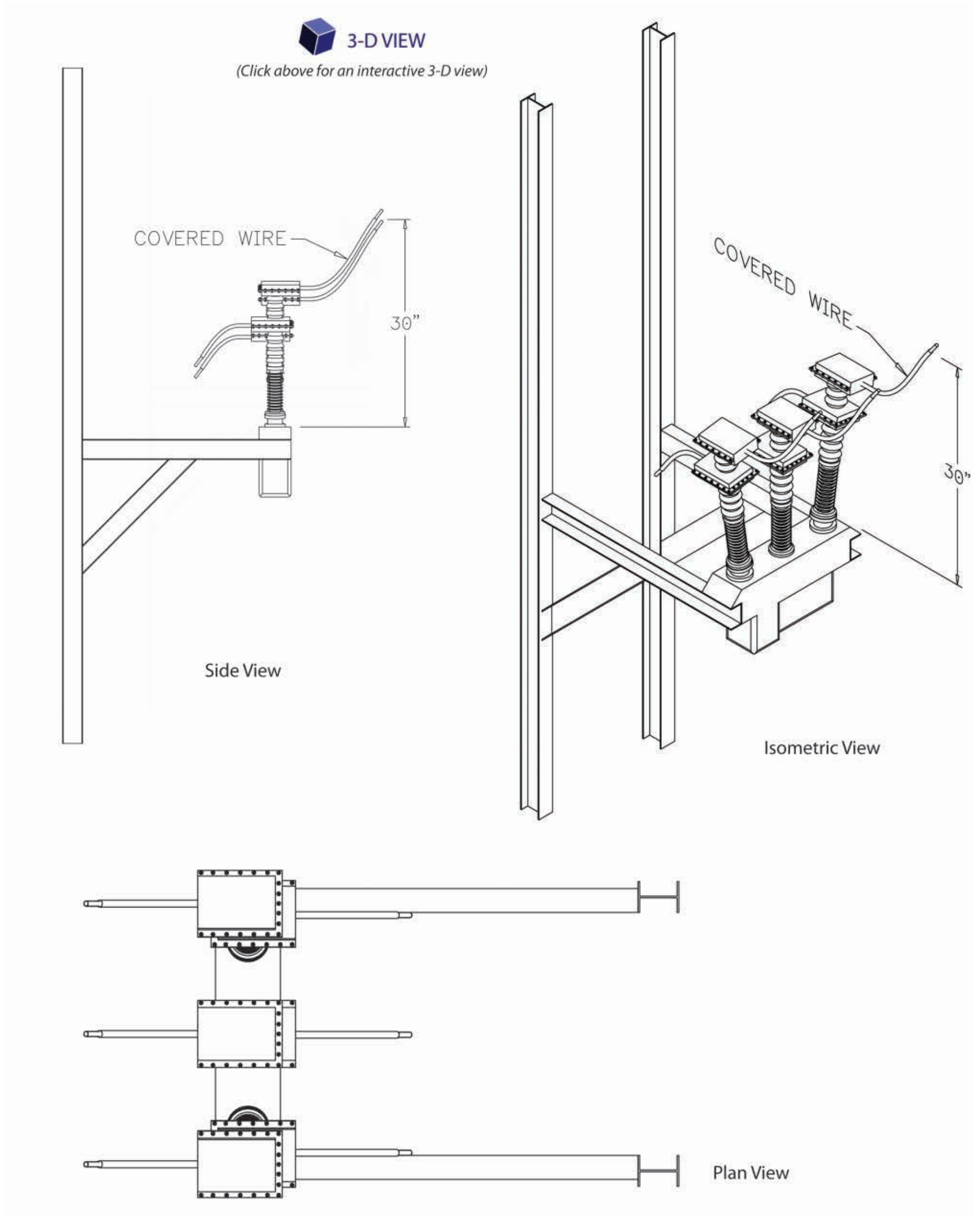

Figure 11—Vacuum Switch, with Bird and Animal Protection

9. Risers

Actual riser installations are shown in Figure 12. A riser is protected as shown in Figure 13. Jumper wire leads should be protected by either covered wire (EC 951/SV 611) or hose (SV 601). Do not cover bolted connections with tape. Covers may be trimmed in the field to fit snuggly. To prevent bird and insect access, ensure no large openings exist. See SV 002, *Bird and Animal Protection—General Installation Instructions* for additional information and photographs. See See SV 301, 311, 471- 483, 491- 602, and 611 for termination product options.

Note: The hose or covered wire should be installed at and adjacent to the riser where there is less than 30″ of vertical separation and/or less than 46″ of horizontal/diagonal separation between potential points of contact. Gaps in hose coverage for grounding should be left below disconnect switches. Termination covers should not cover the entire termination, only the top skirt(s).

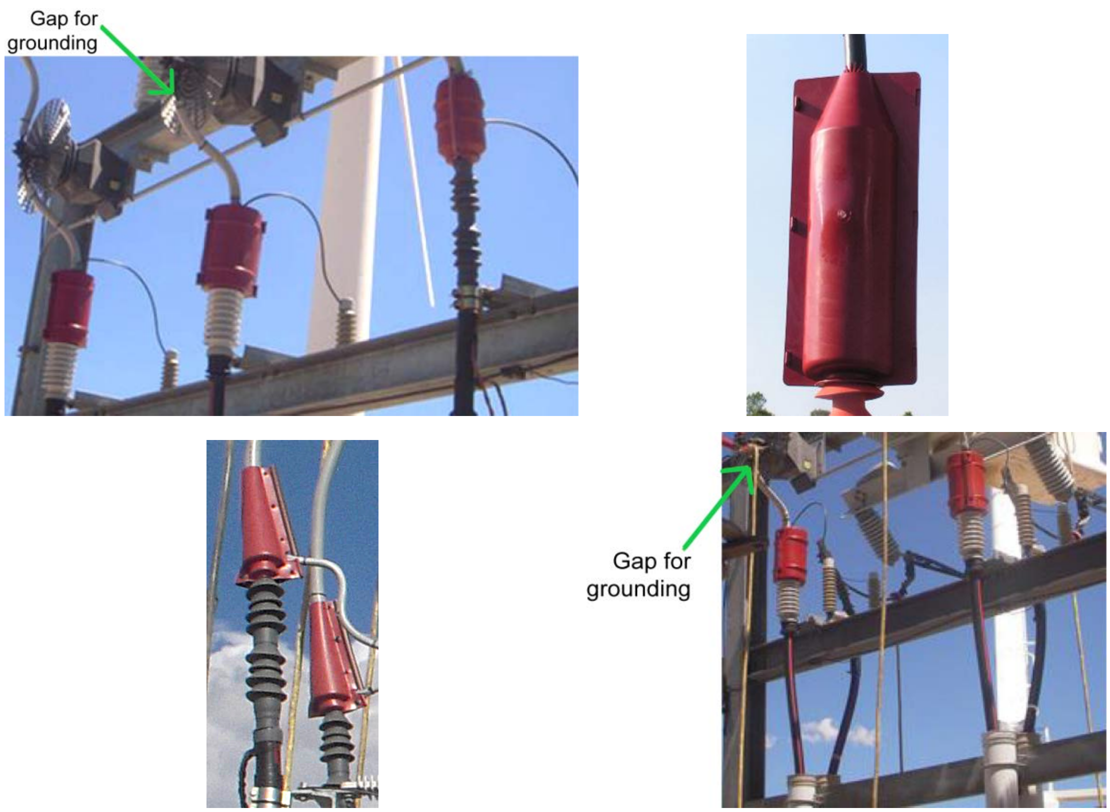

Figure 12—Riser, with Attached Ground, with Bird and Animal Protection

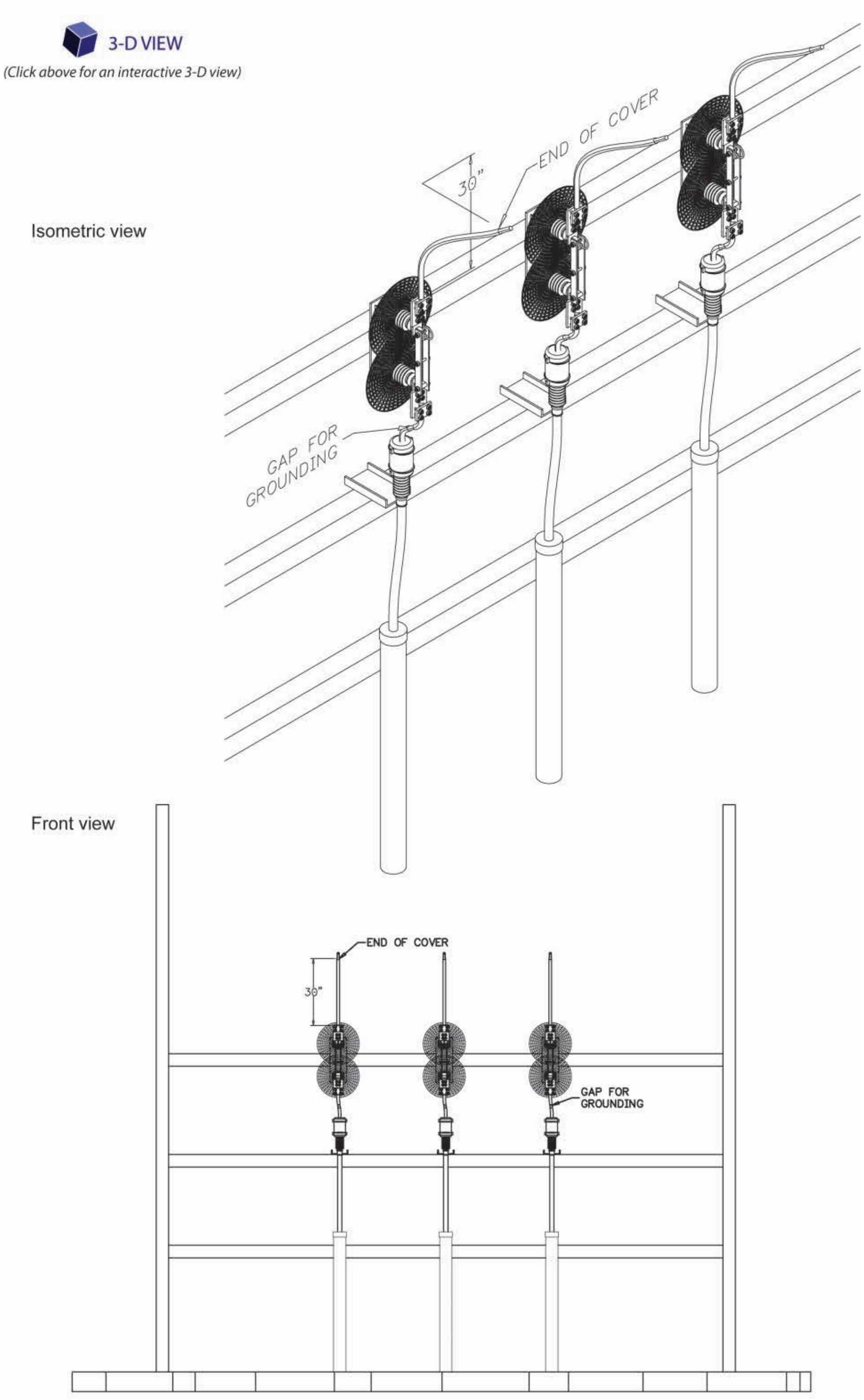

Figure 13—Riser, with Bird and Animal Protection

TD 051 Sign, Danger

RCMS Code: BA

		TD 051	**_**
Material	**SI #**	**Code**	**•**
10" × 14" sign	8002375	C	
Backing plate	8003091	F	

Scope

This standard orders danger signs for transmission lattice towers and backing plates for reinforcing the sign. These signs are bolt-on and require field-drilling. The plate has a predrilled pattern for a two- or three-bolt attachment. The signs must be installed with the backing plate.

Standard References

The following publications also pertain transmission line high-voltage warning signs:

ANSI Z535.1 - 2006, *Safety Color Code*

ANSI Z535.2 - 2006, *Environmental and Facility Safety Signs*

ANSI Z535.3 - 2006, *Criteria for Safety Signs*

ANSI Z535.5 - 2006, *Accident Prevention Tags (For Temporary Hazards)*

IEEE National Electric Safety Code - Latest Revision

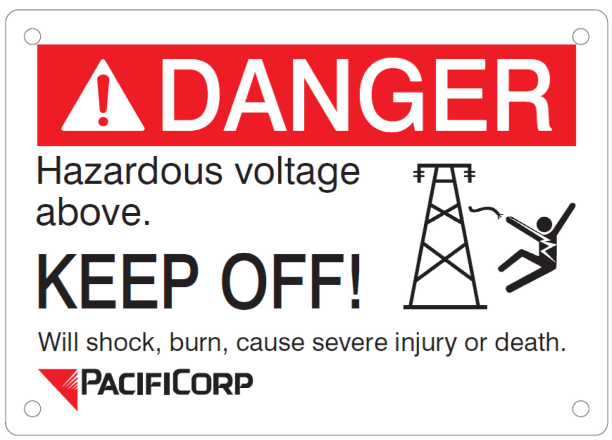

Figure 1—Sign, 10" × 14"

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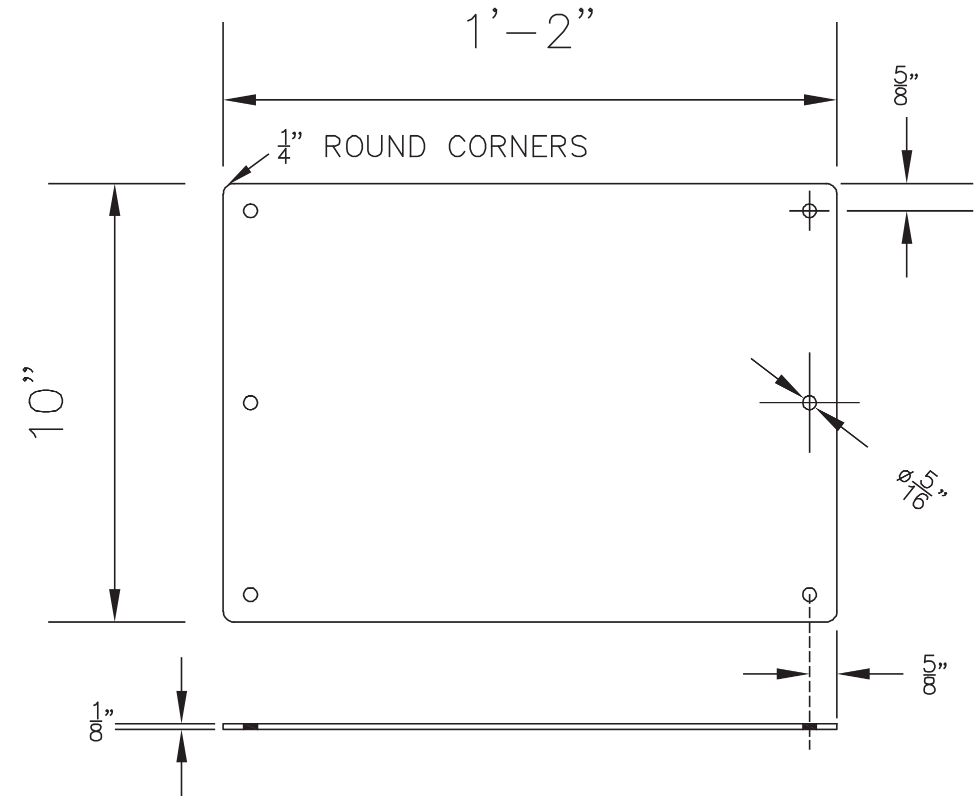

Figure 2—Backing Plate, 10" × 14"

Material

The signs are constructed of a long-lasting material (20 - 25 years minimum of exterior durability) and are UV resistant. Signs are constructed from heavy-duty polyethylene, embedded fiberglass, polyolefin, lexan, or reflective aluminum. The backing plate is made from a 1/8I thick mild steel which is hot- dipped galvanized to resist corrosion.

Sign Description and Layout

The 10″ ×14″ signs are made as shown in Figure 1. The signal word “DANGER” is a minimum of 1.88″ white lettering on red background. Other text and symbols are sized and positioned as shown in Figure 1.

Installation and Placement

To improve the durability of the sign, a backing plate must always be installed with eachsign. Refer to Figures 3 and 4 for three-point and two-point attachment options.

Place the signs approximately in the positions shown in Figure 5. Install four signs, one on each tower face. Field-drill the sign and plate for existing bolt spacing to replace signs. Space the holes as far apart as possible. For new installations, bolt the plate and sign to the tower in at least three places, preferably corners. Alternately, bolt the plate and sign to the tower in two places along a horizontal centerline of the sign. Ensure that the signs are square with the tower.

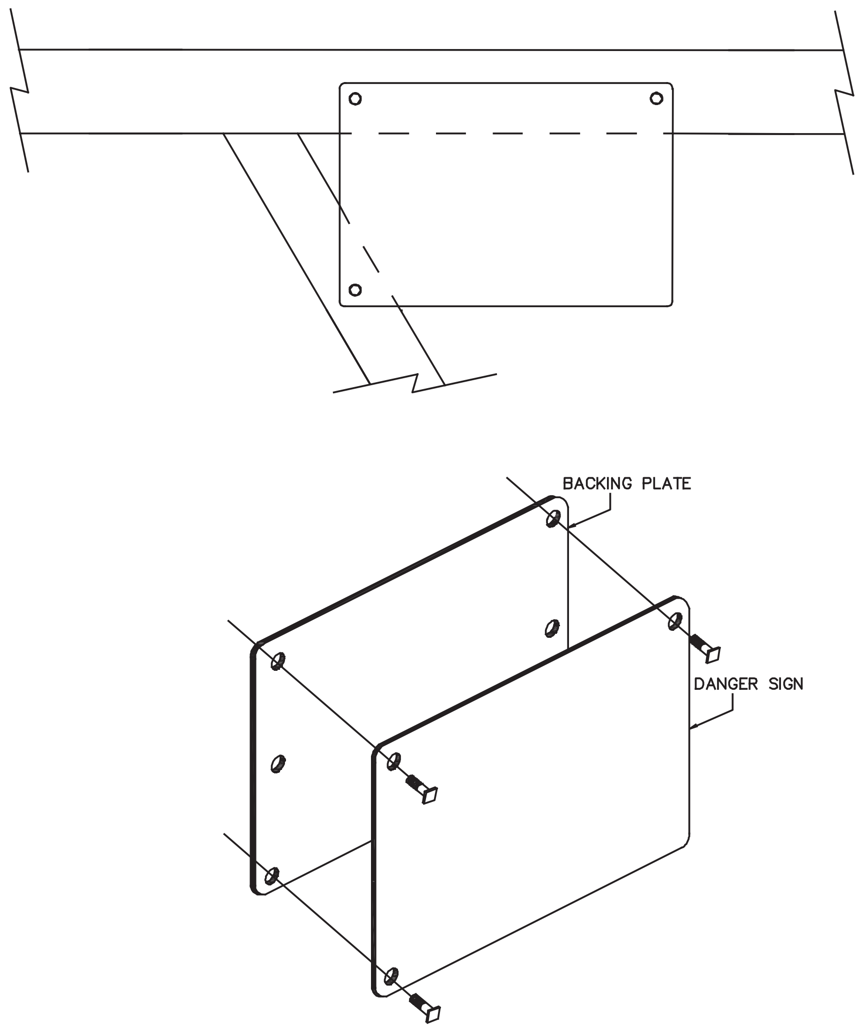

Figure 3—Three-point Attachment (Preferred Method)

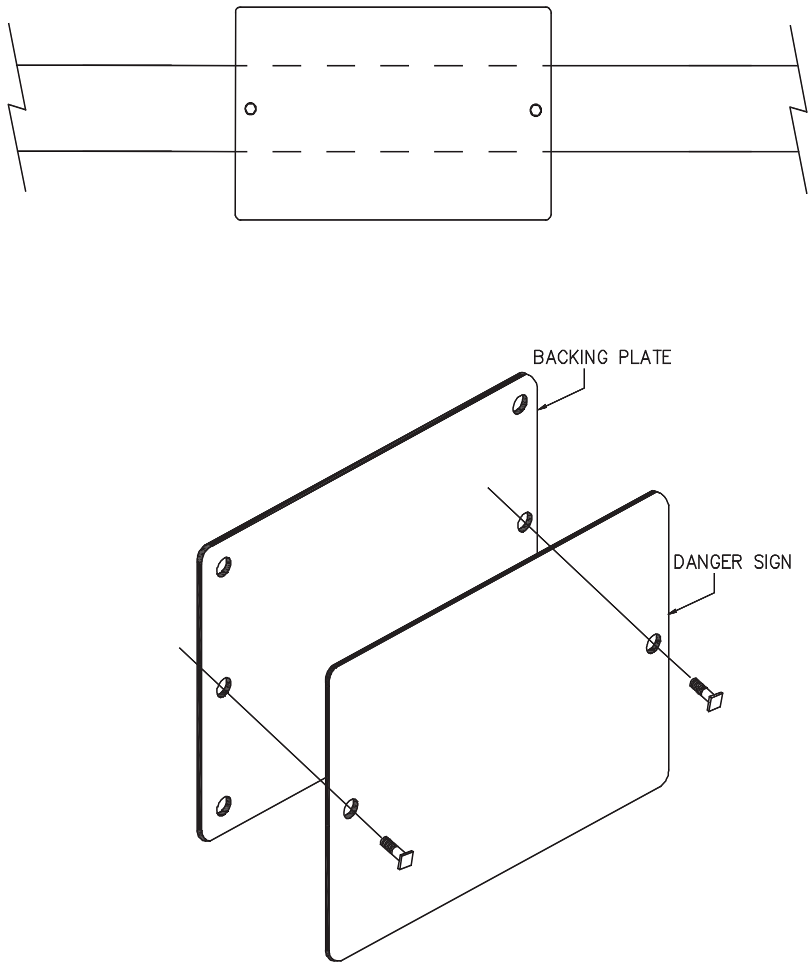

Figure 4—Two-point Attachment (Alternative Method)

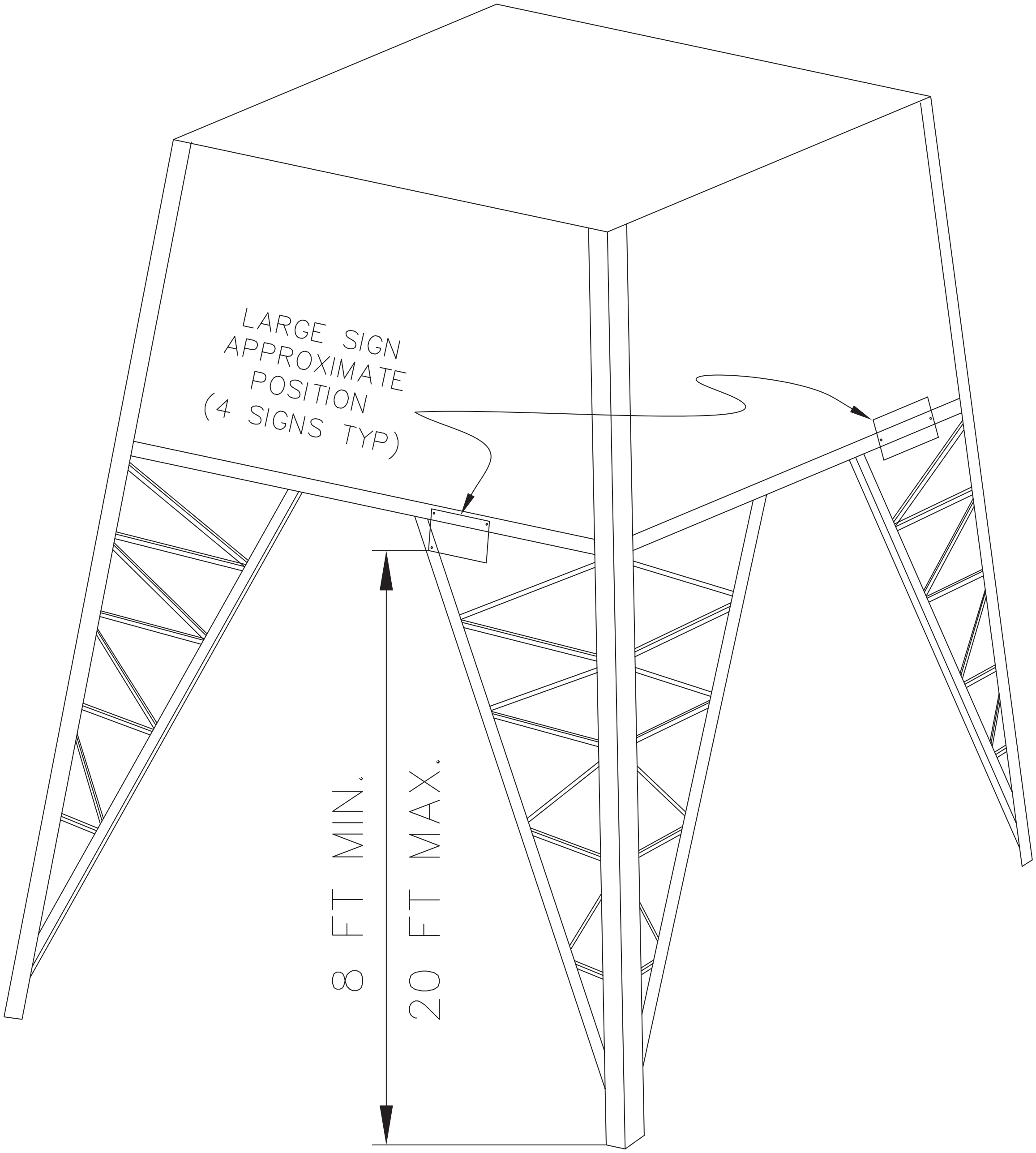

Figure 5—Sign Placement

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