



**PUBLIC UTILITY DISTRICT NO. 1
OF FERRY COUNTY**

Material Bid Documents and Specifications

Call for Bids to Purchase

15/20/25 MVA Three Phase Power Transformer

Bid No. 2025-001

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Section 1: Call for Bids

SEALED BIDS will be received by Public Utility District No. 1 of Ferry County (“Ferry County P.U.D.”) pursuant to RCW 54.04.070 for the purchase of:

15/20/25 MVA Three Phase Power Transformer

All work shall be performed in accordance with District specifications and requirements found in sections 4, 5, Appendix A and Appendix B.

Project Scope: The District is soliciting bids to establish a contract with a qualified vendor(s) to fulfill it’s needs for a 15/20/25 MVA Three Phase Power Transformer.

Bid Submittal Deadline: Monday, July 28, 2025 at 5:00 P.M. Pacific Prevailing Time.

Submittal Delivery: Sealed bids shall be submitted in opaque envelopes that bear the bidders name, the bid number “**2025-001**” and should be sent via UPS, USPS, or FedEx or hand delivered as follows:

P.U.D. No. 1 of Ferry County
Attn: Steve VanSlyke, General Manager / Engineer
686 S Clark Ave
P.O. BOX 1039
Republic, WA 99166

These instructions and specifications will be on file in the office of Public Utility District No. 1 of Ferry County, where they may be consulted or secured for the purpose of bidding.

Bid Submittals: The District will be holding the public bid opening for this contract remotely via WEBEX at 10:00 a.m. on Tuesday, July 29, 2025. The WEBEX information to attend the public bid opening remotely is as follows:

<https://ferrycountypud.my.webex.com/ferrycountypud.my/j.php?MTID=md62eac92b927ae5a481da72cbd502fe6>

Meeting # 2559 315 5516 : Password 1984 : Join by phone +1-650-479-3208

Bid Solicitation Documents: Copies of the bid package may be obtained by contacting Steve VanSlyke at (509) 775-3325, or in the following section of the District’s website: [Ferry County PUD Home - Republic, WA - Ferry County PUD](#). Bid packages are posted on the District’s website typically within twenty-four (24) hours of a project being advertised in the local newspaper.

Bid Security: Only written, sealed bids will be received and considered. No bid shall be considered unless accompanied by a certified cashier's check, or by a bid bond executed by a State licensed surety company, payable to the order of the District, for an amount not less than five percent (5%) of the total amount of the bid (RCW 54.04.080). The bid bond or certified cashier's check must be enclosed in the sealed envelope with the bid at the time the bid is submitted to or received by the District. Section 2.2, of this documents, further expands on submission requirements.

Section 2: INSTRUCTIONS TO BIDDERS**2.1 SCOPE OF CONTRACT**

This solicitation is for the provision of materials and equipment as detailed in Section 4, 5, Appendix A, and Appendix B of this document.

2.2 SUBMISSION OF BIDS

- a. Each bid must be sealed and submitted on or before the scheduled bid opening date and time. Only written, sealed bids that include a bid bond executed by a state licensed surety company or cashier's check for an amount not less than 5% of the total amount of Bidder's bid (RCW 54.04.080) will be received and considered. Bids shall each be clearly marked on the outside of the sealed envelope with the District's project name, bid number, and the bid opening date and time.
- b. The bid bond or certified cashier's check must be enclosed in the sealed envelope with the bid at the time the bid is submitted to or received by the district.
- c. Each bid must be submitted on the District's Bid Proposal Form provided in this bid package, with all details completely and properly filled out.
- d. A checklist will be provided in Section 4, to ensure all bid requirements are met.
- e. Bids will bear no marks, erasures, or writing changes.
- f. No Verbal or telephone bid modifications or cancellations will be considered.
- g. The bidder guarantees there shall be no revisions or withdrawal of bid amount for a period of 45 days after bid opening.
- h. Bids shall be signed by a Principal duly authorized to make contracts.
- i. Bid proposals shall reflect the cost of all materials required by the bid documents, plus additions, deletions, or modifications required by addenda issued prior to bid opening.
- j. Bid opening time and date is as per Section 1 Call for Bids found in this Bid Document.
- k. It is the bidder's sole responsibility to see that the bid is received at the proper time and place. Any bid received after scheduled bid opening will be considered non-responsive.
- l. Prior to the bid opening, bidders may withdraw a bid by written request or by reclaiming bid envelopes.

- m. All bids are for materials delivered to destination; freight paid by the Vendor.
- n. It is the responsibility of the Bidder to see that its bid is submitted in proper form and before the bid submittal deadline. Any Bid received after the bid submittal deadline will be considered late, marked as to the date and time received, and returned to the Bidder unopened.
- o. The Bid Price shall be all inclusive to include the furnishing of all labor, material, tools and equipment necessary for complete construction and delivery of the equipment as required in the District's scope of work. Bid price shall exclude Washington State Sales Tax.
- p. Firm prices shall be quoted, and the bid shall delineate escalation factors, if any.
- q. Any Addenda issued during the time of bidding shall become part of the documents provided to the bidders for the preparation of the bid, shall be covered in the bid, and shall be made a part of the Bidding Documents.
- r. Bidder shall supply one (1) copy of proposals to the indicated address in Section 1: Call for Bids.
- s. All Bidders will be notified of any changes in the specifications in addendum letters. Receipt of addendum letters must be acknowledged in the bid proposal.

2.3 EXAMINATION/CLARIFICATION OF CONTRACT DOCUMENTS

Prior to submission of its bid, Bidder shall carefully examine all of the documents included in the District's bid package. Bidder shall promptly notify the District's Legal Department if any portion of the District's bid documents conflict with applicable laws, codes, rules, regulations or contain obvious erroneous information. Any necessary revisions will be outlined in an addendum.

2.4 PRE-SUBMITTAL QUESTIONS

Questions and requests for clarifications on the Call for Bids to Purchase must be submitted in writing by 5:00 P.M, PST, Friday, July 11, 2025, via email addressed to the Purchasing Contact below. Questions received after this date and time may not be answered.

Please indicate the bid number and title in the email subject line.

Present your questions directly in the body of the email message.

If applicable, cross-reference the specific section of the Call for Bids.

Written answers to all questions and clarifications will be answered by an Addendum. Bidder will be required to sign and submit a copy of each Addendum acknowledging that it has reviewed the questions and answers prior to submitting its bid.

Verbal instructions or interpretations will have no validity, regardless of source. Neither the District nor the Engineer will be responsible for any other explanations or interpretations of the proposed documents.

Purchasing Contact:

Steve VanSlyke – General Manager / Engineer
Public Utility District No. 1 of Ferry County
P.O. Box 1039
Republic, WA 99166
svanslyke@fcpud.com

2.5 EXCEPTIONS TO CONTRACT DOCUMENTS

The District may reject a bid proposal if it contains terms or conditions that are materially different from those contained in these Contract Documents. The District may, at its option, consider a Bid Proposal if it contains terms or conditions that are immaterially different from those contained in these Contract Documents by waiving such irregularity as an informality. The Bidder shall provide, with its Sealed Bid, adequate documentation to support any and all exceptions to the Contract Documents, including technical specifications, which will be reviewed during the District's bid evaluation process.

Any exceptions to this Specification shall be clearly stated in the Bidder's proposal. The fact that there are exceptions will not necessarily preclude the selection of the Bidder's proposal. Any exceptions will be itemized in the evaluation of the proposal. If no exceptions to the Specifications are taken by the Bidder, this shall also be clearly stated.

Alternative offerings will be considered, but they must clearly be indicated as alternatives. A copy of the manufacturers specification for each alternate item must be included with the bid documents.

2.6 EVALUATION OF BIDS

Bids will be awarded to the lowest responsive and responsible bidder based on compliance with District specifications, as determined by the District, and any applicable statutes, policies and procedures. Catalog or item descriptions shall be provided with the bid proposal for all proposed alternative items and for BABA exception items. The District shall be the sole and final arbiter in the determination of whether a bid is responsive and whether a bidder is a responsible bidder.

2.7 REJECTION OF BIDS

The District reserves the right to reject any or all bids, to waive any informalities or irregularities and technical or legal deficiencies in bids received or the bidding process, reject any items of any bid, unless such bid is qualified by specified limitations, to award on a per

item basis unless the bidder states in its bid that its bid is for all items or none, and to accept the bid which in its sole and absolute judgment will under all circumstances best serve the needs of the District.

In the event that all bids are rejected, bidders will be notified in writing and all checks and bid bonds shall be returned promptly to the bidders. Further, in the event all bids are rejected or no bids are received, the District reserves the right to re-advertise or negotiate a contract with third party to meet the needs of the District.

2.8 AWARD OF CONTRACT

Bids will be considered by item within the Proposal Form and may be awarded on any item or combination of items at the option of the District. Once bids have been opened and the District has completed its evaluation process, the District will notify the successful Bidder of a contract award by sending a Notice of Contract Award letter.

It is anticipated that a purchase order will be issued to the successful Bidder(s) within thirty **(30) days** after the due date for the receipt of the proposals.

Bid results and contract awards are not deemed official until approved by the District's General Manager and/or Board of Commissioners.

See Appendix A for loss factors that will be used in the bid review process to adjust the proposed cost of the transformer.

Section 3: LEGAL REQUIREMENTS

3.1 TERMINOLOGY

Whenever these words occur in the bid documents, they shall have the following meanings:

Term	Definition
CONTRACTING OFFICER	The General Manager of the District or its authorized representative
CONTRACT DOCUMENTS	Contract Documents following the District's evaluation of bids and an official Notice of Contract Award to Vendor
CONTRACT PRICE	Sum of the Bid Item Prices of the awarded Bid Items
DISTRICT	Public Utility District No. 1 of Ferry County ("Ferry County PUD")
VENDOR	The successful Bidder who is awarded the Contract to supply the materials or equipment as described in the District's bid package, including and Addenda that may be issued
LEAD TIME	The length of time starting on the date Vendor receives the District's Purchase Order and ending at the time that the item(s) are received at the District

3.2 TRANSPORTATION AND DELIVERY

Following the receipt of a purchase order, contract materials are to be delivered within the lead-time specified by the Vendor on the submitted "Bid Proposal Form". The delivery time will be enforced for all releases of this contract and any contract renewals.

Any change in the lead time shall be reported immediately by a written confirmation and explanation thereof. The delivery date shall be extended for the period of any reasonable delay due exclusively to causes beyond the control and without the fault of the bidder.

The 15/20/25 MVA Three Phase Power Transformer shall be shipped so that it arrives at the District without transit-associated damage. The Vendor will be responsible for any and all damage to shipment incurred in transit, and the reconciliation thereof. A packing list shall accompany each shipment. The District's purchase order number shall be noted on the packing list. Further instructions on shipping can be found in Appendix A.

3.2.1 SHIPPING NOTICE

The shipper shall notify the District's Warehouse a minimum of 48 hours prior to arriving at the delivery destination. This notice may be sent via email or by phone to the below contact:

Contact: Steve VanSlyke

Phone: (509)775-3325

Email: svanslyke@fcpud.com

3.2.2 DELIVERY TIMES

The deliveries of 15/20/25 MVA Three Phase Power Transformer shall arrive by May 2028 or earlier between 08:00 – 15:00, PST Monday through Friday, excluding District observed Holidays, unless other prior arrangement have been made.

3.2.3 SUBCONTRACTOR (SHIPPING COMPANY)

The District reserves the right to request a change in shipping company utilized by the supplier based upon history of damaged goods delivered to the District and/or evidence of unsafe work practices by the shipping company.

3.2.4 DELIVERY LOCATION

Deliver complete 15/20/25 MVA Three Phase Power Transformer to the Transformer Pad at:
Strassburg Substation
25 Creamery Rd
Republic, WA 99166

3.3 CLAIMS AGAINST THE DISTRICT

For the convenience of the parties, it is mutually agreed that any claims or causes of action which the Vendor has against the Ferry County PUD arising from this contract shall be brought in the Superior Court of Ferry County, Washington within 180 calendar days from the date of final acceptance of the contract by the District. The parties understand and agree that the Vendor's failure to bring suit within the time period provided shall be a complete bar to any such claims or causes of action.

3.4 PUBLIC RECORDS ACT REQUIREMENTS

All bids, proposals, Contract documents and related materials (collectively, "Materials") submitted in connection with any proposal or bid are subject to public review and approval by the Board of Commissioners and/ or the District's General Manager. Bidder acknowledges and agrees to such public review and approval. With limited exceptions, all materials submitted become public records and are subject to the provisions of RCW Chapter 42.56 (the "Act"). In most instances, all materials will be subject to inspection and copying by the public. Bidders claiming any exemption from public disclosure shall indemnify and hold the District harmless from any and all costs arising out of a public records request that the Bidder claims contain **proprietary information** or **trade secrets**.

3.5 LIABILITY OF THE VENDOR

Suit, Actions, Claims and Indemnification. The Vendor shall save the District (including all its managers, commissioners and employees) harmless from all suits, actions, or claims brought on account of injuries to any person, including death, and damage to third party

tangible property to the extent caused by the Vendor's negligence in the performance of the work or from any claim arising or recovered under the Workman's Compensation Laws or any other omission by the Vendor or its employees while carrying on operations under this contract. Such defense and indemnification obligations are conditional upon the Vendor being given prompt written notice of the claim and the authority to control the defense of such claim. The District may hire separate counsel at its own costs. To the extent any such claim is contributed to both Parties, the degree of culpability for each Party shall be apportioned in accordance with the principles of comparative negligence.

3.6 LIMITATION OF LIABILITY

3.6.1 FORCE MAJEURE

Neither Party shall be liable for failure to perform or for delay in performance due to any cause beyond its reasonable control, including, but not limited to: acts of God; unusually severe or harsh weather conditions; fire; flood; hurricanes; tornadoes; third party strikes or other labor difficulties; epidemics; quarantine restrictions; war, insurrection or riot; acts of a civil or military authority; embargoes; fuel or energy shortage; blockades; and transportation delays or accidents. In the event of delay in performance due to any of the foregoing causes, the date of delivery or time for completion will be extended by a period of time equal to the greater of: (i) the time reasonably necessary to overcome the effect of such delay; or (ii) the time equal to the period of the delay. Either party may terminate the Contract if the force majeure event extends past ninety days.

3.6.2 CONSEQUENTIAL DAMAGES

Neither party shall be liable for any special, incidental, punitive, indirect, or consequential loss or damage.

3.7 INDEPENDENT VENDOR

The parties agree that the Vendor is an independent contractor and not an employee, or agent or servant of Public Utility District No. 1 of Ferry County, Washington, and the Vendor will hold the District harmless from any claim, personal or property, to itself, its employees and third parties who may arise from the work herein contemplated.

3.8 OWNER AS A THIRD PARTY

The term "third party" as used in this Agreement shall not include the owner or joint venture, or any entity with an ownership interest in the facility upon which the Vendor is delivering equipment or performing services, or their agents, employees, officers, or commissioners.

3.9 WARRANTY

For warranty requirements, see Appendix A.

3.10 CHANGE ORDERS

The District may, from time to time during the progress of the Project, make such changes in, additions to or subtractions from, the Plans, Specifications, Drawings, and/or Exhibits as conditions may warrant. All such changes shall be authorized by a written Change Order, signed by the District and the Vendor. The Vendor shall not be required to perform out-of-scope or extra work without its written approval, which approval shall not be unreasonably withheld, conditioned or delayed.

A Change Order is written order to the Vendor, signed by the District (or its authorized agent) and the Vendor, issued after the execution of this Contract, authorizing an addition, deletion, or revision in the Scope of Work or an adjustment in the compensation or the schedule. Verbal change orders are prohibited.

The increase or decrease in the compensation or change in schedule resulting from a change in the Project shall be determined by mutual agreement. If the parties are unable to agree to such change in the Vendor's compensation or the schedule, the Vendor, upon receipt of a written order signed by the District, shall promptly proceed with the services or work involved. The cost of such additional services or work shall then be determined on the basis of the actual time and expense incurred from performing the services or work attributed to the change. In such case, the Vendor shall maintain a separate time and expense accounting for the additional services or work.

The Vendor agrees that any change in the Contract Amount or Contract Time provided in a Change Order is full and complete compensation to the Vendor for the change(s) to the work, deleted work, modified work, direct or indirect impact on the Vendor's schedule, and for any equitable adjustment or time extension to which the Vendor may be entitled for this Change Order, pursuant to the Contract between the District and the Vendor.

3.11 PRICE ADJUSTMENT CLAUSE

A price adjustment clause, if included must be based on publicly available raw material indexes or defined labor indexes. It is the responsibility of the vendor to state when the cost index will be applied and must be including in the bid.

3.12 DEBARMENT CLAUSE

The Bidder certifies that it is not presently nor has ever been debarred or suspended for debarment by any governmental department or agency, whether international, national, state, or local.

3.13 PURCHASE ORDER NUMBER/PAYMENTS

A Purchase Order number will be assigned by the District to identify all goods purchased under this contract. All correspondence and invoices should be plainly marked with the Purchase Order number for identification purposes.

Payment will be made thirty (30) days after receipt and acceptance of materials ordered. Invoices shall be emailed to mkuehne@fcpud.com or sent to:

To: Ferry County P.U.D. No. 1
Attn: Marilee Kuehne
PO Box 1039
Republic, WA 99166
mkuehne@fcpud.com

3.14 LEGAL NOTICES

All notices from one party to any other party will be made in writing and emailed or mailed to the addresses and persons specified below. A party may change its address by providing notice of the same in accordance herewith.

To: Ferry County P.U.D. No. 1
Attn: Steve VanSlyke
P.U.D. No.1 of Ferry County
686 S Clark Ave
P.O. Box 1039
Republic, WA 99166
svanslyke@fcpud.com

3.15 ATTORNEYS' FEES

In the event of any action or lawsuit between the parties, the prevailing party will be entitled to recover its reasonable attorneys' fees, expenses and costs of litigation, (including on appeal) in addition to any other relief granted or awarded. The parties agree that the venue for any legal action shall be in the State of Washington, Ferry County.

3.16 TERMINATION

The District reserves its right, at its sole discretion, to immediately terminate this Agreement for any reason the District may deem necessary, including but not limited to performance issues such as poor, negligent or inefficient goods, as determined by the District.

Except in emergency situations, the District shall provide the Vendor written notice of early termination and the reasons for any early termination at least five (5) days in advance (where possible). In case of any such termination of the Agreement, the Vendor shall not be entitled to receive any further payment until the goods are wholly finished or replaced and are deemed satisfactory to the District, at which time if the unpaid balance of the amount agreed to be paid to the Vendor under the Agreement shall exceed all the expenses incurred by the District in finishing or replacing the goods, such excess shall be paid by the District to the Vendor or its legal representatives. But if all such expenses shall exceed such unpaid balance, the Vendor shall pay the difference to the District forthwith upon demand. Notwithstanding the above, the Vendor shall not be relieved of liability to the District for damages sustained by the District by virtue of any breach of the Agreement by the Vendor and the District may

withhold any payments to the Vendor for the purpose of setoff until such time as the exact amount of damages due the District from the Vendor is determined.

3.17 TERMINATION FOR CONVENIENCE OF THE DISTRICT

The District may terminate the Agreement at any time and without cause by a notice in writing at least thirty (30) days in advance from the District to the Vendor. In that event, all finished or unfinished documents and other goods shall at the option of the District, become its property. If the Agreement is terminated by the District as provided herein, the Vendor will receive compensation in accordance with the Termination provision above. The thirty (30) day advance written notice requirement only applies to this Termination for Convenience provision of the Agreement. Otherwise, termination for any other reason shall require at least five (5) days' advance written notice (where possible).

Section 4: FERRY COUNTY PUD BID PROPOSAL FORM

15/20/25 MVA Three Phase Power Transformer			
Item#	Estimated Qty Needed	Unit Price	Total Price (Qty. x Unit Price)
1	1		

- Bidder is required to use the District's Bid Proposal Form provided in this bid package.
- Unit pricing shall be submitted as F.O.B. DESTINATION, freight prepaid and allowed based upon a full release. Bid prices submitted shall include freight costs and shall never include tax.

Price Adjustments

Price Adjustment indices included.

Yes	No

See Section 3.11 of this document for more information.

If yes, please list or attach to bid indices and the time of application

Exceptions

Does your submittal make any restrictions or take any exceptions to the conditions or provisions outlined in this specification.

Yes	No

If yes, please explain exceptions:

Lead Times

Does the material in your submittal have a lead time to delivery?

Yes	No

If yes, please explain exceptions:

Bidders Checklist			
Item	Description	Acknowledged or data	Initials
1	Bid proposal form signed?		
2	Bid security included?		
3	Bid exceptions or acknowledgement of no exceptions included?		
4	Addenda (if issued) acknowledgement included		
5	Build America Buy America certification for each bid item included?		
6	Each item for Build America Buy America is marked "met" or "do not meet" requirements as shown in Appendix B?		
7	All alternate bid items have a manufacture's specification sheet included?		
8	Transformer Proposal Form completed?*		
9	Contract Signed?		

*Transformer Proposal Form is provided on the following page, and attached as an auxiliary file.

Transformer Proposal Form

THE UNDERSIGNED RESPONDENT, having familiarized himself with the work required by the Contract Documents, the site where the work is to be performed, local labor conditions, and all laws, regulations and other factors affecting performance of the work and having satisfied themselves of the expense and difficulties attending performance of the work.

HEREBY PROPOSES and agrees, if this bid is accepted, to enter into agreement to perform all work, including the assumption of all obligations, duties and responsibilities necessary to the successful completion of the Contract and the furnishing of all materials and equipment required to be incorporated in and form a permanent part of the work; tools, equipment, supplies, transportation, facilities, labor, superintendence and services required to perform the work; all as indicated or specified in the Contract Documents to be performed or furnished by the RESPONDENT as follows:

Item #	Description	34.5/12.47kV, 15/20/25 MVA Transformer w/o LTC	34.5/12.47kV, 15/20/25 MVA Transformer w/o LTC
	Pricing (USD)	Specified	Bidder To Fill In Data And Answer Yes or No
1	Total Lump Sum Price For Transformer #1, Including Factory Testing		
2	Total Lump Sum Price For Delivery of Transformer #1 To Point of Delivery		
3	Total Lump Sum Price For Off Loading Transformer #1 and Setting On Pad		
4	Total Lump Sum Price For Transformer #1 Installation & Field Service		
5	Lump Sum Firm Price For Transformer #1 including delivery, installation on pad, assembly, vacuum filling, and final acceptance testing per the specifications		
6	Total Lump Sum Price for spare parts as listed in the specification and Instructions to Proposers to be Delivered with Transformer #1		
7	Is a price list provided for required spare parts?	Required	Yes/No

8	Is a price list provided for MANUFACTURER's recommended spare parts?	Required	Yes/No
9	Total Lump Sum Price Reduction Per Transformer to Not Perform Noise Test Per Specification to be delivered with Transformer #1		
	Delivery and Drawings	Specified	Bidder To Fill In Data
10	Delivery Date Unit 1	Earliest Delivery Date	
11	Number of Weeks To Provide Outline Approval Drawings	Twelve Weeks After Date on Purchase Order	
12	Number of Weeks To Provide Remaining Approval Drawings	Sixteen Weeks After Date on Purchase Order	
	Warranty	Specified	Bidder To Fill In Data And Answer Yes or No
13	Is Five Year Warranty Being Provided?	Required	Yes/No
14	Does Warranty Include the Entire Transformer Including all Auxiliary Equipment And Third Party Supplied Equipment Such as Bushings, Arresters, ETM, Etc.)?	Required	Yes/No
15	If No, what is excluded and what is the length of the warranty on these parts?		
16	Are In and Out Charges Included in the Warranty?	Required	Yes/No
17	If so, what is the term of the In and Out coverage?	5 Years	
18	If so, what is the cap for the In and Out coverage?		
19	Is a copy of the Manufacturer's Warranty Provided?	Required	Yes/No
20	Price Adder Per Transformer For Full Inclusive Warranty Per Specification Requirements		
	General	Specified	Bidder To Fill In Data And Answer Yes, No, or Not Applicable

21	The information requested in the specifications with “PROVIDE IN PROPOSAL” shall be submitted with bid		Yes/No
22	Location of Manufacturing Plant		
23	Note: The manufacturing location cannot change without written permission from PURCHASER.		
24	Are Customers Allowed Into The Factory?	Required	Yes/No
25	Altitude of Manufacturing Plant (feet above sea level)		
26	Location of Sales Personnel		
27	Location of Service Personnel		
28	Is a Preliminary Production Schedule Provided?	Required	Yes/No
29	Preliminary Outline Drawing Number (Furnish With Proposal)	Required	Yes/No
30	Are tank welds located within 6 inches of the corners?		Yes/No
31	If No, is documentation provided to demonstrate equivalent strength of not meeting this requirement?		Yes/No/Not Applicable
32	Is documentation provided meeting the specification requirements that the transformer has sufficient mechanical strength to withstand through faults?	Required	Yes/No
33	Are any design and material changes being used that do not have demonstrated performance? If so, what are these and is sufficient documentation provided for FCPUD's review and approval?		Yes/No
34	What method is used to dry the transformer?		
35	Is the documentation provided on how the dryness is monitored during the drying process?	Required	Yes/No
36	List all Special Tools for Installation & Maintenance		

	Overall Dimension, Inches	Specified	Bidder To Fill In Data
37	Height		
38	Width		
39	Depth		
40	Height Over Top of Tank to Remove Bushings		
41	Width Base		
42	Depth Base		
43	Accuracy of all Dimensions		
	Approximate Weight, Pounds	Specified	Bidder To Fill In Data
44	Core and Coils		
45	Tank and Fittings		
46	Oil		
47	Total Assembled, with Oil		
48	Accuracy of all Weights		
	Physical Characteristics	Specified	Bidder To Fill In Data And Answer Yes or No
49	Exterior Paint Finish Coat Color	ANSI #70 Gray	
50	Will Main Tank be Supplied with Rescue Manhole?	Required	Yes/No
51	Number of Phases	3	
52	Frequency	60	
53	Number of Windings	Two	
54	Maximum Elevation for operation	3,300 feet	
55	Maximum Altitude For Continuous MVA Ratings	3,300 feet	
56	Average Ambient Temperature	35 Degrees C	
57	Ambient Temperature range (Max and Min) for operation	-40 Degrees C to +45 Degrees C	
58	Core and Coil Cold Start Temperature	-35 Degrees C Ambient with Core and Coils at -30 Degrees C	
59	Which segment is the LTC located?	Not Applicable	

60	Which segment is the Control Cabinet located?	Not Specified	
	Transformer Ratings, Performance, and Configuration	Specified	Bidder To Fill In Data
61	Nominal Voltage Rating - High Side	34,400 V	
62	Nominal Voltage Rating - Low Side	12,470 V	
63	Winding Connection - High Side	Delta	
64	Winding Connection - Low Side	Wye	
65	Phase Relationship (HV/LV)	LV lags HV by 30 degrees (Dyn1)	
66	Cooling Class	ONAN/ONAF/ONAF	
	Transformer Continuous MVA Rating at 65 Degrees C Rise	Specified	Bidder To Fill In Data
67	High Side Windings	30/40/50 at 3,300 feet	
68	Low Side Windings	30/40/50 at 3,300 feet	
	Transformer Winding - BIL	Specified	Bidder To Fill In Data
69	High Side Windings	200kV	
70	Low Side Windings	110kV	
71	X0 Neutral	110kV	
	Transformer Winding - BSL	Specified	Bidder To Fill In Data
72	High Side Windings	166kV	
73	Low Side Windings	92kV winding design	
	Transformer Positive Sequence Impedance at Nameplate 65 Degrees C ONAN Rating, in Percent	Specified	Bidder To Fill In Data And Answer Yes or No
74	HV to LV Positive Sequence Impedance at ONAN Base Rating	7.00%	
75	Is the reduced tolerance from proposed impedance to tested impedance acknowledged?	Not Applicable	
76	HV to LV Maximum Impedance at ONAN Base Rating		
77	DETC Position For Maximum Z		
78	LTC Position For Maximum Z	Not Applicable	

79	HV to LV Minimum Impedance at ONAN Base Rating		
80	DETC Position For Minimum Z		
81	LTC Position For Minimum Z	Not Applicable	
	Zero Sequence Impedance at Nameplate 65 Degrees C ONAN Rating, in Percent	Specified	Bidder To Fill In Data
82	HV to LV at ONAN Base Rating	Per IEEE Standards	
	Transformer Overexcitation	Specified	Bidder To Fill In Data And Answer Yes or No
83	Maximum sustained output voltage at no load without gassing or exceeding guaranteed temperatures	110%	
84	Maximum sustained output voltage at full load without gassing or exceeding guaranteed temperatures. The load power factor shall be 80% lagging, but the input voltage can be limited to 110%.	105%	
85	Will the overexcitation requirements be met in both step-down and step-up operation in all LTC and DETC taps?	Required	Yes/No
	Transformer Harmonic Distortion	Specified	Bidder To Fill In Data
86	Maximum Total Harmonic Distortion	5%	
	Guaranteed Temperature Rises at Maximum 65 Degrees C Nameplate Rating	Specified	Bidder To Fill In Data
87	Maximum Average Winding Rise	65 Degrees C	
88	Maximum Top Oil Rise	65 Degrees C	
89	Maximum Hot Spot Rise	80 Degrees C	
	Transformer Calculated Temperature Rises at Maximum 65 Degrees C Nameplate Rating	Specified	Bidder To Fill In Data
90	Maximum Average Winding Rise	Calculated Value Requested	
91	Maximum Top Oil Rise	Calculated Value Requested	

92	Maximum Hot Spot Rise	Calculated Value Requested	
	Transformer Losses - Guaranteed (in kW)	Specified	Bidder To Fill In Data
93	No-Load (Ref. Temp. 20 Degrees C)		
94	HV-LV Load Losses at 65 Degrees C ONAN Rating		
95	Total Auxiliary Losses at Maximum Rating		
96	Maximum Total Measurement Error for No Load Losses		
97	Maximum Total Measurement Error for Load Losses		
	Transformer Losses - Not Guaranteed (in kW)	Specified	Bidder To Fill In Data
98	HV-LV Load Losses at 65 Degrees C ONAF/ONAF Rating		
99	Auxiliary Losses 1st Stage Cooling		
100	Auxiliary Losses (no cooling)		
	Transformer HV to LV Guaranteed Efficiency at Percent of Maximum ONAF/ONAF 65 Degrees C Rating, in Percent	Specified	Bidder To Fill In Data
101	100 Percent Of Maximum Rating		
102	75 Percent Of Maximum Rating		
103	50 Percent Of Maximum Rating		
104	25 Percent Of Maximum Rating		
	Transformer HV to LV Voltage Regulation at Maximum ONAF/ONAF 65 Degrees C Rating, in Percent	Specified	Bidder To Fill In Data
105	100 Percent Power Factor		
106	90 Percent Lagging Power Factor		
107	80 Percent Lagging Power Factor		
	Regulation based on the following at Maximum ONAF/ONAF 65 Degrees C base rating at the transformer operating temperature	Specified	Bidder To Fill In Data
108	X %		

109	R %		
	Transformer X/R Ratio at Nameplate 65 Degrees C ONAN Rating at the transformer operating temperature	Specified	Bidder To Fill In Data
110	X/R ratio with DETC and LTC at nominal positions		
111	Maximum X/R Ratio		
112	DETC Position For Maximum X/R Ratio		
113	LTC Position For Maximum X/R Ratio	Not Applicable	
114	Minimum X/R Ratio		
115	DETC Position For Minimum X/R Ratio		
116	LTC Position For Minimum X/R Ratio	Not Applicable	
117	Accuracy in percent of X/R calculation		
	Exciting Current in Percent of Self Cooled ONAN 65 Degrees C Rated Load Current at:	Specified	Bidder To Fill In Data
118	110 Percent Rated Voltage		
119	100 Percent Rated Voltage		
120	90 Percent Rated Voltage		
	Guaranteed Maximum Sound Level at 105% Excitation	Specified	Bidder To Fill In Data
121	ONAN Rating at 1 foot, 105% excitation, and highest flux density DETC and LTCTaps with the LTC in a bridging position if a preventative autotransformer is provided	65 dBA	
122	ONAF/ONAF Rating at 6 feet, 105% excitation, and highest flux density DETC and LTC Taps with the LTC in a bridging position if a preventative autotransformer is provided	68 dBA	
123	At Specified Overload Rating at 6 feet	Not Applicable	
	Estimated Maximum Sound Level at 105% Excitation	Specified	Bidder To Fill In Data
124	ONAN Rating at 1 foot	Calculated Value Requested	

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125	ONAF/ONAF Rating at 6 feet	Calculated Value Requested	
126	At Specified Overload Rating at 6 feet	Not Applicable	
	Oil and Oil Preservation Equipment	Specified	Bidder To Fill In Data And Answer Yes or No
127	Proposed Insulating Fluid (Supplier, Type, & Cut Sheet)	Inhibited Type II Naphthenic based mineral oil, Ergon HyVolt II NG or FCPUD approved equal	
128	Are Minimum Characteristics for Insulating Fluid Included?	Required	Yes/No
129	Type of Oil Preservation System	Inert Gas Constant Pressure System (Sealed Tank with Nitrogen)	
130	What Nitrogen System is Being Provided (Supplier, Type), If Applicable		
	Winding Type (Helical, Disc, Etc.)	Specified	Bidder To Fill In Data
131	High Voltage		
132	Low Voltage/Common		
133	DETC Regulating		
134	LTC Preventative Auto (PA)	Not Applicable	
135	LTC Series (Booster), If Required	Not Applicable	
	Winding Insulation - High Voltage	Specified	Bidder To Fill In Data And Answer Yes or No
136	Manufacturer/Type		
137	Minimum Thickness		
138	Graded Winding?		Yes/No
139	Volts per Turn		
140	Description of Insulation System (Attached if necessary)		
	Winding Insulation - Low Voltage	Specified	Bidder To Fill In Data And Answer Yes or No
141	Manufacturer/Type		
142	Minimum Thickness		

143	Graded Winding?		Yes/No
144	Volts per Turn		
145	Description of Insulation System (Attached if necessary)		
	Winding Insulation - DETC Regulating	Specified	Bidder To Fill In Data And Answer Yes or No
146	Manufacturer/Type		
147	Minimum Thickness		
148	Graded Winding?		
149	Volts per Turn		
150	Description of Insulation System (Attached if necessary)		
	Winding Insulation - LTC Preventative Auto	Specified	Bidder To Fill In Data And Answer Yes or No
151	Manufacturer/Type	Not Applicable	
152	Minimum Thickness	Not Applicable	
153	Graded Winding?	Not Applicable	
154	Volts per Turn	Not Applicable	
155	Description of Insulation System (Attached if necessary)	Not Applicable	
	Winding Insulation - LTC Series (Booster), If Required	Specified	Bidder To Fill In Data And Answer Yes or No
156	Manufacturer/Type	Not Applicable	
157	Minimum Thickness	Not Applicable	
158	Graded Winding?	Not Applicable	
159	Volts per Turn	Not Applicable	
160	Description of Insulation System (Attached if necessary)	Not Applicable	
	Internal Arresters, Non-Linear Resistors, or Reactors	Specified	Bidder To Fill In Data And Answer Yes, No, Not Applicable

161	Are internal arresters or non-linear resistors proposed to limit transient over voltages?	Not allowed without justification	Yes/No
162	If so, is the required justification as outlined in the specifications provided?		Yes/No/Not Applicable
163	Are internal reactors being used to increase impedance?	Not Allowed	Yes/No
	Core	Specified	Bidder To Fill In Data
164	Core Type	3 Legged Core Form	
165	Core Steel Type - Main	See Specifications	
166	Core Steel Type - Preventative Auto (PA)	Not Applicable	
167	Core Steel Type - Series (Booster)	Not Applicable	
168	Include brief description of transformer construction - Include core design and material, main coil design, and method of clamping coil. (Attach if necessary)		
169	What is the Manufacture's maximum allowed core gap?		
170	If it is greater than 1/8" is the documentation provided to justify not meeting this requirement?		Yes/No/Not Applicable
171	What is the minimum winding clamping pressure?	6 N/mm ²	
172	What is the core induction at nominal voltage and nominal taps?	1.72 Tesla	
173	What is the maximum core induction for all tap positions at the maximum excitation condition?	1.93 Tesla	
	DETC Equipment	Specified	Bidder To Fill In Data And Answer Yes or No
174	Is a DETC Being Provided?	Required	Yes/No
175	Manufacturer/Model Number		
176	DETC Location	34.5kV Winding	

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177	DETC Taps	Two (2) 2½% steps above and Two (2) 2½% steps below nominal rated voltage: 36.225kV; 35.363kV; 34.500kV; 33.638kV; 32.775kV. All tap positions shall be full capacity.	
178	Is the DETC Proposed Maintenance Free?	Required	Yes/No
	LTC Equipment	Specified	Bidder To Fill In Data And Answer Yes or No
179	Is an LTC Being Provided?	LTC shall not be provided	Yes/No
180	Manufacturer/Model Number	Not Applicable	
181	Is this a Vacuum LTC?	Not Applicable	
182	Nominal Voltage Rating (Neutral Position)	Not Applicable	
183	If this is an arcing under oil LTC, is an oil filtration system being provided, If so provide manufacturer and model number	Not Applicable	
184	Did MANUFACTURER provide the information, including calculations, to verify that the LTC contacts are good for 1,000,000 operations at full load before contact replacement?	Not Applicable	
185	Range (+/- %)	Not Applicable	
186	Change Per Step	Not Applicable	
187	Number of Steps	Not Applicable	
188	Load Tap Changer Location (What Winding?)	Not Applicable	
189	LTC Constant MVA or Constant Current Below Neutral	Not Applicable	
190	Is the LTC a Variable Flux Design?	Not Applicable	
191	For a variable flux design, what is the maximum percent change in step voltage?	Not Applicable	
192	For a variable flux design, what is the maximum number of tap positions between the nominal voltage tap and LTC neutral?	Not Applicable	

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193	If variable flux design, is an LTC voltage table provided for each tap with the percent change per step provided?	Not Applicable	
194	Is there a Preventative Auto?	Not Applicable	
195	Is there a Series Transformer?	Not Applicable	
196	Is an Artic Breather being provided?	Not Applicable	
197	Regulating Relay (Mfgr./Cat. #)	Not Applicable	
198	LTC Backup Relay (Mfgr/Cat. #)	Not Applicable	
199	LTC Control Voltage Rating	Not Applicable	
200	LTC Motor Voltage Rating	Not Applicable	
201	Is LTC Terminal Board Rated for Full Main Tank Vacuum When LTC Compartment is Empty of Oil?	Not Applicable	
202	Is Tubing for LTC Dehydrating Breather Copper or Stainless?	Not Applicable	
203	Will the LTC Dehydrating Breather Operate Properly with the minimum ambient temperature specified?	Not Applicable	
204	LTC Current Aux Relay (5.0/.02 Amps) (Mfgr./Cat. #)	Not Applicable	
205	Are automatic paralleling controls required?	Not Applicable	
206	Is a paralleling balancing module provided?	Not Applicable	
	Radiators	Specified	Bidder To Fill In Data
207	Number of Radiators per Bank		
208	Number of Radiator Banks		
	Fan Data	Specified	Bidder To Fill In Data
209	Manufacturer/Model Number	Krenz or FCPUD approved equal	
210	Number per Radiator Bank		
211	Total Number of Fans		
212	Horsepower		
213	Voltage Rating		

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214	Number of Phases		
215	Full Load Current, Amperes		
216	Locked Rotor Current (LRA), Amperes		
	Bushings - High Voltage	Specified	Bidder To Fill In Data And Answer Yes or No
217	Bushing Manufacturer		
218	Bushing Style (Cat) Number Being Provided		
219	Location	Roof Segment 3	
220	Voltage Class	34.5kV	
221	BIL	200kV	
222	Current Rating	1200 amps	
223	Creep Distance		
224	Strike Distance		
225	Draw Lead or Bottom Connected?	Bottom Connected	
226	Bushing Stud Connectors included?	Required	Yes/No
	Bushings - Low Voltage	Specified	Bidder To Fill In Data And Answer Yes or No
227	Bushing Manufacturer		
228	Bushing Style (Cat) Number Being Provided		
229	Location	Roof Segment 1	
230	Voltage Class	25kV	
231	BIL	150kV	
232	Current Rating	2000 amps	
233	Creep Distance		
234	Strike Distance		
235	Draw Lead or Bottom Connected?	Bottom Connected	
236	Bushing Stud Connectors included?	Required	Yes/No
	Bushing - XO Neutral	Specified	Bidder To Fill In Data And Answer Yes or No

237	Bushing Manufacturer		
238	Bushing Style (Cat) Number Being Provided		
239	Location	Roof Segment 1	
240	Voltage Class	25kV	
241	BIL	150kV	
242	Current Rating	2000 amps	
243	Creep Distance		
244	Strike Distance		
245	Draw Lead or Bottom Connected?	Bottom Connected	
246	Bushing Stud Connectors included?	Required	Yes/No
	Bushing Centerline Spacing in Inches	Specified	Bidder To Fill In Data
247	Minimum Center-to-Center - High Side	36 inches	
248	Minimum Center-to-Center - Low Side	24 inches	
	Surge Arresters - High Side	Specified	Bidder To Fill In Data
249	Arrester Manufacturer	Hubbell (Ohio Brass)	
250	Arrester Style (Cat) Number		
251	MCOV Rating	22kV	
252	Duty Cycle	27kV	
253	Energy Rating		
254	Current Rating		
255	Strike Distance		
256	Leakage Length		
257	Cantilever Strength		
	Surge Arresters - Low Side	Specified	Bidder To Fill In Data
258	Arrester Manufacturer	Hubbell (Ohio Brass)	
259	Arrester Style (Cat) Number		
260	MCOV Rating	8.4kV	
261	Duty Cycle	10kV	
262	Energy Rating		

263	Current Rating		
264	Strike Distance		
265	Leakage Length		
266	Cantilever Strength		
	Temperature Gauges	Specified	Bidder To Answer Yes or No
267	Is a Main Tank Top Oil Temperature Gauge Being Provided?	Required	Yes/No
268	Is a Hot Spot Temperature Gauge Being Provided?	Yes, X2 bushing	Yes/No
269	Is a LTC Temperature Gauge Being Provided?	Not Applicable	Not Applicable
	Transformer Bushing Current Transformers - High Voltage - Include Ratio, Accuracy, and Thermal Rating	Specified	Bidder To Fill In Data
270	H1, H2, H3	2 CT's Per Phase (2 Sets) – Outer and Inner 600/5 Multi-Ratio with ANSI Standard Taps IEEE Accuracy Class C800, TRF=2.0	
	Bushing Current Transformers - Low Voltage - Include Ratio, Accuracy, and Thermal Rating	Specified	Bidder To Fill In Data
271	X1, X2, X3	2 CT's Per Phase (2 Sets) – Outer 2000/5 Multi-Ratio with ANSI Standard Taps IEEE Accuracy Class C800, TRF=2.0	
272	X1, X2, X3	2 CT's Per Phase (2 Sets) – Middle 1200/5 Multi-Ratio with ANSI Standard Taps IEEE Accuracy Class 0.3B1.8, TRF=2.0	
273	X1, X2, X3	1 CT Per Phase (1 Set) – Inner 1200/5 Single Ratio IEEE Accuracy Class C200, TRF=2.0	
274	X2 (Hot Spot Gauge)	1 CT Inner Single Ratio IEEE Accuracy Class C200 for Hot Spot Gauge, Ratio set by Manufacturer	Not Applicable
	Bushing Current Transformers - HOXO Neutral - Include Ratio, Accuracy, and Thermal Rating	Specified	Bidder To Fill In Data

275	X0 Neutral	1 CT – Outer 1200/5 Multi-Ratio with ANSI Standard Taps IEEE Accuracy Class C800, TRF=2.0	
	Additional Physical Characteristics	Specified	Bidder To Fill In Data
276	CT wire Type (Inside Tank To Control Cabinet)	ETFE/FEP 150 Deg C rated	
277	Control wire Type	Flame resistant, oil resistant, heat resistant, and moisture resistant and can withstand the ambient temperatures specified.	
	Equipment Descriptions	Specified	Bidder To Fill In Data
278	Description of Electronic Temperature Monitor (including manufacturer and model number, number of sensors, output contact set-points, number of output contacts, etc.).	Qualitrol ITM509-200	
279	Description of I/O and/or Automation/Communication Devices	SEL-2533 Annunciator	
280	Description of DGA Monitor	Not Applicable	Not Applicable
	Shipping Information:	Specified	Bidder To Fill In Data
281	Method for Shipping Transformer		
282	Method for Shipping Accessories		
283	Total Gallons of Oil		
284	Method of Oil Shipment		
285	Quantity of Oil Shipped Separate from Tank, Gallons		
286	Total Shipping Weight		
	Dimensions And Weight of Largest Shipping Piece	Specified	Bidder To Fill In Data
287	Height, Inches		
288	Width, Inches		
289	Depth, Inches		
290	Weight, pounds		
	Installation Information	Specified	Bidder To Fill In Data And Answer Yes or No

291	Items Requiring Field Assembly		
292	Is field vacuum filling required?		Yes/No
293	Recommended Minimum Space Between Transformer and Adjacent Wall, inches		
	Will the following be performed per the specifications? If no, provide clear detailed exceptions and clarifications or Bid could be rejected for not being responsive.	Specified	Bidder To Answer Yes or No
294	Is a PE from the state where the transformer is being delivered going to review the transformer design and prepare and verify a seismic report?	Not Required	Yes/No
295	Virtual Monitoring		Yes/No
296	Design Review		Yes/No
297	Observations		Yes/No
298	Factory Acceptance Testing		Yes/No
299	Shipping Requirements		Yes/No
300	Unloading		Yes/No
301	Were the site restrictions and notes, if any, stated in the Data Form included in the quotation for unloading each transformer and moving it to its pad?		Yes/No
302	Transformer Vacuum Filling in the Field		Yes/No
303	Vacuum Processing in the Field - Will Hot Oil Circulation and Leak Down (Leak Up) Processes be Used Per Specification Requirements to Verify Insulation Moisture Content?	Required	Yes/No
304	Transformer Vacuum Processing in the Field - Will Insulation Moisture Content be Less Than 0.5% Per Specification Requirements?		Yes/No
305	Field Testing		Yes/No

306	If required to validate warranty or required in the Data Form, is the cost of the on-site MANUFACTURER's representative included in the purchase price of the transformer?		Yes/No
	Maximum Shipping Withstand Forces in "g"	Specified	Bidder To Fill In Data
307	Longitudinal	Design Value Requested	
308	Vertical	Design Value Requested	
309	Transverse	Design Value Requested	
	Subcontractors	Specified	Bidder To Fill In Data And Answer Yes or No
310	Will any subcontractors be used for unloading, delivery, acceptance testing, assembly, vacuum filling, or final acceptance testing?		Yes/No
311	If so, list all subcontractors and describe their tasks		
	Clarifications and Exceptions	Specified	Bidder To Fill In Variations And Exceptions

312	The following list states any and all variations from and exceptions to the requirements of the Contract Documents and that otherwise it is the intent that the work will be performed strictly in accordance therewith. If no exceptions are taken, state "NONE". (Note: Use separate page, if necessary). If left blank, "NONE" will be recorded. When attaching standard literature like field service processes, factory testing, etc. clearly state on each attachment that the attachment is not an exception to these specifications. If this is not followed, it may be assumed that the attachment is an exception and/or a clarification. Specifically state all exceptions and clarifications to prevent confusion and misevaluation of your bid.		
	Acknowledgements and Signature		Bidder To Fill In Data And Answer Yes or No
313	THE UNDERSIGNED hereby agrees to furnish the required bonds, if requested, at an additional cost and to enter into a Contract within 10 days from and after the acceptance of this bid and further agrees to complete the entire work covered by this bid in accordance with the schedule milestones in the Contract Documents. For every day the Notice of Award is delayed, the completion date will be adjusted the same.		Yes/No
314	THE UNDERSIGNED hereby agrees that the Contract will be subject to liquidated damages in accordance with the General Conditions.		Yes/No

315	THE UNDERSIGNED understands that the right is reserved to reject any and all bids.		Yes/No
316	THE UNDERSIGNED is prepared to submit a financial statement on request.		Yes/No
317	THE UNDERSIGNED acknowledges receipt of Addenda (List Each One)		
318	By (Printed Name)		
319	Title		
320	Date		
321	Telephone Number		
322	Contact Person		

Bidder Information

Bidder Business Name		
Bidder's Washington UBI No:		
Physical Business Address:		
City:	State:	Zip:
Business Telephone Number:	Business Email Address:	
OFFICIAL AUTHORIZED TO SIGN FOR BIDDER		
Print Name & Title:		
Signature:		Date:

Section 5: MATERIAL SPECIFICATIONS

See Appendix A for full 15/20/25 MVA Three Phase Power Transformer specification.

5.1 SCOPE OF CONTRACT

The purpose of this specification is to provide 15/20/25 MVA Three Phase Power Transformer for the District's electric system which have long service lives and are safe for District personnel and the general public.

This specification covers the minimum technical requirements for fabricating and delivering 15/20/25 MVA Three Phase Power Transformer to be furnished to the District. Where there is a conflict with any previously issued District specification, this specification shall govern.

5.2 GENERAL REQUIREMENTS

- a. Build America, Buy America
 - i. All Bid Items are to comply with the manufacturing requirements of Build America, Buy America (BABA) and include certification of compliance.
 - ii. If the vendor does not have access to BABA compliant items, the vendor may submit bids for alternatives that are not BABA compliant.
 - iii. All bid items must be clearly marked as "meet" or "do not meet" BABA requirements.
 - iv. Build America, Buy America requirements are included in Appendix B.

5.3 STORAGE, HANDLING, HAULING AND SHIPPING

- a. See full specification in Appendix A for storage, handling, hauling and shipping instructions.

5.4 INSPECTION OF 15/20/25 MVA THREE PHASE POWER TRANSFORMER AT STRASBURG SUBSTATION

- a. See full specification in Appendix A for the inspection requirements of the 15/20/25 MVA Three Phase Power Transformer.

Section 6: CONTRACT

THIS CONTRACT TO FURNISH AND SUPPLY 15/20/25 MVA Three Phase Power Transformer is made and entered into this _____ day of _____ (month) 2025, between PUBLIC UTILITY DISTRICT NO.1 OF FERRY COUNTY (hereinafter called the "District"), and

_____ Vendor Name

(hereinafter called the "Vendor").

WITNESSETH:

That the District and the Vendor in consideration of the payments hereinafter mentioned agree as follows:

ARTICLE I.

The complete Contract include the Advertisement for Bids, Bidding Regulations, Instruction to Bidders, Proposal Forms, Contract Specifications, Legal Requirements and all modifications incorporated in these documents before their execution. The foregoing documents shall hereinafter be called "Contract Documents." All obligations of the District and the Vendor are fully set forth and described herein.

In the event of a discrepancy between any of the Contract Documents, as above defined, at the request of the Vendor, the District shall give a written interpretation thereof, which interpretation shall govern.

ARTICLE II.

The Vendor agrees to furnish free and clear of all liens and encumbrances all equipment, apparatus, facilities and drawings according to the Specifications contained in the Contract Documents for which he was the successful bidder.

The District hereby promises and agrees with the Vendor to employ and does employ the Vendor to furnish all equipment in strict accordance with the accepted Plans and Specifications and hereby contracts to pay for the same according to the price stated in the Proposal.

ARTICLE III.

Contract Term: Furnish and supply 15/20/25 MVA Three Phase Power Transformer on a one (1) time basis.

The prices submitted with the Bidder's bid shall remain the same for the initial contract term, as well as any contract renewals, unless there are any escalation factors submitted with the Bidder's bid that were accepted and agreed to during the District's bid evaluation process.

Bids will be in accordance with the District's bid documents.

ARTICLE IV.

Vendor's Bid Proposal Form with pricing information is attached hereto in Exhibit "A."

[VENDOR]:

PUBLIC UTILITY DISTRICT NO.1 OF FERRY
COUNTY, WASHINGTON:

By: _____
Title: _____

[Name], General Manager

By: _____
Title: _____

APPROVED AS TO FORM

UBI# _____

[Name], General Counsel

Section 7: BID BOND FORM

THE DISTRICT REQUIRES ALL BID BONDS TO BE IN THE FOLLOWING FORMAT:

KNOW ALL MEN BY THESE PRESENTS: that _____ as Principal(s) (“Principal”) and _____, as Surety licensed to undertake surety business in the State of Washington (“Surety”), are held and firmly bound unto Public Utility District No. 1 of Ferry County, Washington, (the “District”) as obligee, in the amount of _____ Dollars(\$) (being 5% of the total amount of the bid) submitted as part of this bid, for the payment of which we bind ourselves, our heirs, administrators, executors, successors and assigns, jointly and severally, as provided herein..

WHEREAS, Principal is submitting herewith a Bid Proposal for:

NOW, THEREFORE, the condition of this obligation is that if Principal is awarded the contract which the Principal has proposed to undertake, and enters into a contract pursuant to such award and gives a bond for the faithful performance of the contract, and payment in full to subcontractors and laborers, material, men and vendors, then this obligation shall be void; otherwise, the amount hereinabove specified in this Bid Bond shall be paid to the District as liquidated damages, all in accordance with RCW 54.04.080.

SIGNED this ____ day of _____, 2025

(SURETY)	(PRINCIPAL)
By	By
Printed Name	Printed Name
Title	Title
Street Address	Street Address
Mailing Address	Mailing Address
City/State/Zip	City/State/Zip

(Power of Attorney attached)

Appendix A: Material Specification

May 20, 2025

FOR FERRY COUNTY PUD NO. 1

*Specification For
Three Phase Power Transformer
34.5/12.47kV, 15/20/25 MVA*

SUBSTATION NAME: STRASSBURG SUBSTATION

LOCATION: REPUBLIC, WA

PROJECT NUMBER: 0256867

PROJECT CONTACT: John Rettkowski
EMAIL: john.rettkowski@powereng.com
PHONE: (208) 788-0565



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*Specification For Three Phase Power Transformer
34.5/12.47kV, 15/20/25 MVA*

PREPARED FOR: FERRY COUNTY PUD NO. 1

PREPARED BY: JOHN RETTKOWSKI

REVISION HISTORY				
REVISION	DATE	ISSUED FOR	PREPARED BY	CHECKED BY
A	2/28/2025	For Review	JDR	FJM
B	5/20/2025	For Bid	JDR	

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DATA FORM

Purchaser	Ferry County PUD No. 1 (FCPUD)
Description	34.5/12.47kV, 15/20/25 MVA
Functional Requirements	To service 12.47kV distribution bus and loads from a 34.5kV bus in a step-down application. The transformer will be connected to a 34.5kV main bus on the high side with fuses and two sets of single phase wye-connected voltage regulators supplying two 12.47kV feeders on the low side.
Type	Two Winding Distribution Transformer
Quantity	One (1) unit
Step-Up and Step-Down Operation	Step-down operation from 34.5kV to 12.47kV
Number of phases	Three
Frequency	60 Hz
Number of Windings	Two
Voltage - High Side	34,400 V
Voltage - Low Side	12,470 V Wye
Winding - High Voltage	Delta
Winding - Low Voltage	Grounded Wye
Phase Relationship	Low Side shall Lag High Side by 30 Deg, with Dyn1 configuration
BIL – High Side	200kV
BIL _ Low Side	110kV
BIL – Low Side Neutral	110kV
BSL – High Side	166kV
BSL – Low Side	92kV Winding Design
Cooling Class/Stages	ONAN/ONAF/ONAF
Tank Exterior Color	ANSI #70, Gray
Capacity – 34.5kV High Side 65 Degrees C Rise	15/20/25 MVA at 3,300 feet
Capacity – 12.47kV Low Side 65 Degrees C Rise	15/20/25 MVA at 3,300 feet
Maximum Top Oil and Average Winding Temperature Rise	65 Degrees C
Maximum Winding Hot Spot Temperature Rise	80 Degrees C
Maximum Altitude	3,300 feet
Average Ambient Temperature	+35 Degrees C

Maximum Ambient Temperature	+45 Degrees C
Minimum Ambient Temperature	-40 Degrees C
Core and Coil Cold Start Temperature	-35 Degrees C Ambient with Core and Coils at -30 Degrees C
HV to LV Positive Sequence Impedance at ONAN Rating at 65 Degrees C	6.0% minimum to 8.0% maximum at 15 MVA
Is ANSI/IEEE Standard Impedance Tolerance Acceptable or Should It Be Per These Specifications?	Standard ANSI/IEEE tolerances acceptable
Specified X/R Ratio	MANUFACTURER'S choice, no restriction
Maximum Total Harmonic Distortion	5%
Cost of No-Load Losses Per kW	\$4,355
Cost of Load Losses Per kW at base rating	\$586
No-Load Loss Penalty Factor Per kW	\$5,227
Load Loss Penalty Factor Per kW	\$704
System Voltage for Fault Current Calculations	105% of Nominal
Are there additional requirements for core steel besides what is in these specifications?	No
Does Geomagnetic Magnetic Disturbance (GMD) Impact Need to be Studied?	No
GMD study current(s) Ipeak	Not Applicable
Maximum Sound Level at Base Rating at 1 foot at 105% excitation, and highest flux density DETC and LTC Taps with the LTC in a bridging position if a preventative autotransformer is provided	65 dBA
Maximum Sound Level at Max Rating at 6 feet at 105% excitation, and highest flux density DETC and LTC Taps with the LTC in a bridging position if a preventative autotransformer is provided	68 dBA
Does Sound Test Include a Load Sound Test?	Yes
Is Paralleling Required?	No
Even load Splitting	Not Applicable
Are Other Transformer Nameplates Attached For Paralleling?	Not Applicable
Bushings - High Side	Bottom Connected rated for 34.5kV, 1,200 amps
Bushing Location – High Side	Roof Segment 3
Bushings - Low Side	Bottom Connected rated for 25kV, 2,000 amps
Bushing Location – Low Side	Roof Segment 1

Bushings – LV Neutral	Bottom Connected rated for 25kV, 2,000 amps
Bushing Location – LV Neutral	Roof Segment 1
Bushings - BIL - High Side	200kV
Bushings - BIL - Low Side	150kV
Bushing - BIL – LV Neutral	150kV
Contamination Level	Medium
Bushing Minimum Center-to-Center Spacing - High Side	36 inches
Bushing Minimum Center-to-Center Spacing - Low Side	24 inches
Are Bushing Stud Connectors Required (They are already Required on all Grounded Bushings)?	Yes, 4"x4" Pad, Tin Plated Bronze Anderson Type HDSF141D1212TP per specifications
Are PCore Bushing Test Terminals Required?	No
Surge Arresters - High Side	Hubbell, Station Class, 22kV MCOV, 27KV Duty Cycle,
Surge Arresters - Low Side	Hubbell, Station Class, 8.4kV MCOV, 10kV Duty Cycle,
Is the top of the arrester 4-hole pad in-line with or 6" lower than bushing 4-hole pad	In-Line
Are Surge Arrester Discharge Counters Required? If so, which arresters?	Surge Arrester Discharge Counters are not required
Bushing Current Transformers - HV (H1, H2, H3)	2 CT's Per Phase (2 Sets) – Outer and Inner 600/5 multi-ratio with ANSI Standard taps C800
Bushing Current Transformers - LV (X1, X2, X3)	3 CT's Per Phase (3 Sets) – Outer 2000/5 multi-ratio with ANSI Standard taps C800; Middle 1200/5 multi-ratio with ANSI Standard taps 0.3B1.8; Inner 1200/5 single ratio C200 Min for ETM
Bushing Current Transformers – LV (X2)	1 CT - Inner Hot Spot Gauge C200 Min - Ratio Set by MANUFACTURER
Bushing Current Transformers - Neutral (X0)	1 CT – Neutral Current 1200/5 multi-ratio with ANSI Standard taps C800
CT Thermal Rating Factor	2.0
Is a DETC Required?	Yes, a DETC shall be provided
DETC Location	34.5kV Winding
DETC Taps - Volts	5 taps, two 2 1/2% above and two 2 1/2% below the nominal voltage rating: 36,225; 35,363; 34,500; 33,638; 32,775
Is an LTC Required	No
Is Fiber Optic Hot Spot Monitoring Required?	No
Electronic Temperature Monitor	Not Required
ETM Analog Output Range	4-20 mA

Shall ETM Analogs be connected to the Remote Automation/Communication Device(s)?	No, wire to terminal block only and short current outputs at terminal block.
Is Remote I/O and/or Automation/Communications Devices Required?	No
How Shall Transformer Alarms be Connected?	All contacts on all alarms shall be wired to terminal blocks in the main control cabinet.
Is a DGA Monitor Required? If so, what is the manufacturer and model number?	No
Shall DGA Monitor Analogs be connected to the Automation/Control Device?	Not Applicable
Is a Fiber Patch Panel Required?	No
Ethernet Cabling	Not Applicable
Is tempered glass required for all transformer (including LTC) gauges?	Tempered glass is required
Type of liquid level gauge(s) required for main tank and/or conservator	Qualitrol or Messko MTO
Type of liquid level gauge required for LTC	Not Applicable
Is an additional Liquid Level Gauge Required For the Main Tank?	Yes, and the gauge face plate shall be blanked out
Are analog outputs required for the liquid level gauges	No
Is the main tank Liquid Level Gauge “Critical” contact used for Tripping?	No, alarm only
If additional Liquid Level Gauge provided is the contact used for Tripping?	Yes
Is the LTC Liquid Level Gauge “Critical” contact used for Tripping?	Not Applicable
Is Top Oil Temperature Gauge Required?	Yes
Is Hot Spot Gauge(s) Required? If Yes, for Which Winding(s)?	Yes, X2
Type of top oil temperature gauge required for main tank	Qualitrol 104/TR6000 Series or Messko MT-160/RM
Type of winding hot spot temperature gauge required	Qualitrol 104/TR6000 Series or Messko MT-160WR/RM
Type of oil temperature gauge for external LTC	Not Applicable
Are analog outputs required for the temperature gauges?	No
Hot Spot Minor Alarm Setting	115 Degrees C
Hot Spot Major Alarm or Tripping Setting	135 Degrees C
Top Oil Temperature Minor Alarm Setting	90 Degrees C
Top Oil Temperature Major Alarm or Tripping Setting	110 Degrees C

Are Temperature Major Alarms Used for Tripping?	Yes
Type of pressure relief device required for main tank	Qualitrol Series 208 or Messko MPREC LMPRD
Type of pressure relief device required for external LTC	Not Applicable
Shall the output of the pressure relief devices be directed to the base of the transformer?	No
AC Power Provided by FCPUD	120/240 VAC, single phase, 3 wire (no ground from AC source)
Cooling Fan Motor Rating	200 - 230 VAC single phase suitable for operation at either 240 or 208 volt single phase
Are separate circuit breakers and contactors required for each fan?	No
DC Power Provided by FCPUD for ETM, Other DC Devices, and Tripping Seal-in Relays	DC power not available. All devices shall use 120/240 VAC single phase
Main Control Cabinet Location	Not Specified
NEMA Type For Control Cabinet, and Nitrogen Cabinet (if provided)	3R
Is stainless steel required for the control cabinet enclosures required?	No
Are stainless steel core ground and junction box enclosures required?	No
Is Extra Thermal Insulation Required in Control Cabinet? If Yes, What R Value?	No
Is a Lexan window required in the control cabinet?	No
Are sun shields required on control cabinet?	No
Is forced air ventilation with filter and thermostat required for control cabinet?	No, filtered and wire screened air vents only
Is a high melting point material required for all valves on the transformer and LTC (if applicable)?	No
Are Sample Ports Required on Drain Valves?	Yes
Is a 3" gate valve required for the vacuum port?	Yes
Are Additional Tank Valves Required For Future or Required DGA Equipment?	Yes, Main Tank for future DGA equipment
Is a gate valve required on the filling nipple?	Yes
Is a 90 degree fitting required on the filling nipple?	Yes
Are Viton Gaskets Required For Radiator Shutoff Valve Stems?	No
Is bolted rescue manhole required near bottom of main tank?	No

Required Fall Protection Mounting Plate	3M DBI SALA Part # 8510816, which is shown in Attachment B. FCPUD will provide and install a DBI SALA Advanced Post.
Seismic Site Classification Factors	Determined by MANUFACTURER per ASCE 7-16 as outlined in IEEE 693.
Does a PE have to review the transformer design and prepare and certify a seismic report?	No
Is a transformer anchoring system required?	No
Wind and Ice Loading	Wind and Ice Loading Maximum Wind Velocity: Wind load shall be in accordance with IBC 2015. Basic Wind Speed = 100 mph Exposure Factor = C Importance Factor = 1.15 Ice = 1/4 inch radius
Load Loss, Impedance, and Resistance Reporting Temperature	85 Degrees C using 65 Degrees C MVA Rating
Are Switching Surge Tests Required on Windings Below 345kV? If Yes, Which Windings?	No
Applied Voltage Level for 24-hour Overexcitation Tests	110%
Is an overload Temperature Rise Test required at the Overload Rating specified?	No
For duplicate units, can the Temperature Rise Test at the self-cooled rating be omitted?	Yes
For duplicate units can the current injection test, at the highest nameplate current be allowed instead of temperature rise tests?	No
Are additional temperature rise tests required to determine the winding hot spot and oil exponents "m" and "n" per IEEE C57.119?	No
Is a Vibration Test Required Per These Specifications?	No
Insulating Fluid	Inhibited Type II Naphthenic based mineral oil, Ergon HyVolt II NG or FCPUD approved equal
Preservation System	Inert Gas Pressure System
Additional Spare Parts (These are in addition to what is required in the Specifications)	Only what is required in the specifications
Desired Delivery Date	Earliest possible date
Desired Acceptance Dates	6 to 8 weeks after delivery
DDP Delivery Location	Transformer Pad

Delivery Notes	The Desired Delivery Date is not firm. The MANUFACTURER is encouraged to submit earliest possible delivery date that can be provided for consideration.
Are there Liquidated Damages For Late Delivery?	No
Who is Responsible For Inspection and Tests Before Off-Loading the Transformer?	MANUFACTURER
Who is Responsible For Off-Loading the Transformer?	MANUFACTURER
Who is Responsible For Moving the Transformer and Placing it on the Pad	MANUFACTURER
Who is Responsible For Assembling the Transformer	MANUFACTURER
Who is Responsible For Vacuum Filling the Transformer?	MANUFACTURER
Is the Leak Down (Leak Up) Process Required for Vacuum Filling?	Yes
Who is Responsible For Field Testing the Transformer?	MANUFACTURER
Is a MANUFACTURER's on-site representative required by FCPUD to be on-site during assembly and vacuum filling the transformer?	No.
Special Requirements	
Overload Requirements?	No
Dimension or Weight Restrictions?	None
Neutral Grounding Resistor	None
Notes/Clarifications	It is the MANUFACTURER's responsibility to determine the best way to unload each transformer and place it on its pad.
Contact Information And Delivery Addresses	
Correspondence, Drawings, and Instruction Manuals	John Rettkowski POWER Engineers Office: 208-788-0565 Email: john.rettkowski@powereng.com
Shipping Notices	Steve VanSlyke Public Utility District No. 1 of Ferry County 686 S Clark Ave Republic, WA 99166 Office: 509-775-3325 Email: svanslyke@fcpud.com
Delivery Address	Strassburg Substation 25 Creamery Rd Republic, WA 99166
Delivery GPS Coordinates	GPS 48°38'59.16"N, 118°41'8.43"W

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Unloading, Assembly, Vacuum Filling, and Field Testing Contact	By MANUFACTURER
Service Bulletins	Steve VanSlyke Public Utility District No. 1 of Ferry County 686 S Clark Ave Republic, WA 99166 Office: 509-775-3325 Email: svanslyke@fcpud.com

SCOPE, CLASSIFICATION, AND FUNCTIONAL REQUIREMENTS

Scope

This specification sets forth the minimum requirements for operating characteristics and safety features of a power transformer.

Classification

The transformer shall be rated as specified in the Data Form.

The maximum temperature rises shall be as specified in the Data Form.

The transformer will occasionally be subjected to the maximum ambient temperature specified in the Data Form.

When this condition occurs, the transformer shall be able to continue normal operation without a significant loss of life or other conditions that would damage the transformer.

When this condition occurs, the maximum hot spot temperature shall not exceed 120 Degrees C.

When this condition occurs, the Top Oil Temperature shall not exceed 105 Degrees C.

The transformer shall be capable of cold starting in an ambient temperature as specified in the Data Form with the core and coil also at the temperature specified in the Data Form.

The transformer shall be suitable for operation at service conditions as described in IEEE C57 and as modified in these specifications.

When the project altitude stated in the Data Form is above 3,300 feet, the bushing strike distance shall be increased by the applicable IEEE C57 Altitude Correction Factors.

When the ambient temperature conditions stated in the Data Form are outside the “Usual” parameters identified in IEEE C57.12.00, the Manufacturer will identify mitigating measures in their proposal and design review submittals for evaluation and acceptance by FCPUD.

Functional Requirements

As described in the Data Form.

Design and Manufacturing Location

The transformer shall be designed and manufactured in the United States of America.

PROVIDE IN PROPOSAL the location of the manufacturing facility where the transformer will be manufactured. The manufacturing location cannot change without written permission from FCPUD.

FCPUD expects that the Manufacturer’s Engineering and Design Team will have active involvement in the manufacturing of the autotransformer supplied under this specification.

Items like design, core cutting, or assembly of the core or coils that are performed outside the manufacturing plant proposed shall be clearly identified.

PROVIDE IN PROPOSAL a list of the above items and for each item where the service will be performed.

INFORMATION TO BE SUBMITTED WITH PROPOSAL

General

Each Bidder shall submit complete and descriptive information on the Bidder's offering in sufficient detail to permit a complete analysis of the bid.

This shall include the name of the manufacturer and the type or model of each principal item of equipment or material the Bidder proposes to furnish.

The Bidder shall also submit drawings and descriptive material, which will show general dimensions and weights, principle of operation, and the materials from which the parts are made.

Any bid not having sufficient descriptive matter to describe accurately the equipment or materials bid upon will be rejected as irregular.

FCPUD will retain the above drawings submitted by the successful Bidder.

Any material departure from these drawings as submitted will not be permitted without written permission from FCPUD.

Verbal statements made by the Bidder at any time regarding quality, quantity, or arrangement of equipment will not be considered.

The blank Bid Form shall be completely filled for the equipment being bid.

The data listed thereon shall not relieve the MANUFACTURER of the responsibility for meeting the requirements of the detailed specifications.

Bidder shall submit all information requested where it states within these specifications **"PROVIDE IN PROPOSAL"**.

PROVIDE IN PROPOSAL a preliminary production schedule for each unit.

Major items to be shown in bar chart style are compliance submittals, ordering material, fabrication, assembly, testing, and shipping.

The successful Bidder will update and provide this schedule no later than 10 days after order acknowledgement and then again monthly until shipment of the unit(s) has been completed.

PROVIDE IN PROPOSAL a copy of the MANUFACTURER's warranty included in the lump sum bid.

The Bidder shall demonstrate to the satisfaction of FCPUD that the transformer proposed in regard to this Specification has sufficient mechanical strength to withstand, without damage or failure, all through-fault currents in accordance with ANSI C57.12.00.

The Bidder shall demonstrate that the transformer(s) meets this requirement by at least one of the following methods. **PROVIDE IN PROPOSAL** documentation that meets this requirement.

Certified test data showing that a transformer with a core and coil identical in design and construction and identical or similar with respect to MVA capacity, kV ratings, BIL, impedance, and voltage taps has been tested under maximum short circuit conditions without failure.

A description of the test code under which the transformer was tested for short circuit strength.

The Bidder shall demonstrate a history of successful experience with transformers of identical or similar ratings, design, and construction.

The Bidder shall **PROVIDE IN PROPOSAL** a list of all transformers in service with insulation design and core and coils that are essentially identical in design, construction, and rating to the transformer covered by this Specification and shall provide information on the date of installation, location, and failures, if any.

Where such transformers have a cumulative service record of less than 20 transformer years, a list of transformers in service that represents the closest approximation to the transformer covered by this Specification shall be submitted.

The information submitted shall be representative of the total experience of the MANUFACTURER with the design of the transformer to be furnished and shall include the dates of installation (or shipment, if not installed), the ratings of the transformer, and a list of failures and causes of failures, if any have been experienced.

Design and Performance

MANUFACTURER shall only use designs and materials that have demonstrated performance. This means that the designs and material used shall have been proven in use on other transformers that have been in service for at least 1 year. This will be a design review topic.

MANUFACTURER shall disclose any design or material changes that occur that do not have demonstrated performance for FCPUD to review and approve. **PROVIDE IN PROPOSAL** all designs and materials that the MANUFACTURER plans to use that do not have demonstrated performance when proposal is submitted.

FCPUD reserves the right to purchase at Bidder's set price or to reject any and all bids.

APPLICABLE STANDARDS AND REGULATIONS

Standards

Equipment supplied in accordance with this specification shall comply with applicable provisions of the recent version of the following standards:

Acoustical Society of America (ASA)
 Aluminum Association (AA)
 American Aluminum Manufacturers Association (AAMA)
 American Association of State Highway and Transportation Officials (AASHTO)
 American Institute of Steel Construction (AISC)
 American Iron and Steel Institution (AISI)
 American National Standards Institute (ANSI)
 American Society for Testing and Materials (ASTM)
 American Society of Civil Engineers (ASCE)
 American Society of Mechanical Engineers Performance Test Code (ASME)
 American Society of Nondestructive Testing (ASNT)
 Association of Edison Illumination Companies (AEIC)
 Council on Large Electric Systems (CIGRE) Publication 529
 Edison Electrical Institute (EEI)
 Environmental Protection Agency (EPA)
 Institute of Electrical and Electronic Engineers (IEEE)
 National Board of Fire Underwriters (NBFU)
 National Bureau of Standards (NBS)
 National Electrical Code (NEC)
 National Electrical Manufacturers Association (NEMA)
 National Electrical Safety Code (NESC)
 National Electrical Testing Association (NETA)
 National Fire Protection Association (NFPA)
 Sheet Metal and Air Conditioning Manufacturers National Association, Inc. (SMACNA)
 Washington State Building Code (WBC)
 International Electrotechnical Commission (IEC)
 International Building Code (IBC)
 Underwriters Laboratories Inc. (UL)
 Uniform Building Code (UBC)
 All applicable local utility standards and codes of practice

Equipment supplied in accordance with this specification shall also comply with applicable provisions of the American Welding Society and the Society for Protective Coatings.

Equipment supplied in accordance with this specification shall also comply with applicable provisions of the latest OSHA standards.

The MANUFACTURER shall inform FCPUD of all instances where there are conflicts between FCPUD's specifications and the applicable standards or a conflict between the standards for conflict resolution.

Failure to inform FCPUD of any conflict of requirements does not relieve the MANUFACTURER from adhering to the more rigorous requirement.

Regulations

The MANUFACTURER, joint venture partners and all sub-contractors shall comply with the United States of America Federal Acquisition Regulations when purchasing material for use in FCPUD transformers.

The MANUFACTURER shall comply with the provisions of the Build America Buy America requirements for FCPUD Grant Award No DE-CD0000124. Details of these requirements are described in Term 8 of the Award Program Award-Specific Terms and Conditions.

Attention shall be paid to obtaining materials from China, Russia, and other countries that the United States has or may express concern and have or could be developing regulations and restrictions that could impact the project.

Materials shall not be obtained from these countries without FCPUD's permission and potential impacts on the schedule and risks to the project considered, identified, and submitted to FCPUD for review and approval.

The following materials cannot be sourced from China:

Copper

CTC

Electrical steel

Solid insulating material (tape, barriers)

Porcelain

PERFORMANCE REQUIREMENTS

Ratings

Frequency (as specified in the Data Form)

Phases (as specified in the Data Form)

Class (as specified in the Data Form)

Voltage (as specified in the Data Form)

Winding Connections (as specified in the Data Form)

Angular Displacement (as specified in the Data Form)

Capacity (as specified in the Data Form)

Basic Impulse Level (BIL) (as specified in Data Form)

Basic Switching Level (BSL)

The design shall include switching surge analysis for all windings.

MANUFACTURER shall increase the BIL/BSL for the low side windings to pass a full value switching surge test on the high side windings.

FCPUD reserves the right to have all windings tested.

The design test voltage for the high voltage winding shall be as specified in the Data Form.

The design test voltage for all other windings shall be limited to a value that will not damage the windings not being tested.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** or at design review the maximum switching surge test voltages that can be applied to the windings without damaging other windings.

Loading

The continuous loading of each winding shall be as specified in the Data Form.

All components of the transformer, including bushings, internal connections, tap changer, current transformers, in addition to the transformer high- and low-voltage windings, shall be capable carrying loads within limits established in accordance with IEEE C57 and NEMA loading guides.

Specifically, IEEE C57.91-2011 Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators.

Transformer shall also be capable of carrying the overload specified in the Data Form.

The neutral lead conductor and the neutral bushing shall be capable of carrying full load current.

The neutral lead conductor and the neutral bushing shall also be capable of carrying all overloads in accordance with ANSI/IEEE and any additional overloads specified in this specification.

The loading of the transformer shall be dictated by the average winding rise, winding hot spot rise, and top oil rise.

Components such as leads, LTC, bushings or any other component shall NOT determine the maximum loading of the transformer.

The maximum hot spot temperature in the regulating voltage winding (RV) shall not exceed the hot spot in the winding being regulated.

The RV winding shall not be the limiting factor.

The lead temperatures shall not exceed the maximum hot spot of the associated winding.

The winding lead exit temperatures shall not exceed the maximum hot spot of the associated winding by more than 2 Degrees C.

Any component, winding, or accessory that cannot be measured by temperature test shall not be a limiting factor.

The transformer shall be designed and manufactured to allow continuous operation of all windings and the core at the following voltages without gassing or exceeding the guaranteed temperatures:

110% voltage at no-load on the output terminals.

105% voltage at full load on the output terminals.

The load power factor shall be 80% lagging, but the input voltage can be limited to 110%.

If both step-up and step-down operation is specified in Data Form these requirements shall be in both step-up and step-down operation per the requirements in the Data Form.

In the variable flux design it must be assumed during all load conditions and the input voltage is constant so that when the LTC adds or subtract turns from the input side that the flux density changes.

If both step-up and step-down operation is specified in Data Form these requirements shall be in both step-up and step-down operation with the LTC in the maximum flux density position per the requirements in the Data Form.

Impedance and X/R Ratio

The positive and zero sequence impedance of the transformer shall be as specified in the Data Form at the self-cooled, base rated MVA, with the DETC and the LTC on the neutral tap positions.

The tolerance on impedance shall be in accordance with Section 9.2 of ANSI/IEEE C57.12.00 with exceptions as noted below:

If required in the Data Form, the tolerance of the positive sequence impedance for a two winding transformer shall be +/-5%, three winding transformers shall be +/-7.5%, and autotransformers shall be +/-7.5% from the impedance the MANUFACTURER provides in the proposal.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** the maximum and minimum calculated impedances and at what DETC taps and LTC positions these impedances occur.

Reactors to increase the impedance will not be allowed.

All windings shall be self-protecting.

PROVIDE IN PROPOSAL the X/R Ratio at the self-cooled, base rated MVA, with the DETC and the LTC on the neutral tap positions.

The MANUFACTURER shall also PROVIDE IN PROPOSAL the maximum and minimum X/R ratios and at what DETC taps and LTC positions these X/R ratios occur.

In addition, the MANUFACTURER shall provide the maximum percent deviation that could occur during design and testing.

Harmonic Distortion And Resonance

The transformer shall be designed for a load harmonic distortion level as specified in the Data Form without gassing, oversaturation of the core, exceeding temperature rises as specified in this specification and standards or cause any harmful impacts to the transformer.

Losses

The transformer losses will be used in the evaluation of the proposals. MANUFACTURER shall **PROVIDE IN PROPOSAL** the losses guaranteed below which will be used in the evaluation.

The MANUFACTURER shall guarantee the following values:

No-load losses at 20 Degrees C at the 1R LTC tap position, at 100% excitation. In addition, if the transformer has an LTC utilizing variable volts per turn design, the no-load losses shall be measured and guaranteed on the LTC position having the highest no-load losses.

Load losses at the reference temperature specified in the Data Form when loading the transformer at the base rated MVA at the DETC nominal rated tap position (if supplied) and the LTC nominal voltage tap position (if supplied).

Auxiliary losses at the maximum forced cooled rating.

The following life cycle costs (cost of losses) shall be used in the loss evaluation and for design purposes.

Cost of no-load losses (as specified in the Data Form)

Cost of load losses (as specified in the Data Form)

Cost of auxiliary losses (as specified in the Data Form)

The no-load losses and excitation current at 20 Degrees C after impulse tests shall be used as the guaranteed values and shall not deviate from the no-load losses and excitation current values measured before impulse tests by more than five (5) percent.

If the difference between the before and after values are greater than five (5) percent, FCPUD shall be contacted, and a course of action determined.

It is expected that the MANUFACTURER shall determine the cause and correct any problems that result in deviations in no-load losses and excitation current that are greater than five (5) percent.

FCPUD reserves the right to reject the transformer if satisfactory explanations or corrections are not made.

No-load and load losses shall not exceed ANSI C57.12.00 Section 9.3 maximum allowable tolerance as follows:

The no-load losses of a transformer shall not exceed the specified no-load losses by more than 10%, and the total losses of a transformer shall not exceed the specified total losses by more than 6%.

It is expected that the MANUFACTURER shall determine the cause and correct any problems that result in deviations.

FCPUD reserves the right to reject the transformer if satisfactory explanations or corrections are not made.

A transformer which, after factory testing, has actual losses exceeding the guaranteed losses, as stated in the seller's PROPOSAL, shall have its selling price reduced.

The amount of reduction will be calculated by determining the actual losses, in kW, above and beyond the proposed guaranteed kW losses, multiplied by the evaluated cost per kW.

Measured loss values shall be combined when assessing loss penalties.

Increasing the contract price for tested losses that are less than the guaranteed losses will not be permitted.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** the percentage maximum total measurement error for the no-load loss measurement and the load loss measurement systems.

The errors must contain all components of the error including probable calibration errors and other uncertainties in the measurement system.

PROVIDED IN PROPOSAL certified data for the loss measurement errors. The data shall be traceable to the United States National Institute of Standards and Technology or other equivalent standardization organization.

Equivalency will be determined by FCPUD using supporting documentation provided by the MANUFACTURER as part of the PROPOSAL.

A system check to ensure that all errors have been properly applied may be required.

Failure to submit a loss measurement system error or the submission of an error that is obviously erroneous will result in the rejection of the proposal.

The maximum loss measurement error that is acceptable is three (3) percent as per ANSI/IEEE and NIST Technical Note 1204.

Loss measurement errors greater than three (3) percent will result in the rejection of the proposal.

Short Circuit Requirements

The transformer shall be capable of withstanding the mechanical and thermal stresses produced by external short circuits under the conditions specified in ANSI/IEEE except allowances for system impedance are not allowed.

The available short circuit currents shall be calculated based on infinite bus source feeding the transformer.

The source voltage shall be as specified in the Data Form as a percent of the tap/winding rating.

System or auxiliary impedances shall not be permitted in the calculation of the short circuit forces.

The MANUFACTURER shall investigate the different fault conditions (three-phase fault, single line-to-ground fault, line-to-line ground fault, etc.) for the various combinations of tap positions and design for the highest stress conditions.

The MANUFACTURER shall investigate faults on all terminals including high voltage, low voltage, and tertiary or third winding.

The calculations of the short circuit stresses shall consider an offset between winding electrical centers of at least 0.5% of the winding electrical height not to exceed 10 millimeters.

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 exceed 35% of the 0.2% yield strength for non-bonded magnet wire.

If axial cooling ducts are wound within the radial build of the winding, the stress analysis of radial stress in the winding shall be performed with each segment of the winding independently on each side of the axial duct.

If a layer winding is used, allowed with two layer regulating voltage winding, each layer is to be analyzed independently.

Tensile stresses in all windings shall be limited to 80% of the 0.2% yield stress of the conductor material.

Leads in the superstructure of the active part shall be adequately supported to withstand the forces generated during short circuit events.

Leads may not be fastened to the superstructure with fabric tie material or polymeric cable ties.

Leads are to be fastened with pressboard clamps, or FCPUD approved alternative.

Core and coils shall be sized, braced, and designed to withstand full short circuit forces according to the latest IEEE test damage criteria.

The MANUFACTURER is expected to have adequate model and full-size transformer test data on which to base the acceptance criteria for stresses.

The MANUFACTURER shall provide FCPUD a copy of all criteria and calculations used to calculate the fault stresses.

FCPUD prefers that this information be provided in an electronic format that standard programs can read.

Audible Sound Level

The average sound level shall not exceed the levels specified in the Data Form as measured by the procedures outlined in ANSI/IEEE,

The sound level guarantee and the sound level test shall be associated with the maximum sound level tap positions.

The sound level guarantee and sound level test shall be at 105% overexcitation.

If specified in the Data Form, the sound level guarantee shall include both the no-load and load sound contributions.

PROVIDE IN PROPOSAL the maximum sound level at the base rating and maximum ratings.

If overload is specified in the Data Form, the sound level during the overload condition may be higher than the maximum sound level specified in the Data Form if approved by FCPUD at the time of the order (Purchase Order).

PROVIDE IN PROPOSAL the maximum sound level during the specified overload.

Terminals and connectors must be designed and constructed to minimize corona.

Sound level reduction shall not utilize external sound dampening parameters such sound reduction panels installed on the tank walls.

The measured average sound level in decibels at the base and maximum ratings shall be indicated on the nameplate.

Liquid Level

The main compartment shall be designed so that a low-level liquid alarm will not be activated and no energized part shall be exposed when the ambient temperature reaches the minimum operating temperature specified in the Data Form with no load connected to the transformer.

Liquid level at the ambient minimum cold start temperature specified in the Data Form with the core and coils at the temperature indicated in the Data Form shall be such that the transformer can be energized with no energized parts exposed, no alarm, or other problems that would arise due to low liquid level.

The main compartment shall be of sufficient capacity to allow a top oil temperature of 120 Degrees C or the maximum defined overload, whichever is the worst condition, without causing an oil level alarm or expelling oil.

Seismic Requirements

The MANUFACTURER shall determine, subject to FCPUD's approval, the seismic classification factors S_s , S_1 , Site Class, and Importance Factor.

The transformer shall perform its specified functions during and after the seismic event.

The transformer shall be capable of withstanding seismic loading per ASCE 7-16 as outlined in IEEE 693 using the seismic classification factors S_s , S_1 , Site Class, and Importance Factor as determined in the previous paragraph.

The transformer shall perform its specified functions during and after the seismic event.

The transformer shall be qualified for the Seismic Qualification Performance level of the Substation's site, as defined in IEEE 693.

The transformer shall be designed to meet all governing codes, provisions for loads, material specifications, durability, and performance levels.

If required in the Data Form the MANUFACTURER shall submit calculation report, signed and sealed by a licensed Professional Engineer licensed in the state specified in the Data Form, which includes:

Confirmation of the seismic analysis qualification of the transformer as defined in IEEE 693.

Verifying that the transformer meets the code requirements for the location where it will be installed.

The Report shall be provided in an electronic format using Adobe Acrobat PDF file format(s) that is bookmarked for each major section and then sent to FCPUD.

The PDF report file must be copy enabled, printable, and comment enabled.

Each hard copy version of the instruction manual shall include this report as well.

If required in the Data Form the MANUFACTURER shall furnish an anchorage system that meets the requirements of IEEE 693 and the following requirements:

If the Data Form requires a welded system.

The system shall include field-weldable plates, and all hardware necessary for its installation.

The transformer shall be designed to be field welded to embedded plates or beams.

The MANUFACTURER shall indicate, on the outline drawing, locations, size, and length of field welds, and if applicable, locations where welding is not allowed and verified and approved by the Engineer of Record as specified in the anchoring drawing submittal.

If the Data Form requires a bolted system.

The system shall include anchor bolts, removable bolt-on plates, and all hardware necessary for its installation.

The bolt-on plates will aid in locating and positioning of anchor bolts in the field.

Anchor design shall be as per ASCE 7 and all anchor bolt locations, class and grade, and maximum reactions shall be shown on the anchoring system drawing and verified and approved by the Engineer of Record as specified in the anchoring drawing submittal.

A foundation anchoring system drawing shall be included with the approval and record drawing submittals.

Wind and Ice Loading

The transformer shall be able to withstand the wind and ice loading as specified in the Data Form without loss of function.

Per ASCE 7 and other applicable standards.

ACCESSORIES AND ADDITIONAL REQUIREMENTS

Tank and Fittings

Tank shall conform to the requirements of ANSI C57.12.10.

The tank and LTC (if provided) covers and tank external features shall be designed to prevent water collection.

Bracing on the outside of the main tank cover and LTC cover will not be allowed.

The top of the main tank and LTC (if provided) shall be provided with a skid resistant coating.

This shall also include the arrester brackets and any additional surfaces that could be used for stepping or standing.

All manholes and handholes shall have raised flanges with a minimum height to provide 3/4 inch of clear space between bottom of flange and tank with the following additional requirements:

Manhole covers, access plates, etc. shall be circular and a minimum of twenty-four (24) inches inside diameter. Handholes shall be a minimum of nine (9) inches inside diameter.

All manhole and handhole covers shall be the same outer diameter as the covers.

All manhole and handhole covers shall be connected to the tank by a flange welded to the tank having slots wide enough to accommodate bolts with nuts.

Threaded studs (Nelson studs) welded to the tank or turret are not acceptable.

Manholes and handholes, except handholes for the DETC contacts (if required), shall be located such that they are accessible without removal of any other equipment.

The handholes for the DETC contacts cannot be behind the main control cabinet or LTC motor cabinet but can be behind the radiators.

For transformers with a maximum rating through 50 MVA provide a minimum of two (2) manholes with bolted covers in the transformer cover.

For transformers with a maximum rating greater than 50 MVA provide a minimum of two (2) high side manholes and two (2) low side manholes with bolted covers in the transformer cover.

The manholes shall be strategically located to allow access to the lower ends of each bushing, to upper portions of coils, and to permit replacement of current transformers and other auxiliaries without removing the tank cover and/or crawling completely inside the tank.

In locations where access cannot be obtained through the manholes on the tank cover without entering the tank to connect bushings, inspect or replace tap changer contacts (see special requirements for DETC), or perform other emergency repairs; the MANUFACTURER shall provide additional handholes or manholes so tank entry is not necessary to perform maintenance or repairs.

For bushings rated above 230kV, to meet the above requirement one additional handhole per bushing, shall be located on the vertical tank wall for access to the bottom end of these bushings.

To access these handholes, manholes, or covers, removal of radiators, accessories, or other parts shall not be required.

If a DETC and/or Winding Switches are provided the following additional provisions shall be provided:

A handhole shall be provided by the DETC and/or Winding Switch mechanism where the operating rod(s) connect to the operating handle.

Gasketed flanged welded access hand holes shall be provided for access to the DETC and/or Winding Switch contacts if not accessible from the manholes without entering the tank.

These welded plates shall be on a flanged frame and gasketed.
Method shall be approved by FCPUD.

If the DETC and/or Winding Switch current rating is equal to or greater than 150% of the current going through the DETC at the maximum nameplate rating, the DETC has silver plated contacts, and the DETC is maintenance free the access hand holes for the DETC contacts are not required.

If a preventative autotransformer is provided, provide a minimum of one (1) manhole, with bolted cover, located in the vertical tank wall adjacent to the preventive autotransformer so that access to the preventive autotransformer is provided.

If required in the Data Form, one (1) additional "rescue" manhole with bolted cover shall be provided near the base of the transformer located in such a position that rescue personnel could remove a disabled person through this manhole.

Rescue manhole shall be positioned so that the bottom of the manhole is 17 inches above the base of the transformer.

There shall be no bracing or obstructions in the way of the manhole or within 14" of the bottom of the tank for the length and/or width of the entire tank to allow for rescue personnel to remove an incapacitated person from the transformer.

Each horizontal manhole cover shall be constructed with a minimum of two (2) flush-mounted handles to reduce tripping hazards when working on the transformer cover.

Vertical manhole covers shall be constructed with two (2) handles but do not require flush mounting.

Each manhole shall be provided with an alignment mark or index to identify the correct orientation of the cover on the manhole and to simplify its re-installation after removal.

Provide a warning sign adjacent to each opening that can be used for personnel entrance that confined space entry procedures are to be followed before entering.

The tank shall be designed to allow access to the bushing draw leads and bottom connections from inside the tank and to provide enough room above the core and coils to maneuver around.

All gasketed openings shall be designed with means provided for controlled compression of the gasket, utilizing metal-to-metal stops, and gaskets of oil resistant material.

All gasketed joints on top of the transformer or on horizontal surfaces shall utilize flanges, which are raised at least 3/4 inch above the mounting surface.

All gasket materials shall be of the highest quality and specifically chosen for the application considering transport shock and vibration, temperature ranges in storage and in operation, sealed fluids, leakage rates, and ease of repair.

This will be a design review topic.

All gaskets shall be in recessed, machined grooves.

All gasket surfaces shall be made up by flanges.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** a copy of their flange and gasket practices and procedures.

The transformer tank, LTC compartments, LTC conductor pass-through boards, expansion tank, and radiators shall be capable of withstanding full vacuum.

The tank shall be designed so that all current transformers can be removed easily, without removing the main transformer tank cover.

The tank and accessories (subject to tank pressures) shall be designed for 125% of the maximum operating pressure with a 10-psi minimum.

Provide flanges for all bolted-on accessory equipment such as radiators, monitors, gauges, cabinets as noted in these specifications.

All external fasteners such as the bolts for bushing flanges, radiators, brackets, arresters, etc. shall be SAE standard and be made of austenitic stainless steel, 18-8 or better grade or FCPUD approved equivalent.

The nuts shall be silicon bronze or FCPUD approved equivalent.

All other external fasteners shall be metallic or FCPUD approved equivalent.

All external hardware, including bolts, flanges, terminal blocks, wire terminals, and potential interface points, shall be ANSI standard sizes; IEC or metric-sized hardware is not acceptable.

Access to all external nuts and bolts shall not be restricted and shall be positioned such that they can be installed or removed without removing any other item.

Tank shall be welded steel plate construction.

All seams shall be welded inside and outside of the joint.

Welded seams shall be smooth and free from pits, cures, and slag. Tanks shall be oil tight and gas tight with all fittings in place.

Welders are to be certified by AWS D1.1.

Continuous welds shall be used at all seams of transformer tank, stiffener welds, bracket welds, and other equipment welded to the transformer tank.

Non-continuous and tack welding are not acceptable.

Tank shall be designed so that welds will not be located within 6 inches of the corners.

Tanks with corner "T" welds, welded inside and out, with gussets will be considered if the MANUFACTURER demonstrates that the strength is equal to or exceeds a tank with rounded corners with welds no closer than 6 inches to the corners.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** an exception to the 6 inch requirement and submit the demonstration of equivalent strength as part of the proposal.

Equipment that penetrates the tank shall be welded inside and outside of the tank walls.

All mounting bases shall be welded on the inside of the tank as well as on the outside to prevent creation of a hiding location for foreign debris.

Tank shall be reinforced with fully enclosed sidewall braces, with all seams and joints continuously welded on flat surfaces.

Only stainless steel studs shall be used on the tank and studs shall be completely welded around to prevent creation of a hiding location for foreign debris.

Unless specified otherwise, all covers shall be welded in place.

Structural welding shall conform to the requirements of AWS D1.1 or an equivalent welding standard.

The minimum preheat requirements of AWS D1.1 shall be followed and documented in the general welding procedures. Shop welding processes shall also be followed to keep shrinkage and residual stresses to a minimum.

The transformer shall be equipped with lifting lugs, jack bosses, pulling eyes, and skids.

The jacking/lifting lugs shall be suitable for use with 17 inch high jacks and located not less than 18 inches above the base.

Lifting eyes shall be provided on all covers as well as on the tank, core and coil assembly, and conservator (when supplied) and be capable of lifting the tank cover, core and coil assembly, conservator (when supplied), and the complete transformer.

Lifting eyes and jack bosses shall be located on all four corners on the transformer.

Jacking lugs and transformer lifting eyes shall be capable of supporting the total insulated fluid filled assembled weight of the transformer.

Jacking locations shall be located on the foundation plan.

Pulling eyes shall be provided for the attachment of a pulling rig. This allows for movement of the transformer along the direction of either centerline.

Jacking lugs and lifting eyes shall be provided with identifying tags.

Transformer tanks shall be designed with sufficient bracing and strength to permit vacuum filling with insulating liquid.

The tank, including the cover and base, shall be designed such that after installation there will be no permanent deformation caused by shipping or handling.

The tank, base, radiators, attached compartments, and covers shall be constructed of steel and designed to have sufficient strength to withstand filling with oil at full vacuum, stresses produced by the required combination of loads, transportation, and installation stresses, without damage or significant distortion to any part.

The MANUFACTURER shall provide two (2) 2" flanged globe valves at the bottom of the transformer.

These valves shall provide for drainage of oil to within one-half (1/2) inch of the tank bottom.

If internal siphon is used to drain oil lower, this must be identified on the outline drawings as this would affect potential use of the valve for future monitoring.

These valves shall be located on opposite sides of the transformer.

The valves shall have 2" NPT outlet, fitted with a threaded pipe plug.

If specified In the Data Form, the globe valves shall have a built-in 1/4 inch sampling device, which shall be located in the side of the valve between the main valve seat and the pipe plug.

This sampling device shall have a 5/16 inch - 32 male threads and be equipped with a cap.

The cap shall be tethered to the valve body with a metallic chain.

If no sample port is specified in the Data Form, then a valve with a plugged sample port will not be accepted.

The MANUFACTURER shall provide one (1) 2" flanged globe valve on the side of the transformer suitable for return of filtered oil or use with a DGA on-line monitor.

The valve shall be located near the top of the tank per the IEEE standards.

The valve shall be located below the liquid level with the transformer being at the ambient minimum operating temperature specified in the Data Form with the transformer de-energized.

The valve shall have 2" NPT outlet, fitted with a threaded pipe plug.

The sample port shall not be provided.

A valve with a plugged sample port will not be accepted.

If required in the Data Form, the MANUFACTURER shall provide two (2) additional 1" flanged gate valves on the side of the transformer for use with a DGA monitor.

These valves shall be separated by at least 4 feet.

The valves shall have 1" NPT outlet, fitted with a threaded pipe plug.

One valve shall be located on the side of the transformer near the top of the tank in the same segment as the filtered oil valve noted above.

The valve shall be located below the liquid level with the transformer being at the ambient minimum operating temperature specified in the Data Form with the transformer de-energized.

One valve shall be located on the side of the transformer near the bottom of the tank near the winding and 1-2 feet above base in the same segment as the filtered oil valve noted above.

The MANUFACTURER shall provide 2" NPT filling nipple(s) with cap on the top cover.

The NPT filling nipple(s) shall be located in such a position and have appropriate deflector(s) or removable spray device(s) to allow hot oil to splash over the entire core during the vacuum filling process.

If required in the Data Form a gate valve with NPT plug shall be installed on the filling nipple(s).

If required in the Data Form a 90 degree fitting shall be provided so the filling port is horizontal to the tank cover for ease of access and connection.

For transformers with a maximum rating of 200 MVA or larger two filling ports with deflectors or spray devices shall be provided.

The filling port(s) shall be located as far away as possible from the vacuum port, which will be one of the pressure relief device flanges or a separate vacuum port if provided.

A stainless steel nameplate as specified in the nameplates section shall be installed next to the filling port(s) indicating this is the filling port.

The MANUFACTURER shall provide one (1) 2" NPT vacuum nipple with cap in the corner of the top cover.

A stainless steel nameplate as specified in the nameplates section shall be installed next to this plug indicating this is the vacuum port.

If specified in the Data Form, the MANUFACTURER shall provide one (1) 3" gate valve on top of the transformer for the vacuum port.

This valve shall have a 90 degree elbow so that it is horizontal and located so that it can be easily accessible, in a location where it will not be a tripping hazard, and used for the vacuum hose connection during the transformer filling process.

The valve shall have 3" NPT with a threaded pipe plug on the open end and a threaded connection on the other end.

A stainless steel nameplate as specified in the nameplates section shall be installed next to this valve indicating this is the vacuum port.

Valve material

If required in the Data Form all valves described in this section must not be made of material that has a low melting point such as brass or bronze.

The valve shall be carbon steel or another high temperature material to prevent melting of a valve under fire conditions.

Plugs shall be made of a similar high temperature material and have a different composition from the valve to minimize galling.

Selection shall be subject to FCPUD Approval.

If a high melting point material is **not** required in the Data Form all valves described in this section shall be brass or bronze.

There are to be no obstructions within 24" of any valve vicinity.

All valves located within eight feet of ground level shall be equipped with provisions for padlocking.

The interior of the transformer shall be white in color per the Paint Requirements Section of this specification.

The centers of gravity for both operating and shipping states shall be indicated on both Segment 3 and Segment 4. In addition, low side-wall index marks within twelve (12) inches of the base shall be provided on all 4 sides for the completed center of gravity to simplify alignment on the pad.

Base shall be designed for installation on piers, grade beams, or on a rectangular pad. A detailed drawing shall be provided to indicate requirements for structural loading of transformer to foundation.

The transformer base shall have edges suitable for welding and constructed from heavy steel plate with beveled edges suitable for rolling or skidding in any direction.

The base shall have additional means to prevent corrosion such as a mastic coating, coal tar epoxy, or neoprene cover over the bottom of the baseplate designed such that ventilation is provided between the concrete supporting slab and the bottom of the transformer.

Dry thermowells shall be located such that they are always at least 1 inch below the oil level at the minimum ambient temperature specified in the Data Form.

The thermowell shall be one piece and be a Qualitrol, Texas Thermowell, or equal approved by FCPUD that can be used with the ETM and/or temperature gauges provided.

Appropriate adapters shall be provided for the probe.

Two piece thermowells will not be accepted.

Thermowells shall be as specified per ANSI/IEEE C57.12.00 as shown in Figure 4 of ANSI/IEEE C57.12.00.

All electrical clearances from live parts to ground (base of transformer) shall meet the requirements of the NESC.

The serial number of the transformer shall be permanently stenciled or formed by welding near the grounding pads at two locations on diagonally opposite corners.

Core And Coils - General

The core shall be a core form three-legged design.

The transformer main core and coils, including regulating windings, shall be constructed to Class II power transformer standards including round core/circular coil design and construction using all copper conductors.

High voltage and low voltage windings for the main core/coil assembly shall be either circular disk or helical type coil construction.

Layer/barrel windings are not acceptable.

Layer windings may only be used for regulating voltage windings.

The materials and methods of construction used shall be such that the core structure will be strong, rigid, and durable and will have permanently low losses.

Segregated windings are not acceptable; that is a dedicated winding with different wire sizes or stranding types, spliced within the length of the winding.

All preventative auto and series transformers shall be circular core and coil design and either circular disk or helical type coil construction using all copper conductors.

The complete core and coil shall be readily removable from the tank for repairs.

A means shall be provided for properly handling the core assembly when it is removed from the tank.

Any internal blocking or bracing, which is to be removed from the transformer at its destination, is not allowed.

All support blocking in the active parts shall be tight in compression.

The transient voltage analysis of the transformer shall be performed with an analytical tool that includes both the capacitive and inductive circuit elements.

All insulating materials and structures shall be protected from contamination and effect of humidity after receipt, during and after fabrication by storing in separate climate-controlled area.

Internal surge arresters, varistors, or non-linear resistors shall not be included as part of the internal insulation system unless written authorization is first obtained from FCPUD.

These surge arresters will only be considered a "last resort" and will only be considered by FCPUD if MANUFACTURER can demonstrate that the transformer cannot be designed without them or, if they are not used, that the cost increase is excessive.

This demonstration shall consist of a detailed description of why the design cannot be done without their use and the estimated cost increase if they are not used.

If they are used, they shall be located near the top of the transformer where they are easily accessible through a manhole or appropriate hand hole.

FCPUD shall approve the location of the arresters and the specific arrester blocks used.

The MANUFACTURER shall use a vapor phase drying system.

Final pressing of the coils shall be performed after the active part has been dried.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** the method of drying the coils.

Preferred method is to monitor insulation power factor during the core/coil assembly drying process to ensure that the insulation is dried adequately.

The transformer insulation shall be designed to accommodate usual deterioration experienced during the life of the transformer with loading practices based on nameplate loading and any special loading conditions included in this specification.

FCPUD reserves the right to inspect the completed core and coil assembly prior to tanking.

Core And Core Frame

The electrical steel for the core shall be high-grade "non-aging" cold-rolled, grain-oriented, stress free, thin, highly permeable silicon alloy of low-hysteresis loss, electrical steel that also meets the minimum requirements specified in the Data Form.

MANUFACTURER shall **PROVIDE IN PROPOSAL** the type of steel used for the main core and the series and preventative auto cores as applicable.

All core steel intended for an individual core shall be the same core steel type, from the same manufacturer; steel from multiple manufacturing sources shall not be mixed.

Cores shall be constructed using stepped circular cross-sections with fully mitered step lap joints with a minimum of 5 steps for all cores except the booster if used.

The core is to be stacked at the assembly facility and shall be stacked in such a manner as to ensure that the core is "square".

The mechanical structure of the core and coil assembly shall be designed for the maximum transportation accelerations that will be encountered.

Temporary internal bracing for transportation is not permitted.

Laminations:

Each lamination or sheet of core steel shall be free from burrs, sharp projections, rust, scales, or other conditions that may impair the operation or life of the core.

Steel is to be slit to width, properly annealed, and coated with an inorganic insulating material.

Lamination shall employ a surface insulation and other appropriate design techniques to limit interlaminar power losses.

Each sheet shall have an insulated surface which is impervious to hot transformer oil.

The steel shall have smooth surfaces at the edges.

The MANUFACTURER shall employ a periodic burr detection and mitigation such that the maximum burr height resulting from slitting and shearing does not exceed 20 microns.

Excessive edge or surface damage during manufacture may be the basis for the rejection of the core.

The core gaps shall not be greater than 1/8".

Gaps greater than 1/8" must be justified to FCPUD and MANUFACTURER shall **PROVIDE IN PROPOSAL** this justification.

All the exposed edges of the laminations on the core legs shall be protected against rust with a permanent, rust-inhibiting coating. The coating shall be a material such as epoxy or varnish rated for a minimum of 150 Degrees C.

Epoxy or other bonding coatings shall not be applied to the top yoke.

All the exposed edges of the top yoke shall be protected. The coating shall be permanent and be a material such as epoxy or varnish rated for a minimum of 150 Degrees C to protect against rust.

Each core leg shall be leveled, adequately secured, and properly supported to prevent the laminations from slumping during the core upending and coil installation process.

The core shall be properly braced and supported to prevent displacement and deformation during the whole life of the transformer.

Bolts through the core are unacceptable except for preventative autotransformers.

The entire core must be rust free to ensure its maximum life-cycle performance.

Bent core lamination edges on the stacked core are undesirable.

No more than 5% of the stacked core laminations shall be bent at each end at the miter joint.

The axial mechanical support structure for the core and coils shall not be stressed more 65% of the elastic limit of the material during the worst-case conditions of lifting or a short-circuit.

The core-clamping structure shall rigidly hold the core in place to form a sturdy unit structure, which shall protect the core and the coils from mechanical damage due to shipping accelerations or repeated short-circuits. The core-clamping structure shall be electrically and magnetically insulated from the core.

All steel components of the core-clamping structure shall be shot-blasted prior to construction to remove all rust and mill scale.

The dielectric design of the active part and the internal elements of the tank are to control electrical stresses. This involves the electrical stresses within the winding and insulation structure, the electrical stresses for leads and cables, the electrical stresses on ground electrodes, or the stresses developed between any dielectric electrodes.

The core shall be rigidly clamped and blocked to prevent deteriorating vibrations, interference with oil circulation, deformation due to short circuits, objectionable noise levels, and shipment distortions.

Every core step shall be supported in all three axis by step-blocks of high-density insulation to support the core laminations and distribute the top and bottom frame pressure.

The top and bottom yokes and legs shall be of single sheets of steel that run the full length of the leg or yoke to minimize the number of joints in the core and to reduce core loosening over the lifetime of the transformer.

Scrap-less, mitered cores shall not be allowed.

Tie plates or tie rods in the core structure shall be designed to limit the mechanical stresses during lifting of the active part or short circuit events to no more than 65% of the elastic limit of the tie plate or tie rod material.

Internal frames and bracing

The core and coil assembly shall be constrained at the bottom of the tank during the tanking process.

The top of the core and coil assembly (frame) shall be fastened to the tank in at least four locations to prevent movement in all three directions.

The bracing scheme shall not employ welding inside the tank once the core and coils are placed inside the tank.

Metal-to-metal frictional bracing will not be allowed.

Slotted bolt holes shall not be employed.

The core induction shall not exceed 1.72 Tesla in the nominal tap positions and 1.93 Tesla in all tap positions at the maximum excitation condition for the greatest of the following conditions:

110% voltage at no-load on the output terminals.

105% voltage at full load on the output terminals.

The load power factor shall be 80% lagging, but the input voltage can be limited to 110%.

If both step-up and step-down operation is specified in Data Form these requirements shall be in both step-up and step-down operation per the requirements in the Data Form.

The temperature rises within the core are to be calculated. The maximum core hot spot temperature shall not exceed 130 Degrees C and the core outer surface temperature shall not exceed 125 Degrees C with the average ambient temperature specified in the Data Form under the most extreme of the following conditions:

Furthermore, if the maximum ambient temperature specified in the Data Form exceeds the average ambient temperature specified in the Data Form by more than 10 Degrees C the maximum core hot spot temperature shall not exceed 140 Degrees C and the core outer surface temperature shall not exceed 135 Degrees C with the average using the **maximum** ambient temperature specified in the Data Form.

110% voltage at no-load on the output terminals.

105% voltage at full load on the output terminals.

The load power factor shall be 80% lagging, but the input voltage can be limited to 110%.

If both step-up and step-down operation is specified in Data Form these requirements shall be in both step-up and step-down operation per the requirements in the Data Form.

Both the flux density in the core, and the heating effects of magnetic field leakage is a consideration of the surface temperature.

The insulation material between tie bars and the core, and the core frames and core, shall be a high-temperature material (tolerant of 150 Degrees 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.

Material used to form cooling ducts in/next to the core shall not be cellulose but shall have a temperature rating of at least 150 Degrees C.

Windings

MANUFACTURER shall **PROVIDE IN PROPOSAL** the types of windings that will be used and the manufacturer of the paper insulation.

Winding assemblies shall be held in position about the core leg by means of radial spacers, top and bottom end rings, and a clamping system.

Winding bracing shall employ an array of radial spacers, equally spaced and aligned from innermost to outermost windings.

The epoxy used for CTC shall be B stage epoxy unless the 2 second maximum fault current conductor temperature is 135 Degrees C or higher with the transformer loaded at its maximum nameplate rating using the maximum ambient temperature specified in the Data Form, then high temperature epoxy shall be used.

The bonding must not soften during any type of fault based on the short-circuit temperature rise calculations as per IEEE Std. C57.12.00.

CTC with B stage epoxy can be supplied by Sam Dong, REA, Asta, Essex, or FCPUD approved equivalent.

CTC with high temperature epoxy can be supplied by Sam Dong, Asta, or FCPUD approved equivalent.

The conductor for all current carrying parts, including windings and leads, shall be copper or silver bearing copper.

All windings shall be made of rectangular copper magnet wire with thermally upgraded paper used for turn to turn insulation.

Continuously transposed conductor can be used where appropriate.

The conductor is to be tested prior to insulation wrapping through the use of burr detectors to assure conductor/insulation integrity.

The insulating paper shall be applied in either single or multiple strands in such a manner that there is a 30-percent overlapping of the paper surfaces.

Tension shall be maintained during the insulation application to prevent loose wraps.

The paper insulation for winding conductors shall be high density, thermally upgraded, and shall be Dennison (Weidmann) 22HCC, Munksjo or FCPUD approved equivalent.

Paper taped conductor shall be supplied by Sam Dong, REA, Asta, Essex, or FCPUD approved equivalent.

Netted Continuously Transposed Conductor (CTC) shall not be used on windings rated higher than 350kV BIL unless approved by FCPUD.

For FCPUD to consider use above 350kV BIL MANUFACTURER shall demonstrate use with type testing documentation and examples of use at desired BIL level.

The winding conductor insulation shall be thermally stabilized. The performance of the paper shall meet the following criteria:

The paper shall retain at least 50% of its original tensile strength after being exposed to 110 Degrees C for 65,000 hours.

The paper shall have a degree of polymerization of at least 200 after 150,000 hours at 110 Degrees C.

The oil gap stress shall have 20% margin to the degassed oil curve as published by Weidmann for oil gap partial discharge inception.

The insulation design of the leads, cables, switches, etc. to ground is of major interest.

The MANUFACTURER is to confirm a minimum of 20% margin for the electrical strength of the insulation of these accessory components to ground.

The current density of any copper conductor shall not exceed 4.0 amps/mm² at the maximum rating except as noted below:

The copper conductor current density for a buried tertiary (a corner brought out and grounded is still considered buried) shall not exceed 4.5 amps/mm².

The current density of the preventative autotransformer copper conductor shall not exceed 5.0 amps/mm² with the LTC in the stalled position, i.e. when maximum nameplate current is flowing through one leg of the preventative autotransformer.

All joints shall be welded or brazed, except compression type which may be used for terminal connections or attaching leads to winding conductors.

Compression connections shall a full-circumference crimp connection for a tight bond with the conductor.

All welding and brazing shall be accomplished in accordance with American Welding Society standards to eliminate the possibility of hydrogen embrittlement.

Welders are to be certified by AWS D1.1.

Bolted connections may be used at bushings and terminal boards provided suitable locking device is used.

All connections shall be smooth and not contain sharp edges.

Connections shall be wrapped in such a way as to create a smooth electrode.

The winding cylinders shall be made from a single piece of high-density material (1.15 – 1.25 g/cc).

Scarfed and glued joints shall be of sufficient thickness of the material joined to ensure adequate mechanical strength.

The thickness of the cylinder in the scarf joint shall be controlled to within plus/minus 10 percent of the thickness of the cylinder material.

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.

The key spacers shall be aligned vertically to within 1/8 inch when checked from top to bottom of the winding.

No additional taping of the conductors is allowed within 1/8 inch of the key spacer area.

No transpositions or crossovers are allowed within 1/2 inch of the key spacers.

For continuous disc windings, the crossovers shall be located midway between the key spacers.

The end plate blocks shall be a minimum of 1/2 inch wider than the key spacers and shall be exactly positioned such that they are centered over the columns of spacers.

The winding radial build shall be a minimum of 7 mm.

The radial build of each winding shall have a consistent radial dimension.

There shall not be bulging or loose conductors.

There shall not be any gaps between the conductors due to looseness.

The consistency of the radial build has to meet the MANUFACTURER’s requirements and industry best practices.

The consistency of the radial build has to be acceptable to FCPUD even if it meets the MANUFACTURER’s requirements.

The maximum axial key spacer height shall not be more than 50 mm for all windings with a radial build of 50 mm or greater.

If the winding radial build is less than 50 mm, the axial spacer/block height shall be no more than the radial build dimension.

Blocks are preferred over a column of key spacers.

When multiple blocks are used, the blocks shall be separated with glued washers.

If the axial key spacer height space is more than 50 mm, it shall be separated by full circumference washers to maintain the mechanical stability of the winding.

All blocks shall be installed such that the grain is oriented in the horizontal direction, perpendicular to the winding compressive forces.

Weidmann Klackband or FCPUD approved equivalent (with paper on both sides of the blocks) shall be used for cooling ducts in a winding, where applicable.

Coils shall have their full circumference supported by the frame assembly.

Coil supports and full circumference clamping rings are to be fabricated using high-density materials (1.15 – 1.25g/cc).

Metallic coil supports or metallic top/bottom end blocks are not allowed; however, if the MANUFACTURER's design requires metal end blocks, then MANUFACTURER shall review the design with FCPUD and get written approval for its use before proceeding.

The coils of each phase shall be clamped at the top by one-piece coil clamping rings of rigid high strength high density insulating material and provide clamping to 100% of the winding circumference.

The bottom ring may be a segmented ring.

The bottom clamping ring shall be fully supported from below to handle the weight of the windings and the clamping force.

The bottom ring 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 support from the top clamping ring to the top yoke.

The assembly shall be uniformly compressed at pressure greater than the maximum calculated short circuit forces with the safety margins as applicable in these specifications.

The minimum final pressure on the windings just prior to placement in the tank is to be 6 N/mm².

Upon placement of the coils on the core, the method of final sizing of the coils shall be by hydraulic press only and shall not utilize the method of retaining the coil preload stress as the means for sizing.

Utilizing a method of sizing other than by hydraulic press shall only be allowed if the MANUFACTURER can demonstrate that shavings are not generated and that the final preload stress can be determined.

For continuous disc windings, the taps shall be located outside of the disc.

All taps shall be brought out, without any joints or brazing.

All coils shall be protected from contamination and constructed in a separate climate-controlled room to ensure uniform conditions during winding.

All completed coils shall be stored in a separate climate-controlled area.

The cellulose insulation barriers and spacers shall be high-density material (1.15 – 1.25 g/cc).

Insulation barriers between phases can be medium-density.

Low-density pressboard is acceptable for formed insulation parts.

The coils shall be insulated from the core and each other with sufficient insulation to withstand full wave impulse, chopped wave impulse, switching surge, one-hour induced test, enhanced voltage during the induced test, and the one-minute power frequency test for transformers of the specified voltage class.

Based upon the dielectric test values prescribed by IEEE/ANSI C57.12.00, C57.12.10, and C57.12.90, MANUFACTURER shall design for dielectric stress margins of at least 20% in insulation structures between windings, at the winding ends, and at lead exists based on the Weidmann withstand curves.

The uninsulated electrode curve shall be used when the gap is adjacent to any coil, independent of the thickness of the cover over the coil.

The insulation system is to 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).

The regulating winding for the load tap changer shall be fully distributed and be electrically independent from or placed on a separate winding tube from the high and low voltage windings.

Cables, Leads, And Connections

Insulation for winding-to-bushing conductors and leads to the DETC, LTC, and winding to winding shall be thermally upgraded material.

The paper insulation for leads shall be high density, thermally upgraded, and shall be Dennison (Weidmann) 22HCC, Munksjo or FCPUD approved equivalent.

Paper taped conductor shall be supplied by Sam Dong, REA, Asta, Essex, or FCPUD approved equivalent.

All bolted electrical connections in the transformer, except at the LTC terminal board, are to be made with a minimum of two bolts.

The bolt pattern shall be a NEMA 2-hole pattern.

The internal lead routing for the active part shall be neat and orderly. The leads shall be clamped in place to prevent movement during transportation and operation.

The leads shall be supported from the active part support structure with pressboard clamps; i.e. plastic lead ties, string ties or fabric tape ties are not acceptable.

The leads shall be secured in a manner that fully supports the weight of the leads and the forces exerted on them during a short-circuit condition.

Bundles of leads shall be configured to allow free oil flow on lead surfaces.

Leads shall not be attached to the inter-phase barriers.

The routing of leads shall consider the effects of electromagnetic forces between leads during short circuit events, especially with asymmetrical faults.

The dimensioning of lead clearances shall be selected for both dielectric and electromagnetic considerations.

LTC and DETC leads shall be permanently marked with the lead number that is identified on the transformer nameplate.

The marks shall be near the LTC, regulating winding, DETC, and DETC winding taps.

Leakage Flux

The leakage flux analysis shall include the heating effects in leads, cables, connectors, etc. in the cleats and leads structure.

If magnetic shields are provided, the flux density in any part of the shields shall be less than saturation for the material at rated load and at any stated load in excess of nameplate rating.

At rated nameplate loading, the temperature of internal metallic parts shall be limited to 130 Degrees C using the maximum ambient temperature specified in the Data Form.

Furthermore, if the maximum ambient temperature specified in the Data Form exceeds the average ambient temperature specified in the Data Form by more than 10 Degrees C the maximum the temperature of internal metallic parts shall be limited to 140 Degrees C using the **maximum** ambient temperature specified in the Data Form.

The temperature of tank walls and covers, bushing boxes, covers, turrets, and any external parts and accessories attached to the tank such as radiators and brackets shall be limited to the following temperature rises:

For items 8 feet or less above the base of the transformer the temperature rise shall be limited to a maximum of 60 Degrees C.

For items more than 8 feet above the base on the transformer the temperature rise shall be limited to a maximum of 80 Degrees C.

Internal Hardware

Internal bolted hardware shall be connected using locking hardware.

Split or star lock washers shall not be furnished as locking or clamping devices inside the tank.

Double nutting, threaded nylon, or other methods approved by FCPUD, shall be used for locking or clamping on the lead support framework to provide a corona free structure.

Connecting hardware shall be fitted with restraints to avoid loosening over the life of the transformer.

Lead support structures and insulation shall be connected by non-conducting fiber bolts.

Metallic hardware may be used for fastening the lead support structure to the upper and lower core frames.

Fiber bolts shall be epoxy-locked or use two nuts on each bolt to insure against loosening.

The fiber bolts shall not extend past the nut by more than 3/8".

All metallic and non-metallic bolted connections (internal and external) shall have a minimum of three (3) threads exposed past the nut.

All bolted connections shall be torqued to the proper/designed torque value.

Core And Series (Booster) Transformer Grounds

Cores shall be insulated from their support structure, grounded at only one point.

The core and clamping shall each be separately grounded to the transformer tank for electrostatic purposes.

A core that has separate sections as are formed with cooling ducts within the core stack is to be grounded by having a ground conductor inserted into each core section.

The individual ground conductors are to be connected to separate cables and the separate cables are to be routed to a single core ground bushing for external accessibility.

The core ground bushing shall be located within 12 inches of the edge to facilitate access.

This shall include the core for the main transformer windings, core for the preventative autotransformer, and core for the series transformer.

These bushings shall be capable of withstanding the voltage specified in the following table:

Transformer High Side Voltage Class	Bushing Minimum Voltage Rating
Through 138kV	1.5kV
138kV through 230kV	2.5kV

The core ground bushings shall be protected with a weatherproof enclosure.

If required in the Data Form, the enclosure shall be fabricated with 304L stainless steel or type 304 low carbon (0.05% max. carbon content) stainless steel.

The weatherproof enclosure shall have a weep hole on the downslope side of the enclosure that shall also be noted on the outline drawing.

A removable copper strap between the bushing terminal and a 2-hole ground pad welded to the tank shall be provided within the enclosure.

The core insulation to ground shall be capable of withstanding a test voltage indicated in the following table and any voltage that might be developed on the core as a result of transient voltages that are applied to any winding terminal.

Transformer High Side Voltage Class	Test Voltage
Through 138kV	1500V AC or DC
138kV through 230kV	2500V AC or DC

If the core frames are isolated from ground, then external core frame test points shall be installed with a similar method as described for the core ground.

The core frame bushing may be installed in the same enclosure as the core ground bushing.

Installing any other equipment or piping in this enclosure is not allowed.

A stainless steel nameplate shall be provided for each enclosure.

The location where the core ground strap enters the core shall be accessible and visible from the nearest manhole cover.

If a two winding (non-autotransformer) series (booster) transformer is used the winding ground shall be connected to the main tank just above the LTC through connection board. It shall be clearly identified with a stainless steel nameplate as specified in the nameplates section installed next to this manhole that the series transformer winding ground is accessible through this manhole.

Preventative Autotransformer Additional Requirements

A top clamping ring is required. A common slab that clamps all phases is acceptable.

Independent, adjustable independent clamping of the windings and core is required.

The core should be clamped first, then the windings.

The clamping force on the windings shall be considered when calculating the clamping force on the core legs. The top and bottom yokes shall be flat.

Miter type core joint construction shall not be used.

The entire stack of the yoke shall be clamped.

All the insulation between the top and bottom press cross beams as well as core gap material shall be non-hydroscopic, such as fiberglass.

The 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.

The noise shall be measured on both sides.

Full clamping pressure shall be applied to the core legs for the test.

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.

The PA continuity test shall be performed after all the PA and LTC leads have been permanently connected.

The date that the test was performed, the procedure used, and the results shall be included in the certified test report.

If any terminal is disconnected and then reconnected, the PA continuity test shall be repeated.

Sheet windings are not acceptable.

Vibration

Care shall be taken in the design and assembly of the transformers to reduce and to minimize vibration.

The transformer shall be free from any undue or harmful vibration, which would be detrimental to the operation of the transformer, and any auxiliaries mounted on the tank or connected to the transformer.

The average amplitude of all local maximum points shall not exceed 60µm (2.36 mils) peak-to-peak.

The maximum amplitude within any rectangular area shall not exceed 200µm (7.87 mils) peak-to-peak.

MANUFACTURER is to describe to FCPUD how vibration is being mitigated and controlled.

This is a design review item.

Examples of vibration damping would be control dampers for fans, control cabinets, and monitors.

At a minimum the control cabinet shall be shock mounted on rubber insulators.

Conduits

All wiring external to the control cabinets shall be run in rigid metallic galvanized conduit, sized per the NEC with 3/4 inch minimum size unless approved by FCPUD, or FCPUD approved equivalent.

Installation and orientation of conduit LB's shall be such that the wire access covers are positioned for easy access, allowing them to be removed using a standard length screwdriver.

Transformer design shall minimize the use of conduit.

All conduits and condulets originating from the main cabinet compartment shall be two (2) inch (minimum) trade size.

Conduit fill shall not exceed 40%.

MANUFACTURER shall provide conduit fill schedule.

Conduits shall not block access to devices mounted on the exterior of the transformer.

All conduit and flex tubing are to be held in place by welded stainless steel studs or welded Unistrut channels.

Bolted supports are not allowed.

Flex tubing is to be supported with steel bands using Panduit part number MLT2H-LP or FCPUD approved equivalent.

Using the transformer braces or other built-in channel that is subjected to transformer heat is not allowed.

SOOW or equivalent cable with an overall jacket is allowed from the junction box to devices like oil level gauge, etc.

The cable shall be multi-conductor type with an overall jacket and color-coded conductors.

The length shall be minimized (guideline of 12" maximum but still allowing enough length to allow easy removal) and it shall be protected from direct sunlight as much as possible.

Flexible liquid tight conduit is not allowed between conduits.

Where applicable, cords shall be used from the conduit to thermocouples to allow easy removal of the thermocouples for testing. The guideline is 12" from the end of the conduit to the thermocouple.

Wiring to the fans shall be as follows:

A junction box shall be mounted on the transformer tank to service a group of fans (typically four groups).

Rigid conduit shall be installed to this junction box.

Junction boxes shall be installed in the center of each group of fans (typically four fans).

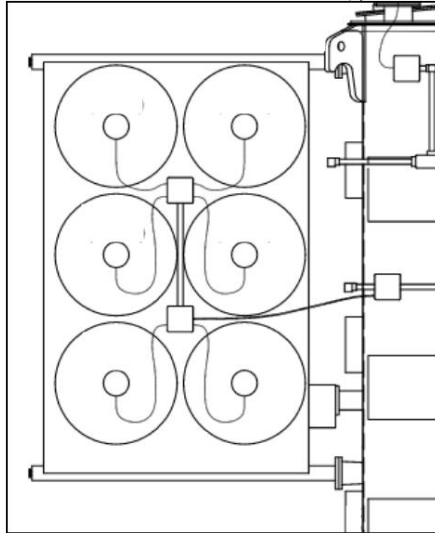
SOOW cords shall run from the junction boxes mounted on the radiator to each fan.

A plug-in connector shall be provided to connect the cord to the fan.

A SOOW cord shall run from one junction box on each radiator to the junction box on the transformer.

If more than one junction box is mounted on a radiator, rigid conduit shall be used between the junction boxes and only one SOOW cord shall be used to the junction box on the transformer.

See diagram below for typical junction boxes and cables for fans mounted on the side of the radiator.



Alternate requirements if fans are mounted on the bottom side of the radiators.

Instead of one junction box on the transformer to service all the fans on the radiator a junction box shall be provided to service typically four fans.

A junction box shall be mounted on the radiator to service four fans.

On One SOOW cord shall be installed from the junction box on the radiator to the junction box on the bottom of the radiators.

A SOOW cord shall be provided from the junction box on the bottom of the radiator to each fan.

The cords can be hardwired to terminal blocks in the junction boxes.

Appropriate strain relief shall be provided for each SOOW cord.

Care shall be used to minimize long SOOW cords and the cords shall be protected from direct sunlight as much as possible.

The dropping of cords shall be minimized.

Fan junction boxes shall be permanently labeled as to what fan plugs into what port.

When rigid or flexible conduit is provided for wiring, the conduit may not enter the top of enclosures, stuffing boxes, or the control cabinet on the top horizontal surface.

The conduit system shall be designed to prevent the entrance of water into the conduit system.

The conduit system shall also be designed to prevent chafing of wire insulation of wires routed in the conduit.

Nylon or plastic wire ties shall not be used to strap cables, capillary tubes, or other devices to conduits or other support structures.

No conduits or conduit boxes shall be located between transformer bushings rated 138kV and below or in close proximity (adjacent) to transformer bushings rated 138kV and below.

All CT junction boxes, conduits, and other items that can be used by a bird or other animal shall be checked for appropriate clearance to live parts by extending a metal plane four (4) feet above the item and then verify that the horizontal clearance (distance) from this plane to the live part meets minimum electrical clearance.

All conduits shall be painted when the final coat is applied.

Spare Parts

The MANUFACTURER shall **PROVIDE IN PROPOSAL** a list of any special tools that are required for the installation and maintenance of the transformer.

In addition, any special tools required for assembly or maintenance shall be provided with the equipment and become the property of FCPUD.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** Recommended Spare Parts list with original manufacturer catalog number and price for each part.

The MANUFACTURER shall furnish copies of the Recommended Spare Parts list with original manufacturer's name and catalog number in each instruction manual.

The MANUFACTURER shall provide the following spare components for each transformer purchased without additional cost to FCPUD:

One (1) complete itemized set of gaskets.

One (1) Fan Assembly - The fan shall be mounted to one of the transformer radiators but not connected and a metal clip installed to block the rotation of the fan blades.

Four (4) spare fuses for each type used in the control scheme.

For each transformer supplied, one spray can of primer and one spray can of finish paint to allow paint repairs.

Additional Spare Parts as specified in the Data Form.

These components shall be delivered with the transformer.

The following spare parts shall be quoted separately and priced individually:

One (1) High Side Bushing

One (1) Low Side Bushing

One (1) Low Side Neutral Bushing if different than Low Side Bushing

One (1) High Side Arrester

One (1) Low Side Arrester

Spare bushings and arresters 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.

Bushings and arrester shall be packaged so that polymer/silicon weather sheds maintain their geometry during shipping and storage.

Materials, Workmanship, And Design

All equipment and materials used shall be new, of the highest quality, clean, properly assembled, finished, and aligned.

Design shall be in accordance with latest applicable industry standards and these specifications.

All work shall be performed and completed in a thorough, craftsman-like manner, by persons skilled in their various trades.

All materials furnished and all work done, must be satisfactory to FCPUD, and in accordance with these Specifications.

Any defects or failures to so comply with these Specifications, shall be corrected by MANUFACTURER at the MANUFACTURER's expense.

Similar unit components shall be made to the same exactness, uniformity, and tolerances, to permit interchange of units of the same design and to provide complete utility in replacement and maintenance.

All material used, or proposed to be used, in the transformer shall be tested and pass the transformer oil compatibility test using the method outlined per ASTM or FCPUD approved equivalent.

The test reports shall be available upon request for FCPUD inspection at any time during the proposal or manufacturing process.

Any material found by FCPUD representative which has not had the oil compatibility test performed on it, or that the MANUFACTURER cannot produce an oil and/or insulating fluid compatibility test report for, shall be tested immediately at the MANUFACTURER's expense.

If the material fails the oil compatibility test, FCPUD will not accept the transformer until all non-compliant material is replaced.

All material used in the transformer shall be subject by the MANUFACTURER to rigid quality assurance and control standards.

The MANUFACTURER shall have complete traceability on all material from receiving until final installation in the transformer.

Material tracking and inspection reports shall be made available to FCPUD representative upon request.

The MANUFACTURER shall have conducted an initial vendor inspection and qualifying audit with ongoing spot checks on all material used in the transformer.

Vendor inspection and audit reports shall be made available to FCPUD representative upon request.

Materials found by FCPUD representative to have not been properly qualified for use by the MANUFACTURER shall, as a general rule, be unacceptable for use in the transformer.

The MANUFACTURER, at the MANUFACTURER's expense, shall make arrangements satisfactory to FCPUD, up to and including the replacement of the non-qualified material.

All material shall be traceable to its point of origin.

All material shall have test reports to verify that the material conforms to the applicable standards.

These reports shall be provided to FCPUD upon request.

Work submitted by the MANUFACTURER that contains excessive errors, may be rejected and returned to the MANUFACTURER, along with instructions from FCPUD, to provide thorough engineering checking and correction, prior to resubmission for approval.

Notification by FCPUD of such inferior or inadequate MANUFACTURER work shall not in any way remove, or reduce the MANUFACTURER's obligation to correct, proof, and resubmit, any or all, design, drawings, or work, which has been rejected as inadequate by FCPUD.

Bushings

If specified in the Data Form the bushings shall be supplied by the manufacturer(s) and catalog numbers specified.

In addition, the bushings shall be supplied with the following ratings:

Bushings shall be provided with the following ratings as specified in the Data Form.

Voltage Rating

Current Rating

If the bushing manufacturer and catalog numbers are not specified in the Data Form the following applies:

Trench COTA bushings will not be allowed.

Approved manufacturers for condenser type bushings are ABB, PCore or FCPUD approved equal.

Bushing manufacturer and catalog number shall be **PROVIDED IN PROPOSAL** for each bushing proposed.

Bushing color shall be ANSI #70 gray.

Bushing current rating shall be at least 120% of the maximum line current at the top MVA rating or at the maximum overload rating (whichever is greater) as specified in the Data Form.

The current rating of each low side neutral bushing shall not be less than the current rating of the associated line bushings.

Final bushing selection shall be approved by FCPUD.

All bushings shall conform to IEEE standard C57.19.00, C57.19.01, and C57.19.100.

Bushing suppliers shall meet the physical requirements specified in IEEE C57.19.01, Paragraph 6 Physical Requirements. Physical requirements include:

Dimensions

Bolt sizes and bolt pattern

Minimum bushing in-tank diameters (enable standard BCT's to fit and replacement bushing to fit through BCT donut hole)

Minimum in-tank dimension for installation of bushing current transformers

Top terminal thread size

Cantilever strength

Internal pressure and vacuum

Bushing voltage tap

Bushing test tap

The transformer design shall not utilize reduced clearance capabilities specific to only one bushing manufacturer.

The transformer design shall allow for interchangeability of all bushings in accordance with IEEE C57.19.00.

FCPUD understands that adaptation of the bushing flange may be necessary for interchangeability.

Internal bushing clearances shall be designed such that bushings meeting the maximum dimensions in the latest version of IEEE C57.19.01 can be substituted with no internal clearance issues or rework of the connections and/or fittings.

For bushings with BIL or current ratings not covered in the latest version of IEEE C57.19.01, the MANUFACTURER shall not use bushing for which only a single supplier is able to meet the internal dimensions for adequate internal clearance.

All bushings shall be removable without removing the tank cover.

Bushings shall be rated by the bushing manufacturer for operation at the maximum altitude specified in the Data Form except the BIL ratings are for 3,300 feet.

Bushings shall be mounted and located as specified in the Data Form in accordance with ANSI C57.12.10.

Creep distance shall be no less than the distances in the following table for the maximum applied line-to-ground voltage for the specified ambient pollution service condition in the Data Form.

If bushings are specified in the Data Form do not meet this requirement it shall be communicated to FCPUD so the conflict may be reconciled.

Service Condition	Minimum Distance
Light	28 mm/kV
Medium	35 mm/kV
Heavy	44 mm/kV
Extra Heavy	54 mm/kV

Bushings shall be mounted on flanges that are a minimum of 3/4 inches above the transformer cover, mounting surface, or top plate of the turret and be the same outer diameter as the bushing flange.

Bushings shall be connected to the mounting flange using through bolts.

Using "Nelson studs" to connect the bushings is not allowed.

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.

Bushings that are bottom connected shall have a non-plated brass connector designed for that application.

For windings with voltage ratings 15kV or lower, the BIL of the phase and neutral bushings, as applicable, shall not be less than 150kV BIL unless specifically allowed in the Data Form.

If specified in the Data Form, all non-grounded bushings shall be supplied with standard, threaded, electro tinned-plated, bronze, stud-type terminals with NEMA 4" X 4" four-hole pad connectors.

Minimum plating thickness shall be 0.001 inch (0.026 mm).

The four-hole NEMA pad shall have machined milled surfaces on both sides to permit conductors to be attached to both sides.

The connectors shall be tin plated suitable for connection to aluminum bus or jumpers and copper bus or jumpers.

Terminals with mechanically applied or "painted" tinning or silver material are not allowed.

For bushings with a voltage rating equal to or greater than 345kV or 230kV above 3300 feet elevation the connectors shall be rated EHV.

All grounded bushings shall be supplied with standard, threaded, electro tinned-plated, bronze, stud-type terminals with NEMA 4" X 4" four-hole pads and grounded per these specifications.

Minimum plating thickness shall be 0.001 inch (0.026 mm).

The four-hole NEMA pad shall have machined milled surfaces on both sides to permit conductors to be attached to both sides.

The connectors shall be tin plated suitable for connection to aluminum bus or jumpers and copper bus or jumpers.

Terminals with mechanically applied or "painted metal" tinning or silver material are not allowed.

Draw lead bushings shall be installed without attaching shielding to the bushings so if the bushings are to be removed in the field, the oil in the transformer will not have to be lowered to a level that would expose the leads and core and coil assembly.

Draw lead type bushing leads shall be insulated.

All bushings with a BIL above 350kV shall be equipped with a bushing voltage tap.

This tap shall be the normally grounded type as shown in Figure 1 of IEEE Standard C57.19.01.

Voltage tap shall be tested at 20kV per the IEEE C57.19.00.

All capacitance-graded bushings with a BIL of 350kV or below shall be provided with a bushing test tap.

This tap is normally grounded.

Test tap shall be tested at 2kV per the IEEE C57.19.00 (latest version)

All bushings shall meet the current rating based on 65 Degrees C transformer top oil rise per Section 4.1 and 7.2.3 in IEEE C57.19.00-2023.

Bushing materials with temperature index greater than 105 must be submitted and approved by FCPUD per Section 5.4.1 of IEEE C57.19.00-2023.

If required in the Data Form all bushings above 34.5kV must quality to IEEE 693-2018 for seismic performance level.

If a bushing seismically qualified to IEEE 693-2018 is not available from any of the bushing manufacturers listed in the Data Form, then a bushing qualified to IEEE 693-2005 shall be provided, subject to FCPUD approval.

All qualification must be based on testing per Section D.5 and D7.2 of IEEE 693-2018, i.e., static pull test for 46 to 138kV bushings and shake table test for bushings above 138kV.

The bushing must pass full routine test per D7.2.2 of IEEE 693-2018 after the seismic qualification test.

Qualification by group is acceptable per Section 4.7 of IEEE 693-2018.

Qualification by calculation is not acceptable.

The high side H2 bushing shall line up with the low side X2 bushing if both sets of bushings are located on the top of the transformer and on opposite segments.

The minimum bushing spacing shall be as specified in the Data Form.

Bushing external clearances shall at a minimum meet the minimum external clearances per IEEE C57.12.00.

Adjustments shall be made as necessary for the specified altitude and grading rings.

These clearances shall not be reduced by the application of surge arresters on the transformer.

These clearances shall be increased as necessary for the switching surges specified in these specifications or required by the IEEE standards.

Minimum center-to-center spacing of the bushings shall be consistent with metal-to-metal flashover distances and surge arrester characteristics including switching surges at the maximum operating altitude specified in the Data Form.

Bushings rated less than 350kV BIL shall have a minimum of 24 inch phase-to-phase clearance from live parts to live parts.

For three-legged core form designs the phase-to-phase spacing shall take into account the 1.5 times phase-to-phase voltage that occurs during line-to-ground switching surges at the altitude specified in the Data Form.

Neutral bushings shall have a minimum clearance of 8" from the bushing 4-hole stud connector to the minimum strike zone of the high voltage and/or low voltage bushings.

All bushing rated 550kV BIL and above shall be fitted with corona shields on the lower end unless the bushing is specifically designed for use without a corona shield and so must be clearly indicated.

Bushings shall have cantilever strength as specified in ANSI C57.19.

For roof mounted condenser bushings, draw lead bushings shall be used if possible and “bottom connected” or “draw lead” shall be noted on the outline drawing bushing material description.

Oil-filled bushings shall be equipped with expansion chambers and oil level indicators.

The oil in the bushing shall be “PCB” free and be so indicated on the bushing nameplate.

All bushings shall be designed such that there will be no undue stress placed on any parts due to temperature changes.

For porcelain bushings the porcelain used in the bushings shall be manufactured by the wet process and shall be homogeneous, free from laminations, cavities, or other flaws affecting its mechanical strength or dielectric quality.

The glazing of the porcelain shall be free from imperfections, such as blisters or burns.

Bushings shall be capable of accepting a minimum of three (3) bushing-type current transformers each and shall accept all current transformers required by this specification.

Bushings shall be from a reputable manufacturer, rated for use with oil, and routinely used with demonstrated performance.

For all Condenser Type Bushings: C1 nameplate power factor cannot exceed 0.5% and C2 power factor shall be less than 1.5%.

Bushing nameplates shall be marked to comply with the requirements of IEEE/ANSI C57.19.00.

Nameplate information shall include test power factor referred to 25 Degrees C at 10kV as measured between bushing conductor and potential test tap, by the Ungrounded Specimen Test (UST) method commonly referred to as C1.

Bushings shall have the tested power factor and capacitance referenced to 25 Degrees C as measured between the bushing flange and potential test tap commonly referred to as C2.

Request for variance approval shall be submitted to FCPUD at least three weeks prior to the start of design review.

For bushings equal to or greater than 345kV or if specified in the Data Form, the connectors shall be rated EHV.

If specified in the Data Form, PCore Test Terminals shall be provided.

Nameplate Requirements

The MANUFACTURER shall supply all nameplates as specified in the ANSI/IEEE standards.

All nameplates shall be made from non-rusting stainless steel or aluminum with Mil spec protective coating.

The information contained on the nameplates shall be inscribed and painted black.

All the information shall be in English and in standard non-metric units of measure unless otherwise noted in these specifications.

The serial number and impedance of the transformer shall be permanently stenciled on the nameplate and provided on construction record drawings.

The accuracy of all weights shall be stated on the nameplate.

The configuration or the core shall be stated on the nameplate: three-legged core form, five-legged core form, shell form, etc.

The MANUFACTURER shall indicate the altitude that was the basis of transformer thermal design on the nameplate.

The MANUFACTURER shall indicate ambient temperature range on the nameplate with the minimum temperature also being applicable for cold start.

The MANUFACTURER shall indicate the measured average sound levels at the base and maximum ratings in decibels on the nameplate.

A nameplate for series transformer and/or preventative auto shall be supplied on the main tank nameplate when applicable.

The following information shall also be included:

Current transformer locations and ratings (ratios, accuracy class, and thermal factor).

Maximum positive and negative operating pressures of the oil preservation system.

Maximum vacuum pressure for which each individual oil filled compartment is designed.

The nameplate shall identify which oil-filled compartments including the main tank and the LTC are suitable for vacuum filling and processing.

Oil level in inches below the top surface of the highest point of the manhole flange at 25 Degrees C and oil level change in inches per 10 Degrees C change in oil temperature.

Total weight of cellulose insulation contained in the transformer.

Voltage for DETC and LTC tap position.

A reference that declares the oil contained non-detectable levels of PCB's at the time of shipping.

Any other information, which the MANUFACTURER deems necessary for proper installation, maintenance, and operation of the transformer.

All voltages on the nameplate shall be the calculated voltages rounded to the nearest 1 volt.

Rounding to the nearest 5 or 10 volts is not allowed.

All nameplate voltages shall represent the actual calculated voltages and not any nominal voltages.

Top view of transformer with major items like bushings, LTC, and conservator identified.

If the transformer is designed for overload per these specifications, the overload percentage shall be stamped on the nameplate as follows: "Designed Overload – XX% For XX Hours".

Current Transformers

Bushing and winding current transformers (CT's) for FCPUD's use shall be provided. The MANUFACTURER shall install current transformers as indicated below.

Single, dual, and multi-ratio current transformers shall conform to ANSI/IEEE

The CT's specified in the Data Form shall be supplied.

All current transformers, including the current transformers(s) for winding hot spot, shall have a continuous thermal rating as indicated in the Data Form at an average ambient air temperature of 30 Degrees C.

All current transformers shall have an insulation class designation of 120 Degrees C

All current transformers have the minimum ANSI accuracy class as specified in the Data Form.

Current transformers shall be supplied by Meramec or FCPUD approved equal.

Insulation of the windings and their secondary leads shall be of suitable high-temperature type insulation to withstand the highest temperature under maximum continuous loading of the power transformer.

All CT wiring inside the transformer tank to the feed throughs on the tank and from the feed throughs to the control cabinet shall be ETFE/FEP 150 Degrees C rated.

All secondary leads of current transformers shall be brought to a common outlet housing near the cover and then to the weatherproof control cabinet.

CT lead splicing is not allowed except when going through the CT block from the interior to exterior of the tank.

The inside diameter of the bushing current transformers shall accommodate the maximum bushing diameter shown as dimension D in Tables 2 and 3 of IEEE C57.19.01 (latest version).

All current transformers shall be constructed and tested according to IEEE C57.13 (latest version).

The average amplitude of all local maximum points shall not exceed 60µm (2.36 mils) peak-to-peak.

The maximum amplitude within any rectangular area shall not exceed 200µm (7.87 mils) peak-to-peak.

Surge Arresters

If specified in the Data Form the surge arresters shall be supplied by the manufacturer and catalog numbers specified.

In addition, the surge arresters shall be supplied with the following ratings:

Metal-oxide type surge arresters shall be provided with the following ratings as specified in the Data Form.

MCOV

Duty Cycle

Current Discharge Rating

Energy Class/Rating

Surge arresters shall be provided and mounted for all non-grounded terminals, except where noted in the Data Form.

The surge arresters shall be in compliance with ANSI C62.11 and shall be ANSI #70, gray in color.

Surge arresters shall have a polymer external housing.

Polymer arrester designs resistant to ultraviolet energy exposure.

Porcelain arresters will not be accepted.

Arresters shall be from a reputable manufacturer and routinely used with demonstrated performance.

Surge arresters shall be designed to minimize the volume of gaseous space inside its housing.

MOV blocks shall be stacked in a single column.

The arrester must demonstrate the ability to resist explosion in the event of a failure.

In case of arrester failure, positive and obvious venting shall occur for discharge current up to the short circuit current discharge capability as specified in the Data Form.).

Terminals capable of bolting to 4" NEMA 4-hole pad connectors shall be furnished on the line side of all arresters.

Arresters shall allow the application of bolt shields for system voltages 230kV and above.

Ground terminals shall be provided that are compatible with #4 AWG through 500 kcmil copper or aluminum wire.

The MANUFACTURER shall provide mounting for the arresters.

The MANUFACTURER shall minimize the distance between the surge arrester and the bushing yet maintain working and electrical clearances, which shall be equal or greater than the terminal bushings.

The arrester brackets shall be strong enough to withstand the cantilever moment without the steel elastic limit being exceeded.

The arrester brackets, if the arresters are not inside a bushing connection box, shall be strong enough to withstand an additional weight of at least one person with tools (300 lbs.) standing on the bracket with all the equipment installed.

The maximum weight that can be put on each arrester bracket shall be listed on the outline drawing.

The arrester's 4-hole pad shall be positioned in relation to the bushing's 4-hole pad as specified in the Data Form.

At the same elevation and in-line with the bushing's 4-hole pad or if Test Terminals are specified in the Data Form, then with the Test Terminal's pad.

Six (6) inches lower in elevation and in-line with the bushing's 4-hole pad or if Test Terminals are specified in the Data Form, then with the Test Terminal's pad.

De-energized Tap Changer

If required in the Data Form, the transformer shall be provided with a full capacity high voltage de-energized tap changer (DETC) if specified in the Data Form, in the winding specified in the Data Form, with taps as specified in the Data Form.

The DETC shall have continuous current, overload current, and short-circuit current carrying capacity equal to that specified for the transformer windings at any operating position.

All taps shall be full-capacity taps of the rated kilovolt amperes.

The tap voltages and maximum line currents shall be shown on the transformer nameplate.

The taps shall be designated both on the nameplate and on the tap changer indicating plate by numbers or letters in sequence with the numeral "1" or "A" being assigned to the voltage rating that provides the greatest ratio of transformation.

The DETC shall be capable of being operated only while the transformer is de-energized.

A single external mechanism shall be provided to change the de-energized tap position in all phases simultaneously.

It shall be located on the transformer tank at a level such that it may be operated from ground level.

All linkages between the tap changer and the operating mechanism shall be internal to the transformer tank.

The de-energized tap changer position indicator shall be visible from ground level.

Provisions for padlocking shall be furnished for each tap position.

A stainless steel nameplate shall be provided for each DETC switch handle.

The DETC shall not require periodic movement for periodic maintenance.

The moving and stationary contacts shall be silver plated.

Switches shall be from a reputable manufacturer and routinely used with demonstrated performance.

Final selection of switch type and arrangement shall be approved by FCPUD.

The catalog number of the switch shall be permanently marked on the DETC.

Cooling Equipment - General

The control of the oil cooling devices shall be by winding temperatures and shall progress in accordance with the provisions for two stage cooling as described in ANSI/IEEE.

The Electronic Temperature Monitor (if provided) Winding Hot Spot and Top Oil Temperature, Winding Hot Spot Temperature Gauge(s), and Top Oil Gauge shall be used for cooling control.

All control equipment for cooling will be installed and wired in the main control cabinet.

This shall include any required motor starters or contactors and circuit breakers.

FCPUD shall have final approval of devices, styles, and catalog numbers such as cooling contactors, starting devices, and control devices.

If required in the Data Form, in addition to a main circuit breaker for each cooling stage, each fan shall have a circuit breaker.

Each fan circuit breaker shall have a normally closed status contact.

For each stage of cooling the normally close status contact shall be connected in parallel so that if a fan circuit breaker opens that an alarm will be provided.

This alarm output shall be connected to a terminal block as specified in the Data Form.

A circuit breaker and contactor shall be provided for each stage of cooling that is operated by the transformer temperature devices as outlined in these specifications.

The contactor shall have a normally open status contact.

The normally open status contact for each stage shall be connected to a terminal block as specified in the Data Form.

If required in the Data Form, in addition to a main circuit breaker and contactor for each cooling stage, a separate contactor and circuit breaker shall be provided for each fan.

The fan circuit breakers for each fan shall have a normally open and normally closed status contact.

The fan circuit breaker normally open contact shall be installed in series with the contactor for that fan.

For each stage of cooling the fan circuit breaker normally closed status contact shall be connected in parallel so that if a fan circuit breaker opens an alarm will be provided.

This alarm output shall be connected to a terminal as specified in the Data Form.

Each fan contactor shall have a normally open status contact.

For each stage of cooling the normally open status contact from the fan contactor shall be connected in series so that if a fan contactor opens an indication will be provided.

This indication shall be connected to a terminal block as specified in the Data Form.

Winding hot spot values shall be derived from an analysis of the local losses in the windings and effects of local oil temperatures.

The use of default factors added to average winding temperatures is not acceptable.

In addition to normally provided controls, each stage of cooling equipment shall be provided with an automatic/manual selector switch to permit operation of all cooling equipment simultaneously or each stage separately for test purposes.

Provisions shall be provided for FCPUD to install a normally closed transformer lockout (86T) contact into the cooling control circuit such that when the 86T operates the cooling equipment will be turned off and disabled until the lockout relay is reset.

Provisions shall be provided in such a way that FCPUD only needs to install this contact to designated terminals on a terminal block.

The MANUFACTURER shall install a jumper at the terminal block across where this contact would be connected that would be removed if FCPUD installs this contact.

Contacts shall be provided from the Cooling Contactors to provide indication that the Cooling has been activated.

These contacts shall be wired to a terminal block for indication/alarm as specified in the Data Form.

All oil piping shall be direct connected, i.e., Dresser type couplings are not acceptable.

Cooling Equipment - Radiators

Transformer shall be provided with a sufficient number of radiators to cool the oil properly. The radiators shall be attached to flanges welded into the tank wall.

The cooling radiators shall be of a design and manufacturer with at least three (3) years of successful field service. Method of radiator assembly and attachment to the transformer tank shall be **PROVIDED IN PROPOSAL**.

Joints shall be made tight by means of suitable gaskets.

Forced oil cooling using oil pumps is not allowed.

Radiators shall have top and bottom indicating shutoff valves, which can be fastened in either the open or closed position for each header assembly where it connects to the transformer and at each radiator where it connects to the header or transformer.

This shall be designed in such a manner that any individual radiator can be removed for repair without removing the transformer from service. Provisions shall be made so that it will not be necessary to shut down all of the cooling equipment when removing any one radiator for repair.

Radiator valves shall be installed so the open/shut lever is in the same orientation for all valves.

The valve stem shall use Viton gaskets/seals if specified in the Data Form.

Each radiator and header shall have a removable plug in the bottom of the radiator and header, vent plug on top, and lifting eyes. Drainage valves in the bottom of each radiator or header will not be allowed.

Vents shall be a screw type vent, not just a plug with cap, otherwise these will be leak points after venting radiators and headers.

All radiators shall be interchangeable.

Radiators shall be pressure tested to 10 psi for twelve hours as part of the transformer when the transformer is pressure tested before shipment.

Each radiator shall be constructed to withstand tank operating pressure and full vacuum without permanent deformation.

The radiators shall be hot dip galvanized, 19-gauge steel minimum and not painted and shall be pressure tested before installation on the tank. Galvanizing shall be in conformance with ASTM designation A-123.

Each radiator shall be designed to be accessible for cleaning and painting, to prevent accumulation of water on the outer surfaces, to completely drain oil into the tank, and to prevent formation of gas pockets when the transformer is being filled.

All radiators are to be detachable and removed from the transformer for shipment.

Fan motors shall meet the following requirements:

Voltage rating as specified in the Data Form.

Totally enclosed, without a centrifugal clutch, and permanently lubricated.

Equipped with sealed ball bearings and an individual thermal protective device equipped with automatic reset.

Have NEMA frames.

Be UL or CSA recognized.

Protection shall be provided for each motor individually, to prevent one motor failure from de-energizing the remaining motors, along with a means of disconnecting failed fan motors from the service bus to facilitate replacement in the field.

Fans shall meet the following requirements:

All fans shall be provided with galvanized blade guards that meet OSHA requirements.

The fans shall have one piece fan blades.

The fans shall be manufactured by Krenz or FCPUD approved equal.

Mounting fans on the bottom of the radiator bank and pointing up will not be allowed unless preapproved by FCPUD. If allowed, the most bottom part of the fan shall be at least 3 feet above the base of the transformer.

Fans of different stages shall be staggered so that when stages are swapped, there is still effective cooling for Stage 1 operation.

Fans shall be arranged and with enough access that any fan can be removed and replaced without taking off any other fan or radiator or any other device on the transformer.

Fans shall be arranged with suitable wiring connectors such that if defective they may be removed for maintenance without taking the transformer out of service.

If fans are mounted on the transformer side of the radiator, a minimum distance of 1 foot plus the fan depth must be allowed between the farthest protruding part of the fan and the tank.

When fans are mounted on the inside of the radiators where they are back to back, a minimum of 24" shall be provided between the back of the fan motors to the back of the fan motors on the opposite radiator.

Dual speed fans are not allowed.

Main Tank Oil Preservation System

The oil preservation system shall be an inert gas pressure system as specified in the Data Form.

The oil preservation system shall meet the requirements of the appropriate section below.

Inert Gas Constant Pressure System (Sealed Tank with Nitrogen)

System shall be complete with low and high pressure, as well as empty cylinder alarms, and all associated controls.

All of these items, including the nitrogen bottle, shall be mounted in a NEMA Type cabinet specified in the Data Form.

All welds on the enclosure shall be continuous to prevent moisture entrance.

The cabinet door shall be hinged and pad-lockable and shall have a viewing window to see all gauges and valves without opening the cabinet door.

The weatherproof cabinet shall have a space heater. Strip heaters shall be rated for 240 VAC, connected at 120 VAC.

Thermostats shall have an adjustable setpoint with graduations in Degrees F.

The nitrogen regulator shall be located above the top of the nitrogen bottle and shall be placed in an area that is easily viewable and will prevent being damaged when replacing the nitrogen bottle.

The bottom of the nitrogen bottle enclosure shall be mounted no higher than six inches above foundation level.

A nameplate indicating operating instructions for the nitrogen system shall be placed on or in the nitrogen system cabinet.

The system shall be a three-stage design with the Stage 1 reducing the pressure from bottle pressure to 100 psi, Stage 2 reducing the pressure from 100 psi to 7 psi and

Stage 3 reducing the pressure from 7 psi to 0.5 psi and controlling the flow of gas to the transformer tank.

The third stage shall also have a pressure relief system that maintains tank pressure between 0.2 psi and 5.0 psi.

A high pressure gauge shall be provided.

A pressure gauge with a scale of -10 psi to +10 psi shall be provided to measure the tank pressure.

A by-pass valve shall be provided to bypass Stage 3 for purging purposes.

A drainable oil sump shall be provided.

All indicating devices shall have their alarm contacts wired to a terminal strip in the main control cabinet.

The nitrogen system shall allow nitrogen into the transformer tank if the tank pressure drops below 0.5 psi.

The nitrogen system shall have a pressure relief valve that operates at 5.0 psi.

The high pressure alarm shall be set at least 1 psi below the tank rating and at least 0.5 psi above the pressure relief valve rating.

The low pressure alarm shall be set at 0.25 psi.

The empty cylinder alarm shall be set at 200 psi.

Stainless steel flexible tubing shall be used to connect the nitrogen bottle to the nitrogen system.

A main tank sample port/purge line shall be provided for dew point measurements that take the sample from the main tank and not through the expansion bracing or other parts of the tank that would not be a representative sample of what is inside the main tank.

This sample port/purge line shall be routed to the nitrogen cabinet with a valve in the nitrogen cabinet.

The routing of the sample port from the transformer tank to the nitrogen cabinet shall not use the transformer expansion bracing.

The transformer bracing can be used as expansion space.

All nitrogen piping shall be copper or stainless steel.

The use of plastic piping/tubes is not allowed.

If isolation valves are needed at the tank for the nitrogen piping to prevent oil from entering the lines during shipment, the valves shall be located near the top of the tank in the line of sight of the nitrogen cabinet with warning labels in the nitrogen cabinet to make sure the valves are open when nitrogen system is in service.

For best purging the nitrogen, piping shall enter the transformer tank at diagonally opposite corners.

The nitrogen cabinet shall be located in a position where the requirements of the previous two paragraphs can be met.

A 200 ft³ bottle shall be provided with proof of FCPUD ownership attached to the bottle.

The nitrogen for use with inert-gas-protected transformers shall be in accordance with ASTM D1933.

The nitrogen shall be certified dry with a dew point of -50 Degrees C at a 20 Degrees C ambient.

The nitrogen shall be supplied in 200 ft³ cylinders equipped with Connection No. 580 of ANSI/CGA-V-1.

The filling pressure shall be 2200 psi at 70 Degrees F.

The cabinet for the nitrogen system must have a parts list provided in the Instruction Book.

Provide weight and detailed description of nitrogen bottle on the outline drawing with a statement that it meets DOT requirements.

Insulating Fluid

Separately shipped oil shall be scheduled for delivery at the point of installation during the time that FCPUD is supervising the installation.

Oil shall be shipped DDP destination.

The electrical insulating fluid shall be as specified in the Data Form. Other insulating fluids or oils will not be accepted.

The same insulating fluid shall be used in the main tank and LTC unless specified differently in the Data Form.

Same insulating fluid means same type with similar test results originating from same supplier and batch.

If FCPUD agrees that another supplier provides the LTC insulating fluid, it shall meet all the requirements of these specifications and be tested separately at the factory to verify it meets the specifications.

The design of the transformer shall be based on standard transformer mineral oil conforming to ANSI/ASTM D3487, Inhibited Type II or the insulating fluid specified in the Data Form, whichever results in the more conservative design such that either type of insulating fluid can be used at a future date.

The exception to this requirement is cold weather operation and cold startup of the transformer.

All cold weather limitations if standard Inhibited Type II mineral oil is used shall be clearly **PROVIDED IN PROPOSAL** and on the nameplate.

If the insulating fluid specified in the Data Form is Inhibited Type II it shall conform to the following specification at delivery. (Other insulating fluids that are not petroleum based shall meet similar requirements for that type of fluid).

Insulating oils for general application, which are covered by this specification, are manufactured from predominantly naphthenic base crudes.

Distillates from these crudes may be acid refined, hydrogen treated, solvent extracted, or processed by other suitable refining methods to yield acceptable mineral insulating oils which meet the test requirement at the point of delivery.

Insulating oils covered by this specification shall be produced from proven crudes by suitable refining techniques, both of which shall have been approved by FCPUD.

After such approval, no change in crude source, processing, or refining methods shall be made that results in a substantial change in the product characteristics without the prior approval of FCPUD.

All additives shall be specifically identified or at a minimum identified by the class of compounds such as metal passivator if the specific information is proprietary.

The Transformer Oil shall meet or exceed the latest revision of ASTM 3487 and Doble TOPS.

Oil with a negative gassing coefficient is preferred but FCPUD will accept oil with a gassing coefficient of less than 30 uL/min for the typical value or if another type of fluid is used, then the minimum requirements of the fluid manufacturer.

If a negative gassing coefficient is required in the Data Form than the gassing coefficient has to be less than 0 uL/min.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** the minimum characteristics for the insulating fluid to be used at the factory for factory acceptance testing and for final filling.

The characteristics of the insulating fluid for final filling shall not be less than that required at the factory for factory acceptance testing.

Oil with a stray gassing tendency is not acceptable.

The MANUFACTURER shall supply the following information for the insulating fluid used in the transformer during factory testing.

The following tests shall be performed.

Interfacial Tension, (dynes/cm) 25 Degrees C, ASTM D-971

Dielectric Breakdown at 60 Hz, (kV), ASTM D-877, Disk Electrode, 1 mm gap

Dielectric Breakdown ASTM D-1816 (kV), VDE Electrode, 2 mm gap

Power Factor at 60 Hz (percent), 25 Degrees C, ASTM D-924

Power Factor at 60 Hz (percent), 100 Degrees C, ASTM D-924

In addition, the Certificate of Analysis provided by the oil supplier shall be provided.

“PCB FREE” shall be permanently stenciled into the transformer nameplate and stickers placed by the drain valves.

The MANUFACTURER shall **PROVIDE IN PROPOSAL** a specification sheet for the insulating fluid they propose to furnish.

Shipping containers, storage containers, and all transfer equipment shall be dedicated to new insulating fluid of the type specified.

The shipping method and containers shall be agreed upon by FCPUD and MANUFACTURER and shall not be changed without prior approval of FCPUD.

Insulating fluid furnished separately shall be delivered at a time and in a manner acceptable to FCPUD.

Delivery shall be coordinated with erection schedules.

All insulating fluid transportation or demurrage costs caused by the MANUFACTURER's failure to coordinate insulating fluid delivery shall be borne by the MANUFACTURER.

Each shipment and tanker shall be tested at delivery by the MANUFACTURER with the test results approved by FCPUD before putting any of the oil in the transformer.

If FCPUD approves beforehand, three samples can be taken from each tanker instead of the above requirement.

One sample shall be sent to a lab for testing, another sample is given to FCPUD, and the remaining sample is kept by the MANUFACTURER.

Insulating fluid unloading, storage, and transformer vacuum process can be started while waiting on test results.

If test results indicate there is a problem or concern with the oil the MANUFACTURER is responsible to correct the situation including replacing the insulating fluid, draining, and cleaning the transformer until FCPUD is satisfied.

The required tests are as follows:

Specific Gravity at 15.6 Degrees C, ASTM D-1298

Color (a), ASTM D-1500

Interfacial Tension, (dynes/cm) 25 Degrees C, ASTM D-971

Visual, ASTM D-1524

Dielectric Breakdown at 60 Hz, (kV), Disk Electrode, 1 mm gap, 35 minimum under ASTM D-877

Dielectric Breakdown at 60 Hz, (kV) VDE Electrodes, 2 mm. gap 55 minimum under ASTM D-1816

Power Factor at 60 Hz (percent), 25 Degrees C, ASTM D-924

Power Factor at 60 Hz (percent), 100 Degrees C, ASTM D-924

Gassing Tendency (uL/min), ASTM D-2300

Oxidation Inhibitor (percent), ASTM D-2668

Corrosive Sulfur Content, ASTM D-1275 B

Moisture Content and Saturation (ppm and percent), ASTM D-1533

Neutralization number (mg KOH/g), ASTM-974

Polychlorinated Biphenyls (PCB's) (ppm or ND), EPA 608

Dissolved Gas Analysis (DGA) test with these limits. If these limits are exceeded for new oil, it is assumed that there is a contaminant (diesel or other contaminant) present in the insulating fluid.

Gas	Maximum Limit
Hydrogen	20 PPM
Methane	10 PPM
Ethane	10 PPM

Gas	Maximum Limit
Ethylene	10 PPM
Acetylene	1 PPM
Carbon Monoxide	20 PPM
Carbon Dioxide	100 PPM

A certificate of analysis shall accompany each delivery.

The unloading time shall be when, in the opinion of FCPUD, the weather is satisfactory for unloading insulating fluid.

FCPUD can reject any oil shipment that does not meet the requirements or if there is any sign of contamination.

If the transformer is shipped oil filled the MANUFACTURER shall perform the following oil tests before the transformer is shipped:

Dissolved Gas Analysis (DGA) with the following maximum limits:

If this is the oil that was used for factory tests the increase in gasses during the tests will be considered.

Gas	Maximum Limit
Hydrogen	15 PPM
Methane	2 PPM
Ethane	2 PPM
Ethylene	1 PPM
Acetylene	Non Detectable
Carbon Monoxide	25 PPM
Carbon Dioxide	250 PPM

Color (a), 0.5 maximum under ASTM D-1500

Interfacial Tension, (dynes/cm) 25 Degrees C, 40 minimum under ASTM D-971

Specific Gravity at 15.6 Degrees C, 0.865-0.910 (60/60) under ASTM D-1298

Dielectric Breakdown at 60 Hz, (kV), Disk Electrode, 1 mm gap, 35 minimum under ASTM D-877

Dielectric Breakdown at 60 Hz, (kV) VDE Electrodes, 2 mm. gap 55 minimum under ASTM D-1816

Power Factor at 60 Hz (percent), 20 Degrees C: 0.05% maximum under ASTM D-924

Power Factor at 60 Hz (percent), 100 Degrees C: 0.3% maximum under ASTM D-924

Water Content: (ppm and saturation): 15 ppm maximum under ASTM D-1533

Neutralization Number (mg KOH/g): 0.015 maximum under ASTM D-974

Oxidation Inhibitor (wt. percent), 0.2% to 0.3%, ASTM D-2668

Corrosive Sulfur Content, Modified (b) Non-corrosive ASTM D-1275

Particle Count – particles per 100 ml (5 micron filter): less than or equal to 10,000

Polychlorinated Biphenyls (PCB's): Not Detectable under EPA 608

Grounding

A minimum of four (4) four-hole NEMA copper faced steel pads shall be provided in accordance with ANSI C57.12.10.

Each pad shall have holes spaced on 1 3/4 inch centers and drilled and tapped for 1/2 - 13 UNC thread to minimum depth of 3/4 inch.

The pads shall be welded to main tank walls on all four corners within 12 inches of the base. Bronze connecting hardware for connecting the ground grid to the ground pads sized for 4/0 to 250 kcmil copper conductor shall be provided by the MANUFACTURER.

Locate grounding materials on the transformer such that access is restricted under normal conditions where possible.

Grounding jumpers shall be supported by clamps spaced not more than two (2) feet apart and located within 6" of any bend.

After assembly, tightening, and securing of the ground connection materials properly tightened and secured, MANUFACTURER shall paint all materials so they will match the transformer to not draw undue attention to copper materials.

The neutral bushing(s) shall be connected to the ground pad on the bottom transformer using the following method:

The neutral bushing terminal shall be connected to a transformer corner ground pad using 4/0 AWG stranded, 600 volt insulated soft drawn copper wire.

A 4-hole 4" pad shall be used to connect this wire to the bushing 4-hole 4" pad on the bushing stud connector.

The insulated grounding wire shall be attached to the main tank sidewall using clamps appropriate for this use.

Surge Arresters attached to the tank for cover mounted bushings shall be grounded using a minimum 4/0 AWG, stranded, soft drawn 600 volt insulated copper ground ring that is separate from the neutral ground.

The copper ground ring shall circle the tank just below the tank cover.

If there is only one set of cover mounted arresters the grounding shall be a looped horseshoe design running through each set of arresters.

The grounding ring shall be attached to the upper part of the main tank sidewall using extended tabs (no more than 6" below the cover's outer edge).

Extended tabs to fasten the ground wire on the top side of the lid will not be allowed and plastic connectors holding the ground wire in place will not be allowed.

Surge arrester ring shall be arranged so that it does not present a tripping or falling hazard to personnel working on top of the transformer tank nor shall it interfere with the operation or visibility of any equipment, sensor, or valve.

The grounding conductor shall be looped through each arrester.

Care shall be taken to have large radius curves in the grounding conductors without sharp bends, which will not be allowed.

The surge arrester grounding ring shall be bonded using jumpers to two ground pads at diagonal corners of the transformer that are not used for the neutral ground using NEMA spaced 2-hole grounding connectors.

If there is only one set of cover mounted arresters the grounding conductors shall be bonded using jumpers to ground pads at the corners of the transformer below the arrester set.

In addition to the normal control cabinet ground, a hidden main tank ground (hidden ground) shall be installed that meets the following requirements:

A braided tinned copper strap shall be positioned behind the control cabinet that connects the control cabinet to the main tank of the transformer.

A two-hole NEMA copper faced steel ground pad shall be welded to the transformer tank behind the control cabinet. The braided tinned copper strap shall be connected to this pad and the pad in the control cabinet that is described in the next paragraph.

A two-hole NEMA copper faced steel ground pad shall be welded to the control cabinet to which the copper strap shall be connected. The 1/2-13" threaded holes shall be drilled out to 9/16" holes and be non-threaded. A Grade 5 bolt shall be used to connect the copper strap to this pad. The bolt shall extend 1" through the pad on the inside of the control cabinet and be secured with a nut. The two-hole NEMA copper faced steel ground pad on the control cabinet shall be constructed to allow FCPUD to use a two-hole NEMA pad to connect a 4/0 ground wire on the inside of the control cabinet. This ground wire will then be taken to the station ground mat through a conduit from the control cabinet. Therefore, this pad shall be clear of all obstructions inside the control cabinet. The control cabinet cut out and two-hole pad shall be welded such that welds are not in the current carry path.

The copper braided strap shall be placed horizontally near the bottom of the control cabinet. The midpoint of the braided strap shall correspond to the midpoint (width) of the back of the control cabinet.

The braided tinned copper strap shall be SEFCOR Type XB2N or FCPUD approved equal, capable of the same or higher ampacity as 4/0 AWG bare stranded copper cable.

The grounding points provided by this hidden transformer ground shall not be used to ground any of the equipment in the control cabinet.

A separate ground bar shall be provided grounding the equipment in the control cabinet.

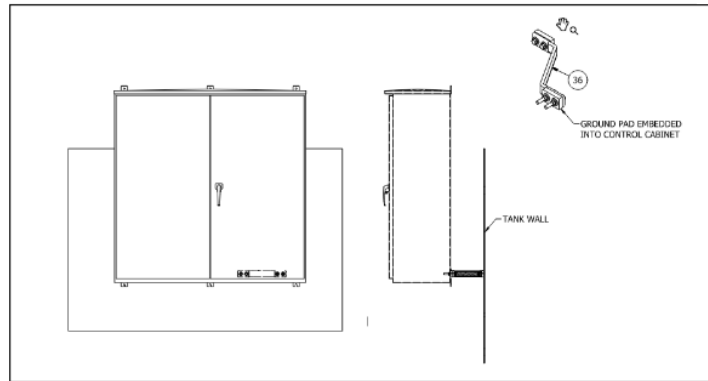
Wires shall not be installed connecting the two-hole hidden ground pad to the equipment ground bar.

The hidden ground pad and equipment ground bar do not have to be electrical isolated from each other.

The electrical path from the metal cabinet due to the hidden ground pad and the equipment ground bar being connected to the cabinet is allowed.

The hidden ground pad and equipment ground bar shall be separated by as much distance as possible and should not be located directly next to each

other. Example, put hidden ground pad in the middle lower part of the cabinet and the equipment ground bar in the lower corner of the cabinet. See diagram and picture below for typical installation for the hidden ground provisions:



Transformer Indicating Devices

All indicating devices required in C57.12.10 shall be provided.

All indicating devices shall comply with C57.12.10 except where noted in this specifications.

Dial type indication gauges shall be removable, with polycarbonate lenses, and shall be water resistant except where noted otherwise in this specification.

If required in the Data Form the gauges shall have tempered glass lenses.

The MANUFACTURER may tilt the gauges, if necessary and allowable per MANUFACTURER instructions.

Each terminal of every switch shall be wired separately to a terminal strip in the main control cabinet.

Sealed Tank Preservation System - The MANUFACTURER shall provide one (1) magnetic liquid level gauge for the main tank.

The gauge shall include one form “c” contact for “main tank, low liquid level alarm” and another form “c” contact for “main tank, low liquid level critical”.

How the critical contact will be used (trip or alarm) is indicated in the Data Form.

These alarm and trip settings shall be set by the MANUFACTURER.

If specified in the Data Form, it shall also be equipped with an analog output wired to a terminal block.

If Automation/Communications Equipment are specified in the Data Form that lists this analog as an input, it shall be wired from the terminal block to this communication or Automation/Communications Equipment.

The liquid level gauge shall have a six-inch diameter dial with a permanently sealed lens and a weep hole.

The indicator shall have a dark-faced dial with light markings and a light-colored indicating hand.

Dial marking shall show the 25 Degrees C level and the maximum and minimum levels.

The magnetic liquid level gauge shall be as specified in the Data Form.

The gauge shall have a stainless steel nameplate as specified in the nameplates section marked as to its intent, Liquid Level Main.

If required in Data Form the MANUFACTURER shall provide an additional liquid level gauge for the main tank.

If the first liquid level gauge is located on the main tank this gauge shall be located next to the other liquid level gauge.

Gauge shall be equipped with form “c” contacts used for “main tank low liquid level trip”.

How the contact will be used (trip or alarm) is indicated in the Data Form.

The contacts shall be set by the MANUFACTURER to activate when the oil level drops to a level where a risk of a flashover can occur.

If specified in the Data Form, it shall also be equipped with an analog output wired to a terminal block.

If Automation/Communications Equipment are specified in the Data Form that lists this analog as an input, it shall be wired from the terminal block to this communication or Automation/Communications Equipment.

The liquid level gauge shall have a six-inch diameter dial with a permanently sealed lens and a weep hole.

The gauge dial shall be blanked out.

The magnetic liquid level gauges shall be as specified in the Data Form.

The gauge shall have a stainless steel nameplate as specified in the nameplates section as its intent, Liquid Level Trip Main.

Sealed Tank Preservation System - The main tank low liquid level gauges shall have the same float arm lengths and be offset vertically from each other by at least 1-1/2 inches”.

The oil level difference between the alarm and trip points shall be at least 1-1/2 inches and match the offset between the gauges.

Sealed Tank Nitrogen Oil Preservation System: A transformer main tank rapid pressure rise relay shall be provided.

The rapid pressure rise relay shall be mounted to sense pressure waves in the gas space above the oil.

The rapid pressure rise sensing unit shall be a Qualitrol Series 910 with an ANSI connector, vertical mounting, and form “c” contacts.

The relay shall be equipped with test plugs to simulate a rapid pressure rise so that the unit can be tested periodically.

The relay shall be mounted on top of the transformer main tank.

The testing port shall be brought down to 30” from the bottom of the tank using 3/8” stainless steel.

The piping for this port shall follow the contours of the transformer tank.

A ball valve shall be provided at ground level for the sample port.

A stainless steel nameplate shall be provided next to the valve indicating this is the rapid pressure relay test port.

A Qualitrol 909-300-01 seal-in relay shall also be provided in the transformer main control cabinet.

This seal-in relay shall be equipped with reset button, indicating light, trip (63X) and alarm contacts and shall be mounted in the main control cabinet.

All circuitry and relays associated with each rapid pressure rise relay scheme for the main tank shall be independent from the rapid pressure rise relay scheme for the LTC.

The power for the seal-in relay shall be as specified in the Data Form.

The Rapid Pressure Rise Relay form “c” contact shall be the input to the seal-in relay.

The tripping output from the seal-in relay shall be used for tripping and wired out to terminal blocks, in the main control cabinet for FCPUD’s use.

Seal-in relay form “c” alarm contacts shall be wired to a terminal block in the main control cabinet for FCPUD’s use as specified in the Data Form.

One (1) dial type liquid temperature indicator-relay as specified in the Data Form shall be furnished and mounted in a thermowell as shown in Figure 4 of ANSI/IEEE C57.12.00 to indicate top oil temperature if specified in the Data Form.

Location and mounting arrangement shall be such that the sensing element can be removed without loss of oil and the thermowell will not interfere with tanking and untanking of the transformer core and coils.

If an analog output is specified in the Data Form, it shall also be equipped with an analog output and wired to a terminal block.

If Automation/Communications Equipment are specified in the Data Form that lists this analog as an input, it shall be wired from the terminal block to this communication or Automation/Communications Equipment.

The thermometer shall have a dark-faced dial with light markings, a light-colored indicating hand, and an orange-red maximum indicating hand with provisions for resetting.

The dial markings shall cover a range of 0 Degrees C to 140 Degrees C.

The gauge shall be marked with a stainless steel nameplate indicating “Liquid Temperature”.

The indicator shall be equipped with a manually reset maximum temperature indicating hand, which shall be accessible from ground level and no higher than four feet from the bottom of the transformer tank.

The indicator shall be vented.

The capillary tube shall be protected with a copper braided cover.

In addition to providing visible indication of the top oil temperature, it shall be equipped with separate contacts as listed below to alarm and/or control the devices specified herein.

The device shall have two (2) sets of normally open contacts for cooling and two (2) sets of adjustable form “c” contacts with factory settings as follows:

For cooling these contacts shall be wired in parallel with the output contacts of the ETM.

The ETM shall be the primary device to initiate cooling with the gauge being a backup.

Switch #1 – Initiate first stage of cooling, ETM setting plus 10 Degrees C (70 Degrees C)

Switch #2 – Initiate second stage of cooling, ETM setting plus 10 Degrees C (80 Degrees C)

Switch #3 – Initiate alarm at the temperature specified in the Data Form

Switch #4 – Initiate alarm or tripping as specified in the Data Form at the temperature specified in the Data Form

Dial type hot spot winding temperature indicator-relay(s) as specified in the Data Form shall be furnished and mounted in a thermowell as shown in Figure 4 of ANSI/IEEE C57.12.00 shall be furnished for the windings indicated in the Data Form.

Location and mounting arrangement shall be such that the sensing element can be removed without loss of oil and the thermowell will not interfere with tanking and untanking of the transformer core and coils.

If an analog output is specified in the Data Form, it shall also be equipped with an analog output and wired to a terminal block.

If Automation/Communications Equipment are specified in the Data Form that lists this analog as an input, it shall be wired from the terminal block to this communication or Automation/Communications Equipment.

The thermometer shall have a dark-faced dial with light markings, a light-colored indicating hand, and an orange-red maximum indicating hand with provisions for resetting.

The dial markings shall cover a range of 0 Degrees C to 160 Degrees C.

The gauge shall be marked with a stainless steel nameplate indicating “Winding Temperature (Location)”.

The indicator shall be equipped with a manually reset maximum temperature indicating hand, which shall be accessible from ground level and no higher than four feet from the bottom of the transformer tank.

The indicator shall be vented.

The capillary tube shall be protected with a copper braided cover.

Winding temperature indicator relay system shall incorporate a current transformer responsive to its associated phase winding current, calibrating resistor, temperature detector element and heater, all mounted and connected to simulate the hot spot temperature of the winding with which it is associated.

The current transformer circuit for the winding temperature gauge shall include a two pole current test switch to allow maintenance personnel to inject current at the test switch to test the thermal relay.

In addition to providing visible indication of the temperature of the winding with the highest calculated hot spot, indicator relay shall be equipped with separate contacts as listed below to alarm and/or control the devices specified herein.

The device shall have two (2) sets of normally open contacts for cooling and two (2) sets of adjustable form “c” contacts with factory settings as follows:

For cooling these contacts shall be wired in parallel with the output contacts of the ETM.

The ETM shall be the primary device to initiate cooling with the gauge being a backup.

Switch #1 – Initiate first stage of cooling, ETM setting plus 10 Degrees C (80 Degrees C)

Switch #2 – Initiate second stage of cooling, ETM setting plus 10 Degrees C (90 Degrees C)

Switch #3 – Initiate alarm at the temperature specified in the Data Form

Switch #4 – Initiate alarm or tripping as specified in the Data Form at the temperature specified in the Data Form

One (1) cover mounted automatic pressure relief device with semaphore flag, which can be reset manually for each 10,000 gallons of oil shall be provided.

The alarm contact shall be routed to the main control cabinet.

The pressure relief device shall be located such as to provide optimal coverage on the cover and whose operation will not result in physical damage to the bushings.

The automatic pressure relief device shall be as specified in the Data Form.

The pressure, at which the device operates, shall be provided on the Control Drawing Legend and on the Bill of Material on the outline drawing.

If required in the Data Form the output of the pressure relief device shall be directed to the base on the transformer.

The piping from the pressure relief device to the base of the transformer shall be a minimum of 3” steel pipe.

The pipe shall extend to 24” above the base of the transformer.

The last 12 inches of the pipe near the base of the transformer shall be painted bright red.

Alarm contacts for liquid-level, temperature indicators, and other alarms shall be non-grounded and suitable for interrupting:

0.02-ampere direct current inductive load

0.20-ampere direct-current non-inductive load

2.5-ampere alternating-current non-inductive or inductive load

250 volts maximum in all cases

The following alarms as a minimum shall be provided:

Highest Winding Hot Spot Temperature(s), Major - If used for Tripping as specified in the Data Form then to Tripping terminal block.

Highest Winding Hot Spot Temperature(s), Minor
Top Oil Temperature, Major - If used for Tripping as specified in the Data Form then to Tripping terminal block
Top Oil Temperature, Minor
Sudden Pressure Trip – Main Tank
Pressure Relief - Main Tank
Low Oil Level – Main Tank
Critically Low Oil Level – Main Tank
Critically Low Oil Level – Main Tank
Cooling Degraded Alarm Stage 1
Cooling Degraded Alarm Stage 2 from ETM (if applicable)
Cooling Stage 1 Activation Indication
Cooling Stage 2 Activation Indication
Reverse Power Flow Alarm (if applicable)
AC Failure Alarms
DC Failure Alarms (if applicable)
Device failure alarms for each individual ETM, annunciator.
Low Nitrogen Pressure Alarm (if applicable)
High Nitrogen Pressure Alarm (if applicable)
Empty Nitrogen Cylinder Alarm (if applicable)
All other alarms as recommended by MANUFACTURER.

All indicating and tripping devices mentioned shall have their alarm and trip contacts wired to a customer terminal strip in the control cabinet.

Main Control Cabinets and Wiring

The main control cabinet shall be accessible from ground level.

The bottom of the cabinet shall be a minimum of 24 inches above the base.

The top of the cabinet should not be above 78 inches, unless approved by FCPUD.

The main control cabinet shall be located in the Segment specified in the Data Form.

The main control cabinet shall be a NEMA Type cabinet as specified in the Data Form.

If required in the Data Form, a Lexan window in the cabinet door shall be provided to enable reading the ETM, if provided, and other devices without opening the cabinet.

The cabinet doors shall have a door alarm.

The alarm contacts for the door alarm shall be terminated on a terminal block in the main control cabinet.

The door contact switch(es) shall be located in a readily accessible area of the enclosure, conspicuously out of site from outside of the enclosure and placed out of direct accidental damage caused by opening and closing the compartment doors.

All cabinet external hardware such as hinges, latches, etc. shall be stainless steel.

If required in the Data Form, the control cabinet and junction cabinets shall be a non-rusting stainless steel with all external hardware such as hinges, latches, etc. shall be non-rusting stainless steel.

Fabricate the cabinet and panels from 1/8" steel or aluminum equivalent. Provide cabinet and panels that are rigid and self-supporting.

Design the panels to facilitate operating, maintenance, and future reconfiguration.

Position the cabinet to allow access to equipment from ground level.

All welds on all enclosures shall be continuous to prevent moisture entrance.

The interior of the control cabinet shall be white in color per the Painting Section requirements of this specification.

The control cabinet shall accommodate an uncut, removable, aluminum bottom conduit plate, 16 gauge maximum, for conduit entry punching in the field.

The removable plate shall be no less than 12" x 24" in size.

A clear path shall be provided between the conduit entrance and all terminal boards.

The MANUFACTURER shall not route conduit to the control cabinet in this bottom area of the cabinet.

This region is for FCPUD connections only.

If required in the Data Form, control cabinets shall have sun shields to prevent the sun from shining directly on the top of the control cabinets.

Provide exterior surfaces of the panels that are free from unused holes, seams, dents, weld marks, burrs, loose scale, sharp edges, or other imperfections. Equip all bolts and screws with lock washers.

Locate all equipment on the panel in order to provide adequate clearance for wiring, inspection, and testing.

Mount the metering, relaying, and control equipment on the panel fronts so that mechanical vibration or shock will not tend to cause false operation.

Do not mount any equipment on the exterior doors.

After fabrication of the panels, properly treat, prime, and paint with at least two (2) coats of epoxy enamel.

Paint all steel parts. Exterior paint to match transformer equipment.

If required in the Data Form, forced air ventilation with filter and thermostat shall be provided to help cool control cabinet during hot days.

The ventilation system shall have wire mesh screens.

The ventilation system shall be approved by FCPUD.

All control cabinet doors, including swing panels, shall be supplied with wind latches. If multiple doors are used in the control cabinet, the wind latches of the inner door shall attach to the outer door.

All control cabinet exterior doors shall have a three-point latch with upper and lower locking mechanism and single handle pad-lockable door opening and stainless steel continuous hinge.

1.1.1 The control cabinet shall be equipped with a drip shield to prevent rainwater from dripping into the control cabinet with the doors in the open position.

1.1.2 Control cabinets shall be thermally insulated to the level required in the Data Form.
The insulation method shall be approved by FCPUD.

The control cabinet shall be equipped with a weatherproof pocket, mounted on the inside of the control cabinet door. The weatherproof pocket shall be of sufficient size to accommodate the instruction book and all drawings.

The weatherproof pocket shall have a hinged top cover to facilitate retrieval of the instruction book and drawings.

The weatherproof pocket shall not interfere with the operation of the relays inside the control cabinet with the door closed.

Sufficient clearance shall be maintained between the weatherproof pocket and the devices inside the control cabinet with the doors in the closed position. The instruction manual shall be placed in a plastic bag inside this weatherproof pocket.

The following electrical accessories shall be provided in the main control cabinet:

One (1) thermostatically controlled heater (minimum 50 watt) to prevent condensation and to maintain required equipment minimum operating temperatures for the equipment located within the cabinet during extreme cold conditions (Waukesha PTC2 heaters are acceptable).

Strip heaters shall be rated for 240 VAC, connected at 120 VAC.

Thermostats shall have an adjustable setpoint with graduations in Degrees F.

One (1) 120 VAC, 100 W equivalent mechanically protected outdoor light (LED is preferred if it will start at the minimum ambient temperature specified in the Data Form) equipped with an outdoor fixture and outdoor door-operated switch.

One (1) 120 VAC, 20 Amp, dual receptacle outlet equipped with a Ground Fault Interrupting Device (GFCI).

The receptacle outlet shall be accessible from the outside of the control cabinet without having to open any control cabinet doors.

The receptacle shall have an in use weatherproof cover.

The weatherproof cover shall be a Hubbell Taymac MX3200 or FCPUD approved equal.

In the control cabinet, connect the low voltage electrical ground connections to a copper bus bar, which shall be connected to the ground system.

All control and alarm circuits shall be completely wired by the MANUFACTURER and brought to a weatherproof control cabinet.

All connections to FCPUD's external circuits shall be brought to the main control cabinet.

All circuits for the required auxiliary equipment such as CT's, fans, etc. shall be factory wired to terminal blocks in the main control cabinet.

The wiring shall be routed in rigid steel conduit and marked in accordance with the factory wiring diagrams.

All items of the cooling control system and auxiliaries, which are not mounted on external devices or on the transformer tank shall be mounted inside the main control cabinet.

All wiring shall be flame resistant, oil resistant, heat resistant, and moisture resistant and can withstand the ambient temperatures specified in the Data Form.

Conductor colors, sizes, and type shall meet the requirements of the National Electrical Code.

Splices in wiring will not be allowed except for CT wiring at the transformer tank feed through blocks.

No more than two wires shall be connected on one terminal.

All CT wiring shall be No. 10 AWG copper wire. Ground connections shall be provided on the shorting terminal blocks.

All transformer auxiliary wiring shall be a minimum of No. 14 AWG copper wire with 600 volt insulation.

The auxiliary wiring shall be routed to the control cabinet in galvanized conduit and fittings. All wiring shall be stranded conductors.

Analog or digital signal paths may be wired with No. 18 AWG wire.

Wire ends shall be permanently fitted with compression barrel type, insulated ring lugs before attaching securely to terminal studs.

Use of ratcheting type crimping tools is required. Open spade or fork connectors will not be accepted. Pins or ferrules shall be used on cage type terminals.

Bare stranded wires shall not be used for any terminations.

Grommets shall be mandatory on all electrical lines which pass through metal.

All exterior connectors shall be of a heat shrink type connector.

All wiring shall be complete and performed in a professional manner and bundled or contained.

Wiring shall be bundled by use of nylon cable ties, at intervals as required to provide a neat appearance.

Size of individually tied bundles shall be limited to 1-1/4 inch diameter. Wiring shall be supported by screw applied or epoxy applied tie mounts.

Self-adhesive tie mounts shall not be used.

Panduit raceways or FCPUD approved equal shall be used for control wiring bundles greater than 12" and customer cables.

The raceway shall not be filled more than the manufacturer's recommended fill and shall not exceed 50%.

The raceway shall be securely attached.

Self-adhesive mounting shall not be used.

All contacts, which are available for FCPUD's use, shall be identified on the schematic and wiring diagrams.

The MANUFACTURER shall design the layout of the electrical wiring in the control cabinet to segregate the MANUFACTURER's wiring from FCPUD's wiring.

Terminal boards shall be wired with one side reserved for the MANUFACTURER and one side reserved for FCPUD.

Factory wiring shall not be terminated on the side of the terminal boards reserved for FCPUD's use.

Short jumpers that are installed at the factory but may be removed in the field for FCPUD's connections, such as a 52a or 86T contacts, are allowed on the customer side of the terminal block.

Some method should be provided to guide and anchor FCPUD's field wiring. Ample space shall be provided for routing and termination of all FCPUD's wiring.

The required FCPUD connections for control power, relaying, etc. shall be clearly identified on the control cabinet wiring diagrams.

A conductor identification sleeve (with near end and far end designations) shall be provided on each end of each wire greater than six inches in length. The label shall not be less than 1/2 inch long and shall be as manufactured by the Dura Mark Company or equal.

Do not install plastic, snap on type identifiers.

The tag shall list the destination device designation and terminal number where the wire is landed.

No less than 10% of the non-shortening terminal block positions shall be unused, to be reserved for future applications.

Terminal blocks are to be identified by a letter and the position number only.

All devices in control cabinet shall be permanently identified and marked with appropriate reference designator as shown on the MANUFACTURER supplied schematic and wiring diagrams.

All control wiring shall be wired to the following terminal blocks:

Current transformer circuits shall be wired to 600 volt #10-32 barrier type terminal strips equipped with shorting bars (General Electric Type EB-27 or equivalent).

Each multi-ratio current transformer shall terminate on a separate block.

For general purpose wiring, 600 volt #10-32 barrier type terminal strips properly sized to handle the loads (General Electric Type EB-25 or equivalent) and wire sizes.

Barriers shall separate the contact strips.

Terminal blocks with clamp type fittings are not allowed.

Terminal board points for terminating transformer AC supply for fans, LTC drive, etc. shall accept the appropriate size of cable for the required ampacity and voltage drop.

The use of "plug-in" terminal boards will not be allowed.

Internal jumpers shall be provided so that AC power and DC power may be landed at only one point.

All screw-type terminal blocks shall be outfitted with slotted head screws. Phillips head screws will not be allowed.

Terminal board covers are not desired. However, a white marking strip shall be furnished, marked, and attached so that terminal points can be identified.

The layout of the terminal blocks shall be vertical with all terminal blocks mounted in the vertical position.

Adjacent terminal blocks shall provide a minimum of six inches between terminal block centerlines.

A minimum of six inches shall be provided between the bottom of terminal blocks and wall mounted devices and the bottom of the control cabinet.

The sides of any terminal block shall not be horizontally located closer than four inches to a cabinet wall.

Position all terminal blocks to allow unrestricted access to the terminal points and associated wiring.

If terminal blocks are mounted on the side panels of the control panel these shall be for CT circuits only. All other terminal blocks for FCPUD's connection shall be located on the back plane of the main control cabinet.

Adequate space shall be provided between the cabinet heater(s) and where FCPUD has to route cables so that cables will not be damaged by the heater(s).

Stainless steel studs shall be provided as necessary to route cables away from the heater(s)

Raceways, control wires, and cables shall be at least three inches from the swing panel edges, vertical walls, or bottom of the control cabinet.

Provide sufficient cabinet space for all cables to avoid cable bunching or stacking between the terminal blocks and the cabinet cable entries.

Control wiring and power wiring shall be separately bundled.

Maximum separation between power and small-signal wiring shall be maintained.

All cables shall enter through conduits and conduits shall enter the side of the control cabinet.

Control Cabinet Ground Bus

Purpose of Ground Bus

To provide a connection point that provides a positive low resistance path to the station ground grid in the control cabinet of a transformer for the purpose of grounding current transformer secondaries and other ground connections.

Method

The ground bus shall be physically positioned as close as possible to the current transformer terminal blocks.

If there are no current transformer terminal blocks, the ground bus shall be installed in a location that eases the connection from FCPUD's incoming cable shields.

There shall be no obstructions in front of the ground bus preventing access to the connection points.

The ground bus shall be copper with the following minimum dimensions $1/4" \times 2" \times \geq 8"$.

Auxiliary and Control Power

FCPUD will provide the AC Power as specified in the Data Form to operate the on load tap changer, cooling equipment, and control circuits.

All auxiliary power and control circuits, which are used to supply power to external circuits, shall be brought to suitable terminal blocks in the control cabinet before existing the control cabinet.

All contacts on auxiliary devices shall be wired to terminal blocks in the same cabinet for FCPUD's use.

One AC terminal board shall be provided for FCPUD to connect each AC power supply.

The terminal block shall be sized to accommodate a wire size up to four AWG sizes larger than the required for 125% of the maximum load.

All jumpers shall be provided and installed to provide AC power from this terminal block to all AC circuit breakers.

The required AC service size (kVA, amps, and voltage) shall be shown on the AC schematic next to the main AC terminals where FCPUD will provide AC Power.

Power (kVA), voltage and amperage requirements of the cooling equipment, Temperature Monitoring Equipment (ETM), controls, cabinet heaters, and all auxiliary equipment including recommended supply wire size shall be provided to FCPUD on the schematics for FCPUD to determine power supply needs.

AC loads shall be supplied by molded-case circuit breakers properly sized for the loads.

Molded-case circuit breakers shall be rated at 240 VAC.

Molded case circuit breakers are to be used exclusively.

Knife switches and fuses are not allowed.

All circuit breakers shall have a minimum interrupting rating of 25 kA.

All AC circuits shall be wired using appropriate wire sizes in accordance with NEC.

Auxiliary equipment, including motors for cooling fans, shall be designed for use on the specified auxiliary power supply.

AC failure relays with form "c" alarm contacts shall be provided for AC circuits as listed below:

For single phase circuits, a single phase relay shall be used.

For three phase circuits, a three phase relay shall be used that will also monitor the phase sequence.

These alarms shall have an adjustable time delay of up to five minutes.

The contacts shall be wired to alarm terminal blocks then to the

At a minimum, AC failure relays shall be installed at the end of the following AC circuit strings:

Cooling stage 1

Cooling stage 2

Cooling controls

Each rapid pressure rise seal-in relay power circuit

Each of the following circuits shall have overcurrent protection using a molded-case circuit breaker:

Cooling Stage 1

Cooling Stage 2

Cooling Controls

Temperature Monitoring Equipment (ETM)

Each rapid pressure rise seal in relay power circuit

Heaters

Lights and Receptacles

DC power is not available at this substation.

Fall Protection

A device suitable for mounting a safety device, located in the approximate center of the tank cover, and capable of supporting hardware including harnesses utilizing gravity brakes shall be provided.

Fall protection provisions shall be approved by FCPUD.

The fall protection mounting device shall be as specified in the Data Form.

Paint Requirements

General

The transformer, all other equipment, and control cabinets shall be painted inside and outside.

The finish coat shall be the color specified in the Data Form.

The paint system must meet the coating system performance requirements in IEEE C57.12.28.

The interior of the transformer tank and tank cover, the core frames, LTC compartment, and the interior of the control cabinets shall be finished with a Federal Std. No. 595-B White No. 17875 paint or equivalent bright white color.

Oil compatibility test shall be performed on the paint to be used inside the tank per ASTM D3455.

Two samples are aged for 164 hours at 100 Degrees C, one recipient full of original oil and other recipient full of oil together with painted panels.

At the end, the oil characteristics, e.g. power factor, in each recipient are measured and the results are compared in order to check if they comply with the standard parameters and there shall not be any change in the painted surface.

- a. The MANUFACTURER shall provide documentation that the paint system has passed a salt spray test of at least 1000 hours with the minimum thickness applied to the transformer.

Galvanized radiators shall not be painted.

A protective coating shall be applied to the base and the bottom surface of the transformer tank as specified in the Tank Section of this specification.

Paint shall be uniform and even, free of runs, sags, checks, or blisters.

Any defects appearing during the warranty period shall be repaired by and at the expense of the MANUFACTURER.

All masking materials shall be removed from the transformer prior to shipment.

All primer and paint shall be lead free.

The MANUFACTURER shall provide a separate non-prorated warranty on the finish for a five (5) year period.

The warranty shall cover rust, rust bleed-through, flakes, paint fading, and paint chipping.

Primer Coat

Surfaces shall be free of abrasives, oils, dirt, or contaminants when primed.

Handling of coating equipment and the steel surfaces to be primed shall be done in a manner to avoid contamination during and following application of the primer.

The surface temperature of the steel to be coated shall be 50° F minimum and at least 5° F above the wet bulb air temperature reading.

The primer coat shall be applied by air or airless spray in accordance with the paint manufacturer's latest recommendations.

The primer thickness shall be 2.0 mils (dry). The primer thickness shall be monitored by a Wet Film Thickness method.

The primer shall be allowed to cure prior to application of second or top coating for a minimum of the time recommended by the paint manufacturer.

Areas with dry film thickness less than 1.7 mils or greater than 5.0 mils shall be corrected by additional primer coating or by re-blasting and recoating.

The primer shall be of zinc rich inorganic type. It shall be recommended by the manufacturer as suitable for protecting against normal, non-corrosive outdoor weathering.

The primer coat shall be applied no more than 12 hours after blasting and on the same day it is blasted.

One (1) spray can of primer shall be furnished with the transformer per the Spare Parts Section to be delivered to the jobsite for field painting of any areas where paint has been damaged during shipment and erection.

Paint – Top Coat

The topcoat shall be a polyamide epoxy type. It shall be recommended by the manufacturer as suitable for protecting against normal, non-corrosive outdoor weathering.

Top coating shall be applied after any corrections have been made to the primed surface and the primer is fully cured.

The topcoat shall be applied to a thickness of 3.0 mils dry (primer plus topcoat = 5.0 mils, dry) using the manufacturer's recommended procedures.

The topcoat thickness shall be monitored by a Wet Film Thickness method.

Areas where the dry film thicknesses of the primer plus topcoat are less than 4.5 mils or greater than 8.0 mils shall be corrected.

Touch-up painting shall be done in conformance with SSPC-PA 1, Shop, Field, and Maintenance Painting, section 3.5.3.

One (1) spray can of the topcoat shall be furnished per the Spare Parts Section with the transformer and delivered to the jobsite for field painting of any areas where paint has been damaged during shipment and erection.

OBSERVATION AND MANUFACTURING TEST REQUIREMENTS

Observation Rights

FCPUD always reserves the right to visit the manufacturing facility (in person or virtually) and to observe the transformer while undergoing construction and testing.

The MANUFACTURER may not charge FCPUD for its right to visit the facility during construction and testing.

FCPUD shall be notified at least three (3) weeks prior to core and coil surveillance, pre-tanking surveillance, and the implementation of the required tests to determine if FCPUD will witness tanking and/or testing and arrange mutually agreed to tanking and test dates.

If a FCPUD Representative witnesses tanking or testing mutually agreed to firm dates shall be provided (2) two weeks before the dates.

If the three (3) weeks' notice is not given or at least two (2) weeks' notice for the agreed to firm dates, FCPUD reserves the right to have the MANUFACTURER delay tanking or testing until the first time in which FCPUD's representative(s) assigned to this purchase are available.

If the MANUFACTURER changes the date after it has been confirmed and agreed to by FCPUD, the MANUFACTURER shall be responsible for all change costs that FCPUD and FCPUD's representatives incur.

FCPUD and FCPUD's representative(s) will try to minimize the change costs.

Furthermore, if FCPUD's representative(s) arrives on site and the transformer is not ready for tanking or testing within a reasonable time or if there is more than a twenty-four (24) hour delay after testing begins because the test equipment is not functioning correctly or a test failure has occurred, FCPUD reserves the right to postpone, and the MANUFACTURER shall reimburse FCPUD for any travel and labor costs incurred by FCPUD due to MANUFACTURER's delays.

This reimbursement shall not be limited to one representative but all FCPUD representatives who have traveled to the MANUFACTURER's facility.

A third party transformer consultant may be employed at FCPUD's discretion and shall enjoy the same rights and privileges as a FCPUD employee.

Remote Core and Coil and Pre-Tanking Observation Additional Requirements:

High resolution camera (hard wired or Bluetooth) with connection to WIFI and/or broadband network.

A cell phone is not sufficient.

Video shall have the ability to zoom in for detailed observation as well as wide angle for overall viewing ability.

Audio shall be provided and can be provided by a cell phone.

The MANUFACTURER shall provide real time contact information to a designated individual, who will be continuously available and present at the transformer for the entire duration of the observation.

This contact information shall be in addition to the communications used for the virtual observation and it is intended to allow communications to be re-established in the event of audio or visual communications failure.

Network connection shall be high speed with adequate bandwidth to not cause delays and interruptions with the audio and video.

The audio and video shall be connected continuously.

The person operating the camera shall be well versed in the technical aspects of the transformer.

Typically, this might be a representative from engineering.

This may vary from MANUFACTURER, but the person shall have a working knowledge of the design details of the transformer being inspected.

The operator of the audio and video shall be able to converse in English.

Remote Witnessing Factory Acceptance Testing Additional Requirements:

High resolution camera (hard wired or Bluetooth) with connection to WIFI and/or broadband network.

A cell phone is not sufficient.

The video shall be mounted on a tripod or other device with a view of the test instrumentation with zooming capability so that the test instrument screens such as digital impulse analyzer, PD measuring equipment, and test instrument readings can be viewed.

The video capability shall be of such that impulse shots can be viewed and compared and all relevant readings are readable for each test.

Audio shall be provided for the duration of the tests and can be provided by a cell phone.

Network connection shall be high speed with adequate bandwidth to not cause delays and interruptions with the audio and video.

The audio and video shall be connected continuously.

The operator of the audio and video shall be able to converse in English.

The MANUFACTURER shall provide real time contact information to a designated individual in the test lab, who will be continuously available for the entire length of time that the transformer is in the test lab.

This contact information shall be in addition to the communications used for the virtual witnessing and it is intended to allow communications to be re-established in the event of audio or visual communications failure.

It is the intent of FCPUD to work with the MANUFACTURER on the above requirements.

It is FCPUD's intent to get enough preliminary notice (3 weeks) to schedule FCPUD's representatives to be present at tanking and/or testing.

FCPUD also wants an agreed to firm date (2) two weeks in advance to allow time to make travel arrangements.

FCPUD will recognize the MANUFACTURER's testing schedules and delays as long as the MANUFACTURER recognizes FCPUD's and FCPUD's representatives needs and will work with MANUFACTURER to minimize the costs of any delays.

To meet this both sides have to work as a partnership.

Delays caused by FCPUD exercising its rights as per the above paragraphs shall not relieve the MANUFACTURER from meeting the required delivery dates.

Requirements for core and coil observation.

The coils be completed but not nested. If MANUFACTURER's practice is to wind the low voltage coil on top of the regulating voltage coil while it is on the mandrel, pictures shall be provided on the outside of the regulating coil before the low voltage winding is wound on top of the regulating voltage winding.

Observation of each coil on both the inside and outside of the coil before any coverings are installed that would obscure the windings.

The core be assembled and upright except the top yoke does not need to be in place but available for observation.

Observation of the core including the top yoke.

Mill sheets for copper including the size of copper, stranding for CTC, paper wrapping thickness, type of paper insulation used, type of epoxy used on CTC, and the strength of the copper.

Mill sheets for the electrical steel. There are typically many pages of data submitted by the supplier, but FCPUD does not need every page. FCPUD needs verification of the steel supplier and the grade of steel used including the thickness.

Winding department QA checklists showing as a minimum the height of the coil, the radial build, and the tolerances allowed for these dimensions.

Preliminary test results are to be provided at the time of the surveillance of any test performed including ratio, resistance, Megger, PA exciting current, and PA Megger.

Copies of any nonconformance reports.

Requirements for pre-tanking observation.

Witness the final pressing of the coils.

MANUFACTURER to provide before arrival at the factory the calculations showing the pressure on each winding resulting from the amount of force applied per phase in the final pressing operation.

- The calculation details shall be provided and enough information to confirm the calculations.

The manufacturing drawings are to be provided for review showing the phase pressing instructions.

Observation of the active part with all the leads in place/installed that would be installed before the unit is tanked.

Barriers on the outside of the DETC and leads shall not be installed until after the observation.

Observation of the tank and the in progress work of the installation of the auxiliaries and control cabinet.

Witness tanking if time permits.

If not previously supplied, mill sheets for copper including the size of copper, stranding for CTC, paper wrapping thickness, type of paper insulation used, type of epoxy used on CTC, and the strength of the copper.

If not previously supplied, mill sheets for the electrical steel. There are typically many pages of data submitted by the supplier, but FCPUD does not need every page. FCPUD needs verification of the steel supplier and the grade of steel used including the thickness.

Winding department QA checklists showing as a minimum the height of the coil, the radial build, and the tolerances allowed for these dimensions.

Preliminary test results are to be provided at the time of the surveillance of any test performed including ratio, resistance, Megger, PA exciting current, and PA Megger.

Copies of any nonconformance reports.

Requirements for witnessing factory acceptance testing.

FCPUD has the option to witness any or all factory acceptance testing.

The test data for all tests already performed shall be presented to FCPUD's representative when they arrive at the factory to witness testing.

Impulse testing cannot begin until FCPUD's representative has reviewed and approved all tests performed before impulse testing.

The FCPUD representative has the right to take copies of all test work sheets and forms pertaining to the transformer under test when they leave the factory after witnessing tests.

If a FCPUD representative visits the factory to perform surveillance on FCPUD's transformer or to witnesses testing, they have the right to take pictures/videos using own device/camera/cell phone (not supplier provided device/camera/cell phone) of the transformer that is being inspected and/or tested and to take these pictures/videos with them when they leave the factory.

The FCPUD representative may take pictures/videos of manufacturing process such as lifting of Active Part to tank or equipment such as induction welding machine, hydraulic clamping, etc. or manufacturing environment monitoring device such as temperature, humidity, pressure, dust control, etc. or manufacturing environment monitoring device result/reading or open/broken door/window/leak in the factory roof/wall letting rain water or dust or foreign material to contaminate the factory manufacturing environment may impact the quality assurance of FCPUD transformers.

The MANUFACTURER shall maintain the right to inspect the pictures taken and remove ones where the MANUFACTURER's proprietary processes may be disclosed.

FCPUD's representative has the right to inspect all QC files pertaining to FCPUD transformers.

If the English language is not used at the factory an interpreter shall be provided whenever a FCPUD representative is at the MANUFACTURER's location for factory inspection, design review, core and coil observation, pre-tanking observation, and witness testing and for any other interaction as required.

This interpreter shall be available to FCPUD's representative at all times when the representative is at the MANUFACTURER's location.

The interpreter shall also be available outside the factory if FCPUD representative requests the interpreter's presence.

The MANUFACTURER shall pay for all costs for the interpreter.

Approval or acceptance of MANUFACTURER's design, procedures, assembly, or tests shall not absolve MANUFACTURER from rectifying any later development of flaws, imperfections, omissions, oversights, or failures during order and warranty period.

Test Requirements

All routine tests listed in Section 8.2.1 of ANSI/IEEE C57.12.00 for Class II Power Transformers shall be performed on each transformer in accordance with the latest version of ANSI/IEEE C57.12.90 and C57.12.00.

Failure to meet any specified parameter may be the basis for rejection of the transformer.

The following tests, routine and additional, shall be made on each transformer.

Unless specified otherwise, all tests shall be performed in accordance with ANSI/IEEE C57.12.90 (most recent version) except where more stringent test voltages are required in these specifications.

Failure to meet any specified parameter may be the basis for rejection of the transformer.

Tests shall not be limited to those described in the specification.

The MANUFACTURER may perform additional tests, which they deem necessary under their quality control program.

Where there is a conflict between any test method or values specified in this section and the IEEE standards, it shall be communicated to FCPUD so the conflict may be reconciled.

The following test sequence shall be used:

Ratio/Phase Relation/Polarity Tests

Insulation Resistance and Core Megger

Insulation Power Factor and Capacitance Tests (overall and bushings)

Single Phase Excitation Tests

DC Winding Resistance Tests

No-Load Loss and Excitation Current Measurements

LTC Voltage Test (if supplied)

Overexcitation Test (can be performed after second No-Load Loss and Excitation Current Tests)

Sound Tests (can be performed after second No-Load Loss and Excitation Current Tests)

Load Loss and Impedance Measurements Including Zero Sequence

LTC Current Test (if supplied)

Temperature Rise Tests

Lightning Impulse Tests

Switching Surge Impulse Tests, if required by Standards or the Data Form

Applied Voltage Tests

Induced Test

No-Load Loss and Excitation Current Tests (No-Load Loss Guarantee Value Established Here)

Insulation Power Factor and Capacitance Tests (overall and bushings)

Single Phase Excitation Tests

Sweep Frequency Response Test (SFRA)

Auxiliary Controls Tests including but not limited to: (Can be executed anytime during testing)

LTC Controls – Manual and AVR (if supplied)

Temperature Controls – Manual and through gauges

Alarms

Sudden Pressure Relay Trips and Alarms

If any other method besides truck shipment is used, perform an additional SFRA (Doble Method) using a Doble 5000 series test set with the unit in its shipping state.

This shall include the requirement of installing temporary test bushings for shipment (remaining in the unit during shipment) before the test is performed.

All testing shall be performed with the transformer fully assembled including controls and sensors.

The bushings to be shipped with the transformer, oil preservation system, and radiators/heat exchangers shall be installed on the transformer and shall be used during all testing.

Prior to any electrical testing, all tank covers shall be completely welded in place with an inorganic gasket material between the cover and tank flange providing a hermetic seal of the main tank.

The cover must be welded in place during final assembly prior to final testing.
Temporary clamping is not acceptable.

Insulation power factor and capacitance tests shall be performed prior to any power frequency voltage being applied to the transformer.

Temporary external barriers are not allowed between bushings or other live parts including live parts to ground and live parts to live parts during factory testing.

Once the first set of Doble and excitation tests are completed, they shall be sent to FCPUD.

A Dissolved Gas Analysis (DGA) shall be performed immediately before Factory Acceptance Tests.

Oil samples shall be taken in accordance with the requirements of ASTM D3613 and tested in accordance with the requirements of ASTM D3612.

A summary of required gas in oil analysis and particle count tests are shown in the following table:

Required DGA	Tanks
Before All Factory Tests	Main

Required DGA	Tanks
After Load Loss Test	Main
Before 24 Hour Overexcitation Test	Main
After 24 Hour Overexcitation Test	Main
Before Temperature Tests	Main Includes Particle Count
After Each Segment of Temperature Tests	Main
After All Temperature Tests	Main Includes Particle Count
Before Dielectric Tests (Impulse)	Main
After Dielectric Tests (Induced)	Main

Insulation Power Factor and Capacitance Tests (Overall And Bushings)

If more than one connection is available for a winding (example: dual voltage winding), overall power factor and capacitance tests shall be performed for each winding connection.

All test voltages and setups shall be according to Doble standard test methods using a Doble M4100 test set.

All reads, test voltage, power factor, milliamps, capacitance, and watts in both directions at 10kV shall be reported.

All test data shall be in DOBLE format.

The overall power factor shall be less than 0.5% when corrected to 20 Degrees C.

Take C1 and C2 power factor measurements and capacitance measurements of all capacitance graded bushings.

The bushing C1 and C2 power factor shall not deviate from the value stamped on the nameplate by more than 10% and the C1 and C2 capacitance shall not deviate from the value stamped on the nameplate by more than 2%.

If deviations more than what is stated occur, FCPUD shall be contacted immediately.

C2 power factor fluctuations that occur in some bushings will be considered and the intent is to review the test results to verify they are acceptable.

The Bushing C2 Test Voltage shall be as follows:

Bushings Rated 69kV or Lower – 500 Volts

Bushings Rated Above 69kV – 2000 Volts

Make a “hot collar” type power factor test of all solid bushings.

The value of each solid bushing shall not deviate by more than 2% from the watts loss of the other solid bushings on the transformer.

Single Phase Excitation Tests

Excitation tests shall be performed at 10kV or the highest voltage (not to exceed 10kV) that the winding can sustain in all combinations of DETC and LTC positions.

The same test voltage shall be used for all LTC and DETC positions.

Perform test on each LTC tap (if supplied) from 16L to 1R while the DETC tap (if supplied) is at the nominal position.

Make excitation tests at 10kV on each DETC tap (if supplied) while the LTC remains at the neutral position.

If more than one connection is available for a winding (example: dual voltage winding), single phase excitation tests shall be performed for each winding connection.

All test voltages and setups shall be according to Doble standard test methods using a Doble M4100 test set.

All reads, test voltage, milliamps, and watts shall be reported.

All test data shall be in DOBLE format.

No-Load Loss and Excitation Current Tests

MANUFACTURER shall measure no-load losses and exciting current at 90%, 100%, 110% voltage before and after the impulse tests.

The values measured after the impulse tests will be used for guarantee purposes.

At a minimum the no-load losses and exciting current shall be measured at LTC (if supplied) positions neutral and 1R.

If an LTC is supplied and is a variable volts per turn design, the no-load losses shall be measured at LTC positions neutral, 1R, and the LTC position having the highest no-load losses.

If more than one connection is available for a winding (example: dual voltage winding), the no-load losses shall be measured for each winding connection.

The core loss shall be corrected to 20 Degrees C.

Load Losses and Impedance Tests

PROVIDE IN PROPOSAL the method for measuring the load losses.

Only methods that have sufficient accuracy for measuring losses at low power factor are acceptable.

Load losses shall be reported at the reference temperature specified in the Data Form.

Measure the load losses and impedances (HV to LV) at the following DETC (if supplied) and LTC positions (if supplied) on the self-cooled rating and maximum nameplate rating:

DETC Position	LTC Position
C	Neutral
C	1R
C	16R
C	16L
C	Highest Loss Position
A	Neutral
E	Neutral

DETC Position	LTC Position
Highest Impedance	Highest Impedance
Lowest Impedance	Lowest Impedance

Measure zero sequence impedance (HV to LV) at the following DETC (if supplied) and LTC (if supplied) positions on the self-cooled rating:

DETC Position	LTC Position
C	Neutral

Impedance, resistance, and inductance shall be reported.

The impedance voltage shall be reported.

Oil samples shall be taken from the main tank for gas in oil analysis immediately after the load loss tests.

Overexcitation Test

The MANUFACTURER shall perform an overexcitation test at the voltage level specified in the Data Form.

The duration of the overexcitation test shall be 24 hours.

Hourly measurement and recording of no-load losses and excitation currents shall be made and recorded.

For variable flux designs, the DETC (if supplied) and LTC (if supplied) positions shall be set to the highest flux density positions.

Oil samples shall be taken from the main tank for gas in oil analysis immediately before and after the excitation test.

Oil samples shall be taken in accordance with the requirements of ASTM D3613 and tested in accordance with the requirements of ASTM D3612.

The maximum increases in the gas levels shall be as shown in the following table:

Gas	Maximum Increase
Hydrogen	15 PPM
Methane	2 PPM
Ethane	2 PPM
Ethylene	1 PPM
Acetylene	Non Detectable

The gas in oil analysis from the two samples taken after the completion of the excitation tests shall be compared to the gas in oil analysis from the pretest sample.

If the gases have increased by more than the limits outlined above, FCPUD shall be contacted and a course of action determined.

It is expected that the MANUFACTURER shall locate and correct any problem that results in gas values above these limits.

Temperature Rise Tests

The test equipment that will be used to inject losses into the transformer for temperature rise tests shall have a power supply of sufficient capacity to provide the total measured losses to the transformer during the entire temperature test.

100% of the measured losses shall be supplied to the transformer during the temperature rise tests.

Reducing the losses supplied to the transformer due to test equipment limitations or other limitations is not allowed.

If more than one winding connection is specified (example: dual voltage winding) separate temperature rise tests shall be performed for each winding connection.

The test lab shall not exceed an ambient temperature of 40 degrees C during the entire temperature rise testing period.

Temperature rise tests made at the self-cooled and maximum forced cooled ratings are required on all transformers.

If allowed in the Data Form, for duplicate transformers the temperature rise test at the self-cooled rating will not be required.

If allowed in the Data Form, for duplicate transformers, the temperature rise test can be replaced with a 12 hour current injection test at the maximum nameplate current. The DETC and LTC tap positions are as required for the temperature rise test and the DGA tests and maximum increases are as indicated for the temperature rise tests.

Temperature rise tests shall be performed before dielectric tests.

Accelerating (boosting) the temperature rise test is not allowed.

The oil and winding time constants, for each stage of cooling, are to be determined during the temperature rise tests.

Using one oil and winding time constant for all stages of cooling is not acceptable.

Temperature rise tests shall be performed at the self-cooled rating and at the maximum forced cooled rating. And if specified in the Data Form at the overload rating.

If required in the Data Form, additional temperature rise tests are required to determine the oil and winding time constants and winding hot spot and oil exponents “m” and “n” per IEEE C57.119.

These tests shall be performed at the 100% rating followed by three tests at 70%, 125%, and base (ONAN) rating.

During these tests the same heat transfer equipment shall be operating.

Overload top oil rise and maximum hot spot temperatures rise shall be recalculated using the data from the temperature rise tests.

The MANUFACTURER shall measure and report both the top and bottom oil rises and cooler inlet and outlet temperature rises for both the ONAN and the maximum forced cooled ratings and compare to the values calculated during design.

Thermal scans are not allowed in place of actual thermocouples for top oil, top radiator, and bottom radiator oil temperature measurements.

The oil temperature rise and winding temperature rise tests shall be performed with the DETC (if supplied) in position “E” (lowest voltage/highest current position) and the LTC (if supplied) shall be set in position 16L (if supplied).

The oil temperature rise and winding temperature rise reported values shall be corrected using the IEEE formulas to the tap position that results in the maximum rise and altitude specified in these specifications.

If an ETM, fiber temperature probes, and/or gauges are specified, they shall be in service during the temperature rise tests and the ETM, fiber probes, and gauge top oil temperature shall be recorded during the thermal tests.

The ETM, and gauge probes shall be in close enough proximity to each other that the results are within 2 Degrees C.

Fiber probes within the same winding shall be within 5 Degrees C of each other.

Tested temperature rise values shall not be higher than 5 Degrees C above the values in the design review submittals.

If any temperature rise on one phase exceeds the corresponding temperature rise on any other phase by more than 4 Degrees C, FCPUD shall be consulted, and further investigative tests shall be performed as necessary.

Winding resistance measurements from shut down shall be plotted and shall be used as the basis for the determination of winding time constant.

Resistance measurements shall be measured at a minimum every 30 seconds for a minimum of 10 minutes.

The raw data, cooling curves, and other required measurements shall be included in the test report.

Temperature readings for the maximum forced cooled rating shall be taken on all three phases of each group of windings (HV, LV, etc.).

Temperature readings for the self-cooled rating test shall be taken on the phase with the highest readings during the maximum forced cooled rating tests.

If the winding rise or the hot spot rise values are within 2 Degrees C of the maximum allowed values, temperature readings shall be taken on all three windings.

The results (top oil temperature, winding temperatures, hottest spot temperatures, load losses, and corrections shall be documented in the test report.

All readings taken during the test shall be provided in the test report.

Oil samples shall be taken from the main tank for gas in oil analysis and particle count analysis immediately before and after the temperature tests.

In addition, oil samples shall be taken from the main tank for gas in oil analysis after each segment of the temperature tests.

Oil samples shall be taken in accordance with the requirements of ASTM D3613 and tested in accordance with the requirements of ASTM D3612.

The particle count shall be measured in particles per 100 ml using a 5 micron filter. The particle count shall be less than or equal to 10,000.

The maximum increases in the gas levels in the main tank with the combination of the base rating and maximum rating temperature rise tests shall be as shown in the following table:

Gas	Maximum Increase
Hydrogen	15 PPM
Methane	2 PPM
Ethane	2 PPM
Ethylene	1 PPM
Acetylene	Non Detectable
Carbon Monoxide	25 PPM
Carbon Dioxide	250 PPM

If an overload temperature rise test is required in the Data Form, the requirements of the preceding paragraph are the same except the maximum increases in the gas levels in the main tank with the combination of the base rating, maximum rating, and overload rating tests shall be as shown in the following table:

Gas	Maximum Increase
Hydrogen	20 PPM
Methane	2 PPM
Ethane	2 PPM
Ethylene	1 PPM
Acetylene	Non Detectable
Carbon Monoxide	50 PPM
Carbon Dioxide	350 PPM

The gas in oil analysis from the two samples taken after the completion of the temperature tests shall be compared to the gas in oil analysis from the pretest sample.

If the gases have increased by more than the limits outlined above, FCPUD shall be contacted and a course of action determined.

In general, it is expected that the MANUFACTURER shall locate and correct any problem that results in gas values above these limits.

Thermal images shall be taken of all sides of the transformer when the transformer has stabilized at the maximum cooled rating.

These images shall be part of the test report.

Calculations shall be revised for the overload (if overload is specified) average winding rise, top oil rise, and hot spot rise and shall be provided as part of the test report.

The following constants shall be provided after the temperature rise tests.

This data, in the following table format, shall be provided in the thermal test section of the test report.

If not required in the Data Form, the winding hot spot and oil exponents “m” and “n” shall be the values identified in the IEEE standards.

All other values shall be determined by temperature rise tests.

Description	Base Rating (ONAN)	80% of Max Rating (ONAF)	Maximum (ONAF/ONAF) – Not Overload Rating
Top Oil Rise Over Ambient			
HV HS Rise Over Top Oil			
LV HS Rise Over Top Oil			
Ratio of HV to LV Load/No-Load Losses (Avg. of N & 1R)			
HV Winding Time Constant			
LV Winding Time Constant			
HV Winding Exponent			
LV Winding Exponent			
Oil Temperature Time Constant			
Oil Temperature Exponent			

Impulse Tests

All winding and neutral terminals shall be tested in accordance with ANSI/IEEE impulse test standards for the BIL specified and in accordance with this specification.

DETC (if supplied) and LTC (if supplied) positions during the tests shall be per ANSI/IEEE C57.12.90 with the DETC and LTC set to the positions shown in the following table.

If an LTC is present, it shall be set to the first bridging position above the nominal voltage rating.

Bushing Being Tested	HV Tap Setting	LV Tap Setting
H1	Lowest	Highest
H2	Nominal	N or 1R
H3	Highest	Lowest
X1	Highest	Lowest
X2	Nominal	N or 1R
X3	Lowest	Highest

The voltage and current traces for all impulse tests shall be recorded utilizing HIAS computerized registration system or equivalent.

The values for all impulses shall be recorded including all wave shaping impulses.

Discrepancies or differences on impulse test oscillograms will not be allowed except those caused by integral protective devices as outlined in ANSI/IEEE C57.98 and ANSI/IEEE Std. 4.

If such discrepancies or differences exist due to circuitry or other problems on any phase, the problem shall be corrected and all tests shall be repeated on all phases already tested.

If there is a substantial time delay (30 minutes or greater) between the impulse tests on any terminal, then the impulse test sequence shall be restarted on that terminal from the beginning.

If more than one winding connection (example: dual voltage winding) is specified impulse tests shall be performed on each bushing for each winding connection associated with that bushing.

A series of impulse tests shall be conducted on all terminals H1, H2, H3, X1, X2, X3, X0, etc. in accordance with ANSI/IEEE C57.12.90.

Strict adherence to the order of the impulse tests is required.

The minimum test sequence to be used on all terminals that will not be grounded such as H1, H2, H3, X1, X2, and X3 shall be as follows:

One (1) Reduced Full Wave

One (1) Full Wave

Two (2) Chopped Waves

Two (2) Full Waves

The following is the minimum test sequence that shall be used on grounded terminals such as X0, H0, and H0X0 if they are brought outside the transformer and grounded.

One (1) Reduced Full Wave

Three (3) Full Waves

If internal surge arresters, varistors, or non-linear resistors are installed that operate during impulse tests the following minimum test sequence shall be used on all terminals that will not be grounded such as H1, H2, H3, X1, X2, and X3 shall be as follows:

One (1) Reduced Full Wave

One (1) 75% Full Wave

One (1) 90% Full Wave

One (1) Full Wave

Two (2) Chopped Waves

Two (2) Full Waves

One (1) 90% Full Wave

One (1) 75% Full Wave

One (1) Reduced Full Wave

If internal surge arresters, varistors, or non-linear resistors are installed that operate during impulse tests the following minimum test sequence shall be used on grounded

terminals such as X0, H0, and H0X0 if they are brought outside the transformer and grounded.

One (1) Reduced Full Wave

One (1) 75% Full Wave

One (1) 90% Full Wave

Two (2) Full Waves

One (1) 90% Full Wave

One (1) 75% Full Wave

One (1) Reduced Full Wave

Switching Surge Tests – If one winding is rated 345kV or higher switching surge tests shall be performed on all terminals such as H1, H2 and H3 that are rated 345kV or higher and shall be performed in accordance with ANSI/IEEE C57.12.90.

The tests shall consist of MANUFACTURER's standards for the positive waveforms to prevent saturation of the core and consist of following.

One (1) reduced full voltage negative waveform

Three (3) full voltage negative waveforms

DETC (if supplied) and LTC (if supplied) shall be set for the maximum voltage transfer to the other windings.

For a switching surge test on the high side with the DETC located on the high side and the LTC located on the low side typical tap settings will be as follows:

DETC Position	LTC Position
E	Neutral

Switching surge tests are not required on windings below 345kV unless required in the Data Form.

FCPUD can add switching surge test requirements at any time before factory testing for an additional cost.

If additional switching surge tests are required in the Data Form or added at any time by FCPUD before testing begins, the switching surge test voltage shall be at full voltage on the high side windings and levels agreed to by MANUFACTURER and FCPUD or as specified in the Data Form.

The tolerance of the voltage magnitudes and waveforms shall be according to the IEEE standards except for the items noted below:

No Exceptions

For Full Wave and Reduced Wave Tests, if the tail of the waveform cannot meet the IEEE standards 50 microsecond requirement the following applies:

If other test equipment is available at the factory that has more capacity to provide the proper wave shape the transformer shall be tested with the equipment that has more capacity.

If test equipment is not available with more capacity FCPUD will accept a shorter tail than what the IEEE standards require as long as the tail is long enough (usually at least 30 microseconds) to get enough detail to make a valid comparison.

If the above items do not resolve the problem, as a last resort and with FCPUD's approval, a series resistor may be added at the grounded end of the winding per the IEEE standards to extend the tail of the waveform.

This resistor shall be the lowest value possible, not to exceed 500 ohms, to get enough detail in the tail to make a valid comparison.

FCPUD will accept a shorter tail under this condition, as long as a comparison can be made.

Oil samples shall be taken for gas in oil analysis immediately before the impulse tests.

Oil samples shall be taken in accordance with the requirements of ASTM D3613 and tested in accordance with the requirements of ASTM D3612.

Applied Voltage Test

The applied voltage test shall be made in accordance with the appropriate ANSI/IEEE standards and with the test voltages as specified in IEEE C57.12.00 (most recent version) for Class II transformers.

For wye windings where the neutral BIL is lower than the phase BIL the test voltage applied shall be per the BIL of the neutral.

110kV BIL neutral shall have a test voltage of 34kV, 125kV BIL neutral shall have a test voltage of 40kV, 150kV BIL neutral shall have a test voltage of 50kV, 200kV BIL neutral shall have a test voltage of 70kV, 250kV neutral shall have a test voltage of 95kV, 350kV neutral shall have a test voltage of 140kV.

If more than one connection is available for a winding (example: dual voltage winding), a separate Applied Voltage Test shall be performed for each winding connection.

Sound Test

If more than one connection is available for a winding (example: dual voltage winding), separate sound level tests shall be performed for each winding connection.

Transformer sound measurements shall be made on each transformer in accordance with ANSI/IEEE C57.12.90.

The sound test shall be performed with the DETC (if supplied) and LTC (if supplied) in the highest flux density positions where the highest sound level is generated.

The so

und tests shall be performed at 105% overexcitation.

At a minimum the no-load sound shall be measured and reported in the Certified Test Report at the base rating and each stage of cooling.

If required in the Data Form, the load sound level shall also be measured and combined with the no-load sound level.

The load, no-load, and combined sound levels reported in the Certified Test Report.

Induced Voltage Test with Partial Discharge Measurements

The low frequency induced voltage test with partial discharge measurements shall be made in accordance with ANSI/IEEE standards as specified for Class II transformers with the following modifications.

The One-Hour Level and Enhanced Level shall be performed using the voltages specified in IEEE C57.12.00-2021 for Class II Transformers.

If more than one connection is available for a winding (example: dual voltage winding), a separate Induced Voltage Test shall be performed for each winding connection.

The DETC (if supplied) shall be set to the nominal tap position and the LTC (if supplied) shall be set to 15R for an LTC with an autotransformer (bridging position) or 16R for an LTC without a preventative autotransformer.

During the test the pressure inside the transformer tank shall not be increased by artificial means to reduce the partial discharge (PD) level.

The pressure and liquid level inside the transformer tank and/or conservator tank shall be at the usual service conditions during the test.

Any exceptions that increases the tank pressure by more than 0.5 psi over normal operating pressure requires FCPUD approval prior to the test.

Such as an elevated conservator,
The Certified Test Report shall include a note confirming this approval.

Increasing the pressure may be done as a remedial step to diagnose a source of high PD, as an example to identify and collapse suspected bubbles in the liquid,

The test shall be repeated with no added pressure as stated above after the bubbles are eliminated.

Apparent partial discharge shall be measured and reported both in terms of the RIV at 1 MHz, generated in accordance with ANSI C57.12.90, and in terms of Pico-coulombs for wide band in accordance with ANSI/IEEE C57.113.

All bushings with capacitance taps (115kV and above) shall be monitored for Pico-Coulombs and microvolts.

If the transformer voltage rating is less than 115kV the capacitance taps on the high side bushings shall be monitored.

The partial discharge shall be measured and recorded at the One-Hour level as the voltage is being increased to the Enhancement Level.

The partial discharge shall be measured and recorded at the Enhancement Level.

The first reading following the enhancement shall be taken five minutes after the voltage reaches the One-Hour Level and every five minutes thereafter for a total of 60 minutes.

The partial discharge level shall not exceed 100 microvolts or 250 Pico-Coulombs during the hour.

Maximum allowable RIV shall be 200 microvolts and 500 Pico-Coulombs for the enhancement test.

The partial discharge level shall not increase more than 30 microvolts or 50 Pico-Coulombs during the hour beyond the values observed at the 158% level prior to the enhancement as the base reading.

There shall be no continuous increase during the hour or during the last 20 minutes of the hour.

Potential discharge of anyone phase shall not be higher than 200% of another phase.

In the event that the 100 microvolts limit or the 250 Pico-Coulombs limit, the 30 microvolts increase or the 50 Pico-Coulombs increase or the continuous increase requirement are exceeded, the cause shall be determined and corrected.

The readings shall remain stable during the test.

If instability occurs, the cause for the instability shall be investigated and corrected.

If this occurs, FCPUD has the right to require that the test be started over again.

In the event that a deviation from the specification exists, FCPUD, in conjunction with the MANUFACTURER, will consider available options including extended testing.

The final course of action must be acceptable to FCPUD.

Oil samples shall be taken from the main tank for gas in oil analysis immediately after the induced test at the end of the dielectric testing.

Oil samples shall be taken in accordance with the requirements of ASTM D3613 and tested in accordance with the requirements of ASTM D3612.

Sweep Frequency Response Analysis (SFRA) Tests

Perform SFRA tests (Doble method) using a Doble 5000 series test set using Doble recommended tests and setups.

Measurements shall be made for each high side winding with the untested bushings open circuited, each low side winding with untested bushings open circuited, and each high side winding with the low voltage line bushings (X1, X2, X3) short circuited.

The core shall be demagnetized prior to the start of any SFRA testing with a superfine setting (24 steps) at 10 Amps.

The Frequency Response Tests before preparing for shipment shall be performed with all temporary bushings removed and leads in their final assembled locations.

The transformer condition shall be the same as after it is assembled and filled in the field.

The DETC (if supplied) shall be set in the nominal voltage position and the LTC (if supplied) shall be set in position 16R.

If any other method besides truck shipment is used, perform an additional SFRA tests (Doble Method) using the Doble 5000 series test set with using Doble recommended tests and setups with the unit in its shipping state.

This shall include the requirement of installing temporary test bushings for shipment (remain in the unit during shipment) before this test is performed.

Turns Ratio Test

Turns ratio tests shall be performed at the DETC tap positions (if supplied) and LTC tap positions (if supplied) in accordance with the following table:

DETC Position(s)	LTC Position(s)
C	16L through 16R

DETC Position(s)	LTC Position(s)
All	Neutral

If more than one connection is available for a winding (example: dual voltage winding), the turns ratio per the table above shall be performed for each winding connection.

Turns ratio test results should not deviate more than one-half of one percent (0.5%) from the nameplate ratio.

Winding Resistance Tests

Resistance tests shall be performed on each winding.

At all DETC (if supplied) tap positions.

At all LTC (if supplied) tap positions 16L, and 1L through 16R.

If more than one connection is available for a winding (example: dual voltage winding), the winding resistance tests shall be performed for each winding connection for the taps listed above.

Winding temperature shall be recorded at the time of the test. Winding resistance test results from the different phases shall compare within one percent (1%) of each other.

If a two winding series transformer is used, resistance tests shall be made on the regulated winding with the LTC in neutral only.

Resistance tests shall be performed on all primary windings.

For autotransformers the resistance of the common winding shall include the LV bushing.

For delta windings and ungrounded wye windings the measurements shall be phase-to-phase.

For grounded wye windings the measurements shall be phase-to-neutral.

Test results shall be reported at the temperature tested and at the temperature specified in the Data Form.

Test results shall be reported for each winding (measurement) as well as the three phase sum.

Current Transformer Tests

The current transformers shall be tested in accordance with ANSI/IEEE C57.13. In addition to the CT manufacturer's test report, after installation in the transformer and wired to the control cabinet terminal blocks.

The tests shall be performed from the terminals in the main control cabinet.

The CT tests shall include at a minimum the following tests:

Excitation Tests – All Ratios

Ratio – All Ratios

Polarity

Winding and Lead Resistance – All Taps

Insulation Resistance

Control and Power Wiring Tests

All control and cooling equipment shall be functionally tested.

Functional testing means applying the appropriate inputs (voltage, current, pressure, temperature, etc.) to a device and verifying all required responses or outputs. The types of tests usually included, but not limited to, are the following:

Low Frequency Withstand Tests

Low frequency withstand voltage tests shall be performed on all control and secondary wiring in accordance with Section 5.16 of ANSI/IEEE C37.09.

Rapid Pressure Rise Relays

Rapid pressure rise relays (main tank and LTC, if applicable).

Operational “go/no” test using a Qualitrol KIT-013 Rapid Pressure Rise Relay Field Test Kit or FCPUD approved equal.

Cooling Equipment Tests

Cooling equipment shall be functionally tested using the gauges, ETM, and control switches to verify proper operation.

Motor starting current for fans.

Fan rotation checking air flow.

Alarm Sensors Tests

Alarm sensors tests (top oil temperature, winding temperature, low oil, etc.) (function and calibration tests) shall be performed.

Wiring Verification

All control and cooling terminal block wiring should be verified to match the MANUFACTURER’s drawings.

Trip Checks

All low voltage wiring, including control and indication wiring shall be given full functional tests including but not limited to the following and commonly referred to as “Trip Checks”:

Functionality of all trip and alarm circuits.

Nitrogen Gas Equipment Checks (if supplied)

Check regulator operation.

Check valve positions.

Test moisture content of nitrogen gas per ASTM D3283.

Auxiliary Losses

Control/auxiliary and cooling consumption losses shall be measured at all stages of cooling.

All associated control equipment including heaters shall be energized.

Tank Pressure Test

Tank shall be leak tested by applying a pressure of 125% or the maximum operating pressure with a 10 psi minimum for a minimum of 12 hours.

If leaks are found, they shall be repaired and the test repeated.

The transformer shall be assembled and the radiators, bushings, and conservator (if provided) shall be installed for this test.

Volts Per Hertz Curve

A graph of the voltage versus time curve (V/Hz) shall be provided with the Certified Test Report.

Tests After Dry Out Before Tanking

The MANUFACTURER shall furnish insulation resistance, single phase excitation, and power factor values taken on the windings immediately after dry out.

Special Test Requirements

A detailed test plan shall be sent to FCPUD three (3) weeks before the scheduled test date.

The test plan shall include test voltages, tap settings, and acceptance criteria including the requirements of these specifications.

Typically the test plan provided is similar to the test plan provided to the testing department and used during the factory acceptance tests.

When the test plan is submitted the MANUFACTURER shall provide a statement that all test equipment being used for testing FCPUD's transformer have up to date calibrations and that all appropriate test equipment is operational and functioning properly.

To reduce schedule delays and assist in meeting the time parameters FCPUD will consider requested changes in the test sequence for non-dielectric tests.

The requested changes must be submitted with the detailed test plan and must be approved by FCPUD.

All testing shall be accomplished using the United States 60 Hz standard.

Testing using 50 Hz and then calculating the results at 60 Hz will not be accepted.

All devices shall be connected and functioning during testing.

This includes but is not limited to LTC controls, cooling controls and devices, and temperature monitor.

There shall be no intentional delays in the entire dielectric test sequence.

The lightning impulse tests, applied voltage tests, and induced voltage tests shall be carried out continuously with minimal delays to allow only for the test circuit setup.

If any tests results are off due to the transformer core being magnetized, the core shall be demagnetized and the test repeated until proper test results are obtained.

The entire test sequence shall be repeated if failure occurs at any time during the test sequence that requires untanking, repairs, and/or rework of the active parts.

If any repairs are performed during or after testing, the MANUFACTURER shall re-perform any tests requested by any FCPUD representative at no cost to FCPUD.

FCPUD shall be notified immediately of any failure of testing and all testing shall be stopped at that time until course of action is determined by FCPUD.

The MANUFACTURER may be required to repeat testing already performed to satisfy the reason of a failed test at no cost to FCPUD.

If a problem occurs during any dielectric test, which results in the lowering of the oil and repairs below the top of the core and coil assembly, all dielectric tests completed up to that point shall be repeated.

FCPUD shall be notified immediately of any unusual damage occurring during construction of the transformer and all tests which do not meet specified or standard values.

FCPUD shall be permitted, at their option, to personally inspect such damages and/or test failures and inspect and approve all repairs to the transformer.

Certified Test Report

Certified Test Reports shall be provided for each transformer.

The PDF report file must be copy enabled, printable, and comment enabled.

A Certified Test Report shall be placed in each instruction manual and two (2) copies sent separately from the transformer.

The MANUFACTURER shall also present evidence of quality control testing and proof that the transformer has passed these tests.

FCPUD shall approve the transformer quality control test results before the shipment of the transformer.

All reports shall be in English and in standard non-metric units of measure except temperatures shall be in degrees Celsius.

The Test Report shall be printed on 8 1/2" x 11" size paper and bound in a lightweight folder with the MANUFACTURER and the serial number clearly printed on the cover.

The Test Report shall also be provided in an electronic format using Adobe Acrobat PDF file format(s) that is bookmarked for each major section and then sent to FCPUD.

The PDF report file must be copy enabled, printable, and comment enabled.

The electronic files for the Doble power factor, excitation, and SFRA tests shall be sent to FCPUD in the format that can be read by the Doble test programs when the Certified Test Report is submitted to FCPUD for review.

The settings files for the ETM and other electronic devices shall be submitted when the Certified Test Report is submitted to FCPUD for review.

As a minimum, the test reports shall include:

Copy of the test plan.

All items required by IEEE C57 standards.

All items required in these specifications.

Table showing transformer ratings, winding configurations, DETC and LTC tap range, and BIL level of each winding.

Preventative Auto tests before tanking (if applicable)

Losses

Phase Voltage

Phaser Currents

Average Sound Level

Losses, Efficiencies, and Voltage Regulation.

Provide statement of accuracy of loss measurement system, tested losses at guaranteed taps, and guaranteed values for comparison.

Table listing No-Load Losses and excitation current for all tested taps before and after impulse at a reference temperature of 20 Degrees C.

Table listing Load Losses at for all tested taps at the reference temperature specified in the Data Form.

Table listing percent efficiencies at 25%, 50%, 75%, and 100% of maximum nameplate rating at the reference temperature specified in the Data Form.

Table listing percent voltage regulation at maximum nameplate rating at 80%, 90%, and 100% lagging power factor at the reference temperature specified in the Data Form.

Table listing control and auxiliary losses at each stage.

Volts Per Hertz Curve

a.1 A graph of the voltage versus time curve (V/Hz) shall be provided.

Impedances

Table listing impedance at the reference temperature specified in the Data Form for all tested taps and MVA ratings.

Impedance, resistance, and inductance shall be reported.

Impedance voltage shall be reported.

Impedance MVA base shall be reported.

Table listing zero sequence impedance and if applicable "T" diagram with a listing the impedances for each branch at the reference temperature specified in the Data Form for all tested taps.

Winding Resistance Tests

Table listing each winding resistance for each tap along with the measured temperature for each winding at the reference temperature specified in the Data Form.

Include in the table shall be the sum of the 3 phases at the reference temperature specified in the Data Form.

In the table list the deviation of each winding resistance from the average winding resistance for each tap.

Temperature Rise Tests

The complete data log for each temperature rise test. All temperatures are in Degrees C and include at a minimum the following:

Ambient temperature

Top oil temperature

Top radiator temperature(s)

Bottom radiator temperature(s)

Noters when shutdowns occur and resistance measurements taken

ETM and/or fiber temperatures

The following shall be provided for each temperature rise test summary. All temperatures are in Degrees C and where appropriate corrected to the highest loss taps and altitude specified in these specifications.

- Hop spot factor from engineering
- Hot resistance versus time curves
- Cold resistance measurements and temperature
- Average winding rise
- Calculated winding gradient
- a.2 When ETM and/or fiber temperature probes are present, temperature readings from the ETM and/or fiber probes shall be included in the Certified Test Report when the ETM and/or fiber temperature reading is available for the above items.
- a.3 Thermal images of each side of the transformer and top at the peak of the temperature rise test.
- a.4 Overload maximum hot spot temperatures and maximum top oil temperature shall be recalculated using the data from the temperature rise tests. This information shall be listed below the temperature rise tests summary table.
- a.5 An attachment that contains a copy of temperature rise test log with all measured temperatures including the ones measured by the ETM, fiber probes, and temperature gauges shall be included.
- a.6 As an attachment, resistance measurement log for each winding including ambient, heat run MVA rating, and kW used for heat run.

The resistance of each winding at each time interval from the time the readings are first obtained through 10 minutes shall be listed.

Resistance shall be calculated back to time 0 and this value with the average winding temperature shall be summarized at the bottom of the table for each winding.

Table showing the data required as outlined in these specifications to be able to properly set any ETM.

Impulse Tests

As an attachment, a sequential Impulse Log listing all impulses, including calibration shots, shots not used for comparison and actual failure shots, if any. The listing shall include the following information:

- Bushing Designation (X1, X2, etc.)
 - DETC and LTC Position
 - Wave Type
 - Required kV
 - Record Number
 - Test kV
 - Crest Time
 - Flashover Time
 - a.3 As an attachment, a color copy of each impulse trace that was used for comparison shall be included.
- Each trace shall be provided individually and then the comparison traces, with offset, on sheets at the end of the individual traces.
- Traces that were not used and wave shaping traces do not need to be provided.

A summary table preceding the impulse traces that were used for each winding listing the following information for each trace:

Bushing Designation (X1, X2, etc.)
 DETC and LTC Position
 Wave Type
 Required kV
 Record Number
 Test kV
 Crest Time
 Flashover Time

b. Applied Voltage Test

b.1 A table listing the voltage rating of each winding tested, the voltage applied, and the duration of the test shall be included.

c. Induced Voltage Tests

c.1 A table shall be provided listing each winding and the rated L-L voltage for tap tested and the Enhanced Level test voltage and the One Hour Level test voltage for each winding.

c.2 A table shall be provided listing the readings during the induced test and shall include the following:

Test voltage value on highest voltage winding
 Test voltage on winding voltage applied
 Percent of nominal voltage applied on winding voltage applied
 Time of readings
 Pico-Coulombs and microvolt readings for each time interval

d. Over-Excitation Test

d.1 A table shall be provided with the following:

Time
 Current in RMS
 Voltage in RMS
 Average Oil Temperature
 Tested Core Loss
 Calculated Core Loss at 20 Degrees C
 Excitation Current

Hot Spot Indicators

A table shall be provided, listing calibration data for each hot spot gauge including the reference gradient and currents and connections used.

If applicable, include a statement and/or table showing the hot spot settings that were input into the ETM.

Sound Tests

Table indicating results of sound tests showing sound levels at the base rating and maximum rating.

If sounds tests require the sound due to load current, show results of both the energized and loaded sound tests and the sum of the results.

Detailed diagram showing the location of the sound measuring devices and the sound level over time for each device including background ambient sound levels.

Core Insulation (Megger) Tests

List the results of the following insulation resistance tests:

- Main Core
- Frame to Main Core
- Preventive Autotransformer Core
- Frame to Preventive Autotransformer Core
- Series Core
- Frame to Series Core

Dew Point

The moisture dew point prior to shipment or before oil filling at the factory if unit is shipped full of oil shall be included with the following information:

- Measured Dew Point
- Core Temperature at Time of Test
- Tank Pressure at Time of Test
- Insulation Moisture Content

Ratio Tests

Table(s) listing following ratio test information:

- Tap
- Nameplate Ratio
- Measured Ratio for Each Phase
- Percent Deviation from Nameplate Ratio

Power Factor and Capacitance Tests

Doble format including all readings.

Include Bushing Tests.

Single Phase Excitation Tests

Doble format including all readings.

SFRA Factory Tests

Table listing each SFRA test with the transformer in its assembled state including tap positions during each test.

Each trace shall be shown separately. The traces shall also be combined for each test type (Example Types: H-X, H-H0, X-X0, etc.).

A statement shall be provided that the SFRA test in the shipping state, if applicable, has been performed along with a Table listing each SFRA test including tap position.

These traces do not have to be part of the Certified Test Report, just the statement and table.

Labeled photographic record of test lead hookup and routing for each test connection shall be included.

Current Transformer Tests

Excitation Tests – All Ratios.

Ratio – All Ratios.

Polarity.

Winding and Lead Resistance – All Taps/Ratios.

Insulation Resistance.

ETM, Top Oil, and Winding Temperature Gauge Tests

Probe verification (accuracy).

Setup and all output contacts (alarm, cooling, and tripping) verification.

Cooling Equipment Tests

Functional tests.

Motor starting current for fans.

Fan rotation checking air flow.

Nitrogen Gas Equipment Checks (if supplied)

Regulator operation.

Check valve positions.

Test moisture content of nitrogen gas per ASTM D3283.

Calibration tests for each sudden pressure relay

Alarm sensors tests (low oil, off step, etc.) (Including both functional and calibration tests)

Terminal block wiring check against MANUFACTURER's final drawings

Results on control and secondary wiring low frequency withstand voltage tests

Tank Pressure Tests

Provide results of tank pressure test including pressure applied and duration of test.

Other Tests - List what additional tests were performed and if applicable list the reference test data file

Test Failures/Deviations/Problems

Provide statement(s) describing test failures, deviations, or problems, if any, and description of resolution.

Factory QA Reports on any failures of this transformer that result in factory process improvements.

Work Sheets

All work sheets and rough data shall be supplied to FCPUD upon FCPUD's request.

Photographic record of the manufacturing of the transformer from digital images taken by high-resolution, 12 megapixel or higher, digital camera shall be submitted.

The camera and associated equipment used to take the photographs shall be approved by FCPUD.

All digital images shall be provided to FCPUD in an electronic format (email, download site, etc.) and provided in each electronic supplied instruction manual.

Hard copies of the Instruction Manual shall include a USB Thumb Drive or other digital media approved by FCPUD containing all digital images and placed in the instruction manual pouch of each instruction book.

At a minimum, the following photographs shall be included:

Photos of each winding type.

Photos of the core steel before installation of the windings.

Photos of the assembled unit before tanking, including photos of the completed lead structures, the LTC and the DETC.

Photos of the assembled unit after tanking.

SHIPPING AND RECEIVING

General

Manufacturer shall be fully responsible for designing and manufacturing the transformer in such physical size and weight so that it can be shipped to the point of delivery.

The Main Tank and cover shall be a single shipment. Units with shipping covers are not acceptable.

Manufacturer shall submit a written transportation plan for delivery of the transformer to the destination for FCPUD's review and approval.

Shipping Requirements

Shipment shall be made DDP to location (destination, pad, etc.) as specified in the Data Form with full freight allowed and prepaid.

FCPUD contact for all Shipping Notices and Packing Lists is indicated in the Data Form.

The MANUFACTURER shall deliver transformer on the date specified in the Data Form.

Early delivery shall be approved by FCPUD before shipment.

FCPUD contact for all Shipping Notices and Packing Lists is indicated in the Data Form.

The shipment paperwork included with the shipment shall include documentation of what is supplied in each gas bottle shipped with the transformer.

Deliveries will only be accepted on FCPUD working days and hours unless other arrangements have been made.

FCPUD working days and receiving times are indicated in the Data Form.

The MANUFACTURER shall notify FCPUD five (5) working days before delivery and everyday thereafter of the actual location and estimated delivery date of the transformer.

Any delays in unloading the transformer or the auxiliary equipment shall be the responsibility of the MANUFACTURER.

The MANUFACTURER shall send shipping notice to FCPUD estimating the arrival date of the shipment two (2) weeks before shipment.

The shipping notice shall describe each shipment of material or equipment.

Shipping notices shall include the following:

- Customer Name
- Description of Material
- Purchase Order Number
- Manufacturer Order Number
- Name and Address of Manufacturer
- Date

The MANUFACTURER shall furnish a separate packing list with each shipping crate with name of item of equipment being shipped.

Packing lists shall also state that the transformer is being shipped filled with dry air or fluid filled.

Immediately upon completion of packing the rail car or other transportation vehicle, a copy of the packing list shall be emailed to FCPUD.

All transformer equipment shall be shipped by rail or truck in an upright position, either with or without fluid.

The MANUFACTURER shall ship the transformer filled to the 25 Degrees C level if at all possible and/or furnish sufficient transformer insulating fluid in clean tank trucks with sealed pumps and hoses at the job site and delivered to the site as outlined in these specifications.

The tank trucks shall be certified clean and dry.

Make up (or topping off oil) shall be provided in the gas space of the unit (overfilling) if possible.

Each compartment, which will contain insulating fluid, of each unit that is shipped dry (without insulating fluid) shall be shipped filled with dry air at positive pressure with a means for monitoring.

The dry air shall have a dew point reading of -50 Degrees C or drier at 20 Degrees C ambient temperature to ensure exclusion of moisture and external atmosphere until filling.

The MANUFACTURER is responsible for furnishing and delivery of a dry transformer to the jobsite.

Transformers shipped filled shall employ an adequate method of oil preservation during transit employing positive nitrogen pressure with a means for monitoring.

The nitrogen shall have a dew point reading of -50 Degrees C or drier at 20 Degrees C ambient temperature.

The MANUFACTURER is responsible for furnishing and delivery of a dry transformer to the jobsite.

The MANUFACTURER shall provide an inert gas, such as nitrogen (oil filled) or dry air (not oil filled), supplied in a pressurized cylinder, maintaining a regulated positive pressure during the shipment period.

If the transformer is found without a positive pressure, or the moisture content is higher than established limits, the MANUFACTURER will be responsible for re-establishing acceptable conditions.

Equipment shall be shipped as completely assembled as possible within shipping facility and route limitations.

The MANUFACTURER shall be responsible for packaging all parts for shipment so that they will not be damaged and can be stored outside for a reasonable period of time.

The MANUFACTURER shall be responsible for and make good any and all damage due to improper preparation or loading for shipment.

Arresters and bushings shall be packaged so that polymer/silicon weather sheds maintain their geometry during shipping and storage until they are installed.

The transformer shall be wrapped in a protective covering for shipment.

Protective shipping covers for gauges, viewing windows, site glasses, etc., shall be provided.

Bushings installed in the transformer shall be seal wrapped for shipping.

Core grounds shall be accessible for testing through shipping packaging to facilitate acceptance testing prior to unloading the transformer.

If bushings are removed for shipment, each bushing shall have a tag attached that indicates what position it was in during testing so it can be installed in the same position during assembly in the field.

The bushing leads shall be attached to eye hooks under bushing cover plate, and not tied off to the windings.

Bottom connected bushings must be shipped installed in the transformer if the transformer is shipped filled with insulating fluid.

Detachable radiators or heat exchangers shall be shipped detached and filled with dry air complete with steel, gasket-sealed, and blind-flanges in place.

The MANUFACTURER shall be responsible for manufacturing and shipping the transformer such that it will withstand, without damage, all forces encountered during truck, water, or rail shipment.

When shipping by rail, signs shall be placed on all four sides of the transformer that state "Do Not Hump".

When shipping by rail, the MANUFACTURER shall use special cars designed to provide maximum protection from shock.

The transformer shall fit on a depressed center rail car 9 feet wide, with lower flat portion of the car 25 feet in length.

For rail, barge, and/or ocean shipments, at a minimum, the transformer shall be designed and constructed to handle the accelerations shown in the following table. The longitudinal direction is intended to be the direction of travel.

Direction	Accelerations
Longitudinal	5g
Vertical	3g
Transverse	3g

PROVIDE IN PROPOSAL the minimum accelerations that the transformer will be designed to withstand.

A minimum of two (2) suitable recording devices on all shipping methods shall be attached before loading the shipment.

The recorders shall be capable of measuring in three directions: horizontal, vertical, and transverse.

The recorders shall be sealed to prevent tampering.

Battery powered, Electronic Digital Impact Recorders (Lat-Lon or equivalent) with GPS technology for online shipment tracking and reporting of the magnitude of axial, transverse, and vertical forces shall be provided with all shipments.

GPS device time-synched with tracking via an internet website shall be provided so that any major impacts can be traced to a particular time and location.

Impact recorders shall be equipped with a password protected customer account for tracking unit allowing online customer tracking and reports to data, impact

reports, photos, maps and displays of the shipment during transportation at the customers preference.

The tracking devices shall periodically (several times a day) transmit the location of the transformer and all impacts to which the transformer has been subjected, to a “cloud” based FCPUD accessible location.

This shall be done in such a fashion that FCPUD can view this data on a real time basis.

These recorders shall register all impacts and the readings from these impact recorders shall be available to FCPUD personnel upon receipt of equipment as outlined under Measurements/Readings Before Transformer Section.

Calibration data showing that the impact recorders are in proper calibration shall be available to FCPUD personnel at time of receipt of equipment.

PROVIDE IN PROPOSAL what method(s) will be used to ship the transformer.

Estimates of the shipping weight of the largest piece, the shipping weight of the heaviest piece, and the total shipping weight shall be transmitted to FCPUD.

The dimensions of the largest piece shall be included.

The MANUFACTURER is responsible to review the shipping destination drawings and shipping route.

The MANUFACTURER shall provide requirements for all transportation including, turning radii, loading for ground structures, overhead crane clearances, and permitting.

Any extra charges for any items that could have been foreseen and not included in the bid will not be allowed.

If not shipped with oil, the transformer shall be shipped with positive inert gas pressure, with a means of monitoring.

The MANUFACTURER is responsible for furnishing and delivery of a dry transformer to the jobsite.

Fans shall be mounted on and shipped with the appropriate radiator bank(s).

Observation Before Disassembly At Factory

After the transformer has been completely assembled and all control wiring completed, an observation of the transformer shall occur as follows.

Digital images taken by a high-resolution, 12 megapixel or higher, digital camera shall be taken and provided to FCPUD for approval and include the following:

Each segment of the transformer

Top of the transformer

Inside the control cabinet

Front view of each swing panel

Back view of each swing panel

Each side of the back plane of the cabinet

Hidden ground, if applicable, on the inside and outside of the main control cabinet.

The camera and associated equipment used to take the photographs shall be approved by FCPUD.
All digital images shall be provided to FCPUD for review and approval before shipment.

Measurements And Approvals Before Shipment

Factory Dew Point Measurement

The MANUFACTURER shall take a dew point measurement prior to shipment or before oil filling at the factory if unit is shipped oil filled.

The MANUFACTURER shall email FCPUD the results of the dew point measurements and the dew point instrument calibration data for approval.

At a minimum, the MANUFACTURER shall provide the actual dew point measurement, the core and coil temperature when the dew point measurement was taken and how the temperature was determined, the date and time the transformer was filled with dry air, and date and time the dew point measurement was taken.

The MANUFACTURER shall not ship the transformer until written permission from FCPUD is received.

This information shall be also recorded on a weather resistant tag and attached to the interior of the control cabinet prior to shipping.

Dew Point Instrument

The dew point measurement shall be taken with a reliable definitive dew point instrument approved by FCPUD.

Fog type dew point meters will not be allowed.

The dew point measurement taken with FCPUD's approved instrument shall be the official dew point instrument used to determine if additional drying is needed.

Acceptable Dew Point

The dew point shall show a moisture content in the insulation of less than 0.5% as determined by the IEEE standards using methods approved by FCPUD.

Tank pressure shall be considered when calculating the dew point.

All readings shall be made no earlier than twenty-four (24) hours (48 hours if unit is shipped with oil) after the transformer has been disassembled for shipment and filled with dry air.

FCPUD reserves the right to take its own dew point measurement of the transformer before it is filled or shipped to FCPUD.

The MANUFACTURER shall provide two (2) week notice to FCPUD before the pre-shipment dew point measurement.

The MANUFACTURER shall not open the transformer after the dew point measurement is taken for any reason without written permission from FCPUD.

If the MANUFACTURER opens the transformer another dew point measurement before the unit is shipped will be required that meets the requirements of this specification.

The costs associated with taking the second reading shall be paid by the MANUFACTURER.

If the dew point measurement taken by FCPUD or the MANUFACTURER is greater than the maximum allowed, the MANUFACTURER shall perform additional drying before the transformer is shipped.

FCPUD reserves the right to refuse shipment if the transformer does not meet the specified criteria.

The MANUFACTURER shall perform a DC core ground resistance measurement of the main core, preventative auto core (when supplied), and series (booster) transformer core (when supplied), when the transformer is ready for shipment.

If shipped by rail, barge, or ocean transport, the MANUFACTURER shall perform SFRA tests (Doble Method) using a Doble 5000 series test set with the unit in its shipping state per the requirements of the Factory Testing Section.

This shall include the requirement of installing temporary test bushings for shipment (remaining in the unit during shipment) before the test is performed.

Before shipment FCPUD shall approve the following:

Certified Test Report

Dew point readings

Shipping Core Ground Measurement

Shipping SFRA (if applicable)

Weight measurements

Additional Requirements For Barge Shipment

For barge transport of any transformer or accessory, the following additional requirements shall be included in the unit price of each transformer:

Photographic record of the transformer from digital images taken by high-resolution, 12 megapixel or higher, digital camera shall be taken every time the transformer changes custody and before unloading from any railcar, at port of loading before leaving for the final destination, and at port of entry before leaving for final destination.

At a minimum, pictures shall be taken of all four sides and top of the transformer.

The camera and associated equipment used to take the photographs shall be approved by FCPUD.

All digital images shall be provided to FCPUD using a method approved by FCPUD (email, download site, Thumb Drive, etc.).

A recording pressure gauge shall be provided to monitor tank pressure that can provide the maximum and minimum tank pressure and when each occurred.

The minimum monitoring time shall be at least 14 days or 150% of the anticipated length of the trip, whichever is longer.

The impact recorders shall be inspected by the MANUFACTURER and the impact data reviewed by the MANUFACTURER and FCPUD prior to any transformer being moved from the barge.

Transformer experiencing shocks greater than 100% of the maximum impact allowed shall have a detailed internal inspection performed by both the MANUFACTURER and FCPUD before leaving barge unloading port for final destination.

MANUFACTURER shall provide written assurance on the integrity of the internal core and coil assembly following the inspection if no corrective actions are necessary.

MANUFACTURER shall perform the following tests every time the transformer changes custody and at a minimum before unloading from any railcar, at barge loading port before leaving for the final destination, and barge unloading port before leaving for the final destination.

These tests shall be performed, prior to FCPUD's acceptance and removal of each transformer from its shipping conveyance.

MANUFACTURER shall perform SFRA tests (Doble Method) using a Doble 5000 series test set with the unit in its shipping state per the requirements of the Factory Testing Section.

Test lead set up and routing shall match those used at the factory prior to shipping. These traces shall be compared with the pre-shipment SFRA tests.

DC core ground resistance measurement of the main core, preventative auto core (if supplied), and series transformer core (if supplied),

Any other MANUFACTURER recommended tests, necessary to ensure that each transformer arrives at the delivery port damage free, shall be performed.

If pressure has been lost or any other sign that the tank seal has been compromised a dew point measurement shall be performed.

MANUFACTURER shall provide all in-shipment tests to FCPUD.

All electronic test files generated shall be provided to FCPUD upon completion of the tests.

Additional Requirements For Ocean Transport

For ocean transport of any transformer or accessory, the following additional requirements shall be included in the unit price of each transformer:

Photographic record of the transformer from digital images taken by high-resolution, 12 megapixel or higher, digital camera shall be taken every time the transformer changes custody and before unloading from any railcar, at port of loading before leaving for the final destination, and at port of entry before leaving for final destination.

At a minimum, pictures shall be taken of all four sides and top of the transformer.

The camera and associated equipment used to take the photographs shall be approved by FCPUD.

All digital images shall be provided to FCPUD using a method approved by FCPUD (email, download site, Thumb Drive, etc.).

Daily weather projections shall be provided, to FCPUD, for the area in which each transformer is located during shipping.

Each transformer shall be equipped with one automatic pressure sensor that is attached and configured to display each tank's internal pressure during the entire ocean transport time with a minimum reporting and recording time of at least 45 days or 150% of the anticipated length of the trip, whichever is longer.

The pressure sensor shall record or indicate the maximum and minimum pressures experienced by the transformer during transit.

FCPUD shall be provided with all of the necessary software, licenses, and passwords to enable real time monitoring of each shipment.

Additional impact recorder requirements.

Two additional impact recorders shall be installed prior to shipment, and each shall be supplied with a minimum recording interval of at least 45 days or 150% of the anticipated length of the trip, whichever is longer.

The impact recorders shall be inspected by the MANUFACTURER and the impact data reviewed by the MANUFACTURER and FCPUD prior to any transformer being moved from the port of entry at the final destination country.

Transformer experiencing shocks greater than 100% of the maximum impact allowed shall have a detailed internal inspection performed by both the MANUFACTURER and FCPUD prior to leaving the port of entry.

MANUFACTURER shall provide written assurance on the integrity of the internal core and coil assembly following the inspection if no corrective actions are necessary.

The recording shall indicate the installation date with UTC time.

If both recorders stop running, a thorough inspection on the external and internal parts of the associated transformer shall be made by the MANUFACTURER's Representative at no additional cost to FCPUD.

This inspection shall occur at port of entry before leaving for final destination.

At the time of shipping, tank pressure, temperature, dew point, and date of preparation shall be certified and recorded on a weather resistant tag and attached inside the control cabinet.

MANUFACTURER shall perform the following tests on the transformer every time the transformer changes custody and at a minimum before unloading from any railcar, at port of loading before leaving for the final destination, and at port of entry before leaving for the final destination. These tests shall be performed, prior to FCPUD's acceptance and removal of each transformer from its shipping conveyance.

These tests shall be performed, prior to FCPUD's acceptance and removal of each transformer from its shipping conveyance.

MANUFACTURER shall perform SFRA tests (Doble Method) using a Doble 5000 series test set with the unit in its shipping state per the requirements of the Factory Testing Section.

Test lead set up and routing shall match those used at the factory prior to shipping.

These traces shall be compared with the pre-shipment SFRA tests.

DC core ground resistance measurement of the main core, preventative auto core (if supplied), and series (booster) transformer core (if supplied),

Any other MANUFACTURER recommended tests, necessary to ensure that each transformer arrives at the destination port of entry damage free, shall be performed.

If pressure has been lost or any other sign suggests that the tank seal has been compromised a dew point measurement shall be performed.

MANUFACTURER shall provide all in-shipment tests to FCPUD. Transformer cannot leave the destination port of entry until tests are approved by FCPUD.

All electronic test files generated shall be provided to FCPUD upon completion of the tests.

FCPUD shall be notified at least three (3) weeks prior to transformer arriving at the destination port of entry to determine if FCPUD will go to the port of entry to inspect transformer, impact recorder and witness testing.

If a FCPUD Representative is going to be present, an agreed to firm date shall be provided (2) two weeks before the dates or as soon as possible thereafter.

If the three (3) weeks' notice is not given or at least two (2) weeks' notice for the agreed to firm dates, FCPUD reserves the right to have the MANUFACTURER delay the inspection and testing until the first time in which FCPUD's representative(s) assigned to this purchase are available.

If the MANUFACTURER changes the date after it has been confirmed and agreed to by FCPUD, the MANUFACTURER shall be responsible for all change costs that FCPUD and FCPUD's representatives incur.

FCPUD and FCPUD's representative(s) will try to minimize the change costs. Furthermore, if FCPUD's representative(s) arrives on site and the transformer is not ready for inspection and testing within a reasonable time or if there is more than a twenty-four (24) hour delay after testing begins because the test equipment is not functioning correctly, FCPUD reserves the right to postpone, and the MANUFACTURER shall reimburse FCPUD for any travel and labor costs incurred by FCPUD due to MANUFACTURER's delays.

This reimbursement shall not be limited to one representative and shall include all FCPUD representatives who FCPUD intended to travel to the port of entry.

A third party transformer consultant may be contracted at FCPUD's discretion and shall enjoy the same rights and privileges as a FCPUD employees and representatives.

Measurement/Readings Before Unloading Transformer

MANUFACTURER shall arrange to have the transformer and parts inspected at the jobsite prior to removal from transportation mode (train, truck, barge, or shipment).

All readings shall be made at the rail site if shipped by rail or job site if shipped by truck before the transformer is off loaded.

FCPUD will be on site for monitoring the receiving of the transformer and accessories.

The impact recorders shall be inspected, and impact data reviewed by the MANUFACTURER and FCPUD.

Photographic record of the transformer from digital images taken by high-resolution, 12 megapixel or higher, digital camera shall be taken before unloading from a railcar and/or truck.

At a minimum, pictures shall be taken of all four sides and top of the transformer.

The camera and associated equipment used to take the photographs shall be approved by FCPUD.

All digital images shall be provided to FCPUD using a method approved by FCPUD (email, download site, Thumb Drive, etc.).

Record arrival gas pressure.

Perform SFRA tests (Doble Method) using a Doble 5000 series test set before the transformer is unloaded from a rail care or trailer if an SFRA test was performed in the transformer's shipping state.

Perform DC core ground resistance measurement main core, preventative auto core (if supplied), and series (booster) transformer core (if supplied) of the transformer before it is unloaded from a rail care or trailer.

Transformers experiencing shocks greater than 100% of the maximum allowed impact shall have a detailed internal inspection performed by both the MANUFACTURER and FCPUD prior to acceptance.

MANUFACTURER shall provide written assurance on the integrity of the internal core and coil assembly following the inspection if no corrective actions are necessary.

If this is required, MANUFACTURER shall perform this inspection at no additional cost to FCPUD.

UNLOADING, ASSEMBLY, VACUUM FILLING, FIELD TESTING, AND FINAL ACCEPTANCE

General

If required in the Data Form, a factory representative shall be on-site to supervise the assembly and vacuum filling of the transformer.

The cost of the representative shall be included in the transformer purchase price.

If the Data Form specifies that the MANUFACTURER performs unloading, assembly, vacuum processing and filling, and/or final acceptance testing the MANUFACTURER shall follow the requirements of these specifications.

In addition, the MANUFACTURER shall outline the personnel and procedures to be utilized by the MANUFACTURER and the MANUFACTURER's representatives to ensure that the transformer will be unloaded, moved to the pad, assembled, vacuum filled, and tested safely and timely in an energized substation environment.

The MANUFACTURER shall provide a field service plan for review at least three (3) weeks before the transformer is delivered.

If these services are specified in the Data Form, they shall be included in the purchase price of the transformer with no additional cost to FCPUD.

The MANUFACTURER shall demonstrate to FCPUD that all equipment, personnel, and sub-contractors involved with the unloading process, assembly, and final acceptance testing possesses adequate and current insurance meeting FCPUD's requirements.

All equipment, personnel, and sub-contractors shall be responsible for following their internal safety process, which shall meet or exceed FCPUD's safety regulations.

The MANUFACTURER shall perform a tailboard safety meeting at least upon arrival and at the beginning of each day on site.

Record shipping gas pressure prior to assembly.

Prior to the transformer being opened or any work begins on the transformer, a dew point reading and the transformer's external core ground shall be tested for acceptable insulation resistance values.

These are one-time tests before beginning work on the transformer and are not intended to be done at the beginning of each day when working on the transformer.

All tests and inspections will be performed on de-energized, isolated (and grounded) transformers, free of any customer connections.

Any delays in unloading/receiving the transformer or the auxiliary equipment shall be the responsibility of the MANUFACTURER.

FCPUD contact for Unloading, Assembly, Vacuum Filling, and Field Testing is indicated in the Data Form.

The MANUFACTURER shall notify FCPUD weekly of the status of the other activities outlined in this section.

The MANUFACTURER shall arrange with FCPUD for a FCPUD representative to be on-site to witness the unloading, assembly, vacuum processing and filling, and testing of the

transformer and accessories and to arrange for an appropriate FCPUD representative to be available when a fenced substation yard needs to be accessed.

These technical specifications contained herein outline the minimum technical requirements.

These requirements are not intended to replace the MANUFACTURER's or MANUFACTURER's Contractor own processes and procedures when they exceed and/or enhance the requirements outlined in these specifications.

If during oil handling excessive cellulose insulation is observed in the oil or other foreign material, all oil handling shall stop and FCPUD shall be contacted immediately.

Unloading, Moving, and Placing On Pad

The MANUFACTURER's Representative shall visit the site along with all crane and moving subcontractors to determine how the transformer will be unloaded and moved to the pad before the bid is submitted.

Any extra charges for any items that could have been foreseen and not included in the bid will not be allowed.

The MANUFACTURER shall obtain all the necessary permits and coordinate with local authorities and utilities.

The MANUFACTURER shall unload and place the transformer on its foundation using the MANUFACTURER's and industry recommended practices.

The MANUFACTURER shall assemble the transformer according to the MANUFACTURER's and industry recommended practices.

The MANUFACTURER shall place the transformer on its foundation with the transformer's filled and assembled center of gravity in the center of the foundation unless directed otherwise by FCPUD.

If conduits are in the foundation, the control cabinet shall be over these conduits.

The MANUFACTURER shall unload all transformer parts and accessories (radiators, bushings, arresters, etc.) and place in a location approved by FCPUD within 50 feet of the transformer foundation.

Assembly

Uncrate and inventory parts, while also checking for damage.

Install all parts removed for shipment including but not limited to the items noted below:

Radiators/Fans

HV Bushings

LV Bushings

Arresters/Brackets

During assembly, the MANUFACTURER shall perform an internal visual inspection inside the transformer at no cost to FCPUD even if the MANUFACTURER is not assembling the transformer.

If there appears to be any shipping damage further testing shall be performed and corrections made as needed.

When transformer tank is open, reasonable care shall be used to keep moisture from getting into the transformer. These measures can be but are not limited to:

When the tank is open, dry air shall be used to purge the gas space to prevent moisture from entering the tank.

The tank shall not be opened if it is raining, snowing, foggy, or the humidity is above 95%. FCPUD is not responsible for delays due to weather.

The transformer shall only be opened when required to perform work.

The transformer shall be closed and purged with dry air or dry nitrogen when work is not occurring inside the transformer.

MANUFACTURER shall log all open time and provide this information in the field report.

At a minimum this log should include the date/time tank was opened, ambient temperature and weather conditions at the time it was opened, date/time when closed, ambient temperature and weather conditions at the time it was closed.

Note any significant weather condition changes (rain, show, etc.) during the open time.

If the highest nominal voltage rating of the transformer is above 138kV and personnel have to enter the tank, the transformer shall be completely drained and the vacuum processing specified in these technical specifications shall be performed.

If the highest nominal voltage rating of the transformer is 138kV or below the following applies:

The oil can be drained to the top of the core.

Care must be taken to minimize the exposure of leads running across the top of the core.

In this case when the work is completed the transformer can be "Topped Off".

If the oil must be drained below the top of the core or any leads running across the top of the core are exposed, the transformer shall be completely drained and the vacuum processing specified in these technical specifications shall be performed.

Written procedures, approved by FCPUD, shall be used to verify that everything that enters the tank exits the tank.

Safeguards shall be established so that no item inadvertently enters the tank.

Care shall be taken when handling material or tools inside the tank to prevent dropping and loss.

If material or tool is dropped into an inaccessible area, all work inside the tank shall stop and FCPUD or FCPUD's Representative contacted immediately.

Power tools are not allowed inside the tank.

If the transformer is not delivered oil filled, a dew point measurement shall be taken before the tank is opened.

The dew point results shall meet the same criteria as the factory dew point before shipment.

The dew point measurement shall be taken early in the morning before the sun hits the tank for best results.

If the ambient temperature does not reach the required temperature so that the core is warm enough (generally this means 10 Degrees C or higher) to perform this test, the

test may be waived by FCPUD if there are no other signs of moisture ingress into the tank.

If the dew point measurement taken by either FCPUD or the MANUFACTURER is greater than the maximum allowable the MANUFACTURER shall pay for any additional drying before the transformer is filled.

The procedure for drying the transformer shall be approved in writing by FCPUD.

FCPUD reserves the right to refuse the acceptance of the transformer if this approval is not obtained.

If additional drying of the transformer is required, the procedures in this Section shall be repeated before vacuum filling is started.

If the transformer is not delivered oil filled and it has been without oil for over 90 days oil reimpregnation of the insulation shall be required using a process that is approved by FCPUD.

Four (4) weeks shall be allowed within the 90 days to unload, move, assemble, and vacuum fill the transformer.

Vacuum Processing and Filling

The MANUFACTURER shall use the leak down (leak up) process as specified in these specifications using equipment that meets the minimum requirements of the MANUFACTURER and FCPUD.

The process specified shall be used for the initial filling of the transformer and for all warranty repairs where the transformer is drained.

A processing log shall be maintained that records vacuum levels and moisture removal data. Data shall be recorded every hour.

When handling oil appropriate attention shall be paid to containment if a spill were to occur.

This, in general, means that oil cannot enter any drainage system or leave the site.

The MANUFACTURER is responsible for cleanup of all oil spills.

If an oil spill occurs, all oil handling shall stop and the MANUFACTURER or MANUFACTURER's Contractor shall notify FCPUD or FCPUD's Representative immediately.

The transformer and LTC (if supplied) pressure relief devices shall remain in service during oil processing.

The MANUFACTURER shall demonstrate that they have the appropriate equipment to perform the job. This equipment shall include but not limited to the following:

The MANUFACTURER shall furnish sufficient transformer insulating oil in clean tank trucks with sealed pumps and hoses to the job site.

The MANUFACTURER shall give FCPUD five (5) days' notice of intent to deliver the oil so that personnel will be available at the job site to inspect the delivery.

Oil storage facilities such as pillow tank, tanker, storage tank and/or other storage device.

These facilities shall have been used exclusively for transformer oil.

The tank trucks shall be certified clean and dry.

They shall be cleaned before transported to the job site and shall be free of material and/or residue.

Upon inspection if they are not clean and/or have any type of residue, they shall be cleaned off-site or replaced.

Vacuum processing equipment similar to a Baron vacuum processor with the following requirements.

Any filtering process that cannot meet these specifications requires an adequate explanation for the exception and must be approved by FCPUD.

Capable of delivering 1.9 L/s (1800 gal/h) at 70 Degrees C at less than 10 mg/kg (10 ppm) water, with 190kW heating capacity.

The process shall use a 5.0 micron intake filter and a trailer discharge filter of 0.5 micron or finer.

Filters are required for when the oil is pumped from the oil storage container into the processor.

- Filters shall include a particulate filter approved by FCPUD and separate moisture filter such as the Velcon “Superdri” or FCPUD approved equivalent.

Real time vacuum chamber dew point monitoring is required.

- The dew point meter and probe shall be calibrated annually. Certification of calibration shall be available for inspection by FCPUD.

Vacuum gauges for reading processor vacuum chamber and separate gauge to read the transformer vacuum level are required.

Temperature gauges for reading processor inlet and outlet temperatures are required.

When oil is being processed, real time moisture removal rate or inlet and outlet water measurement shall be available.

Booster pump for circulating hot oil under vacuum (to be used in conjunction with pumps on vacuum processor) shall be available.

The following process shall be used for vacuum processing the transformer using Leak Down (Leak Up) methods to determine insulation moisture content.

If Leak Down (Leak Up) is specified in the Data Form the following process shall be used for vacuum processing the transformer using Leak Down (Leak Up) methods to determine insulation moisture content.

The vacuum filling process shall demonstrate that the insulation moisture content is less than 0.5% before filling the transformer.

Circulate hot oil (max 1/3 full) under vacuum while trying to maintain a vacuum of 0.5 Torr or less until the core and coils are up to temperature (minimum of 55 Degrees C).

Hot oil circulation shall occur for at least 24 hours.

For the hot oil circulation, the MANUFACTURER shall use spray device(s) or deflector(s) to spray hot oil on the core and coils.

If more than one filling port is provided both filling ports shall be plumbed together and used to adequately spray oil over the top of the core and coils.

Once the core and coils are up to temperature (55 Degrees C) as approved by FCPUD, drain the oil and pull a vacuum of at least 0.5 Torr.

The insulation temperature shall be estimated using the following (and what makes sense).

If fiber probes are present in the windings, use the transformer temperature measuring device or a portable device to read the temperature from the fibers.

- Use the temperature from the winding closest to the core, which is typically the low voltage winding.

Measure temperature of core ground bushing using a thermal measuring device.

Using the following table based on processor inlet/outlet temperatures:

Difference between Inlet and Outlet Temperatures (Degrees C)	Use Processor Inlet Temperature Minus the Temperature Shown Below (Degrees C)
Greater Than 10	Difference Between Inlet And Outlet
Less Than 10	2/3rds The Difference Between Inlet And Outlet

- After 12 hours of hard vacuum with no oil circulation, assume a 3 Deg. C drop off from the previous read, use a 6 Deg. drop for 24 hours of vacuum, etc.

Transformer temperature gauges.

It should be noted that depending on the situation any one of the methods above may not be accurate.

- A consultation shall occur and the final determination is determined by FCPUD.

Monitoring the dryness during the oil circulation and vacuum process is done by using a leak down (leak up) test every 12 hours.

The dryness is determined by valving off the transformer and measuring the change in the vacuum in the transformer over 30 minutes.

- The knee of the curve is the vapor pressure used for the Piper Chart.

The insulation moisture content is determined using a Piper Chart.

- Using the Piper Chart, draw a vertical line from the temperature (insulation temperature as determined above) and a horizontal line from the vapor pressure determined in the leak down graph.
- The insulation moisture content is where the lines intersect and is determined from the angled lines on the Piper Chart.
- The Piper Chart for each leak down performed shall be included as part of the processing records and provided in the field report.

At least three leak down (leak up) tests shall be performed with the first one being performed 2 to 3 hours after the hot oil circulation process has begun, the vacuum is less than 1 TORR, and the core temperature has been rising.

A moisture removal monitoring device shall be used.

Electronic monitoring that measures dew point of the vacuum chamber exhaust and moisture removal rates is acceptable.

The transformer can be filled when the following conditions are met as approved by FCPUD.

Once two leak down (leak up) tests in a row show a moisture content of less than 0.5% then the vacuum filling process can begin using proper procedures if the following conditions are met.

- The leaks down (leak up) tests while oil is circulating do not count.

For transformers rated 138kV and below, the transformer has been under vacuum after the circulating oil was drained for at least (18) eighteen hours.

For transformers rated above 138kV, the transformer has been under vacuum after the circulating oil was drained for at least (24) twenty four hours.

Rise (slope) of the leak down chart 0 to 5 minute line has leveled out.

Leak down chart 5 to 30 minute data points and the 5 to 30 minute line are a good match with little separation between the data points and line.

Slope of the 0 to 5 minute line compared to the slope of the 5 to 30 minute line are similar, but do not have to be exact.

Vacuum is low and stable.

The vacuum exhaust dew point measurement is less than -50 Degrees C.

All data must be recorded and submitted to FCPUD.

FCPUD will monitor the process and approve the core temperature before the hot oil circulation is drained and the moisture content before the transformer is filled.

The following FCPUD reviews are required:

When core reaches temperature when circulating hot oil before removing the oil.

After each leak down test.

Before starting fill.

Fill in FCPUD's leak down spreadsheet and email spreadsheet and processing log to FCPUD's Representative for review.

Procedures in case of loss of vacuum during filling:

If vacuum is lost during filling and the vacuum is 5 TORR or higher, the oil in the transformer must be drained and the process started over.

If the vacuum is between 2 and 5 TORR contact FCPUD or FCPUD's Representative for guidance.

If the loss of vacuum is less than 6 hours, continue using the spreadsheets and charts that were being used.

If the loss of vacuum lasts more than 6 hours, contact FCPUD or FCPUD's Representative for guidance on whether a new set of spreadsheets and charts needs to be started and if the hot oil circulation has to be re-performed.

The determination will be based primarily on core temperature.

Field Testing and Inspection

Visual External Inspection, to include, but not limited to:

Examine paint finish and repair by permanent methods.

Record shipping gas pressure prior to opening the transformer.

Thoroughly inspect all visible assembly parts and connections.

Thoroughly inspect for leaks and repair any leaks by permanent methods.

Operation Tests and Inspection

Check all gauges and relays to assure proper working condition.

Check and operate all cooling equipment.

Visually inspect and operate no-load tap changer (if supplied).

Visually inspect and operate load-tap-changer (if supplied) to both extremes.

Operate load-tap-changer control (if supplied) in automatic.

Operate all cooling controls.

When the transformer has been assembled, vacuum processed, and filled, MANUFACTURER will complete the tests listed below.

The final acceptance of the transformer will be based on the results of these tests.

If the test limits are not achieved, the MANUFACTURER shall find and correct the problem.

The requirements and acceptance criteria are the same as specified for the factory tests.

These tests shall include the same taps and test voltages as the factory tests.

The following tests shall be performed and compared to the factory tests using established industry and Doble criteria.

DC core ground resistance measurement

This measurement shall be within the limits specified by the MANUFACTURER in its Instruction and Maintenance Manual.

Insulation Power Factor and Capacitance Tests

Single Phase Excitation Tests

Winding Resistance

Arrester Leakage Current

Turns Ratio Tests

SFRA Tests

The Doble power factor, excitation, and SFRA tests shall be performed using (adding to) the electronic files from the factory tests.

Current Transformer Tests

Polarity

Ratio (all ratios)

Control and Power Wiring Tests as outlined under factory testing including functional testing of All items as listed in the factory testing requirements section.

MANUFACTURER shall make the following oil tests after assembly and vacuum processing on the main tank and LTC using Dissolved Gas Analysis (DGA) and meeting the following maximum limits:

Gas	Maximum Limit
Hydrogen	15 PPM
Methane	2 PPM
Ethane	2 PPM
Ethylene	1 PPM
Acetylene	Non Detectable
Carbon Monoxide	25 PPM
Carbon Dioxide	250 PPM

Color (a): 0.5 maximum under ASTM D-1500

Interfacial Tension, (dynes/cm) 25 Degrees C, 40 minimum under ASTM D-971

Specific Gravity at 15.6 Degrees C, 0.865-0.910 (60/60) under ASTM D-1298

Dielectric Breakdown at 60 Hz, (kV), Disk Electrode, 1 mm gap, 35kV minimum under ASTM D-877

Dielectric Breakdown at 60 Hz, (kV) VDE Electrodes, 2 mm. gap 55kV minimum under ASTM D-1816

Power Factor at 60 Hz (percent), 20 Degrees C: 0.05% maximum under ASTM D-924

Power Factor at 60 Hz (percent), 100 Degrees C: 0.3% maximum under ASTM D-924

Water Content: (ppm and saturation): 15 ppm maximum under ASTM D-1533

Neutralization Number (mg KOH/g): 0.015 maximum under ASTM D-974

Oxidation Inhibitor (wt. percent), 0.2% to 0.3%, ASTM D-2668

Corrosive Sulfur Content, Modified (b) Non-corrosive ASTM D-1275

Particle Count – particles per 100 ml (5 micron filter): less than or equal to 10,000

Polychlorinated Biphenyls (PCB's): Not Detectable under EPA 608

The following FCPUD reviews are required:

After completion of all tests before MANUFACTURER leaves site.

Allow time for FCPUD's Representative to review.

Any test with abnormalities or failures immediately after the test is performed.

Email test data and Doble DTA and SFRA files to FCPUD's Representative for review.

Field Report

If MANUFACTURER is responsible for assembly and/or final testing, a report of these activities shall be provided.

All reports shall be in English and in standard non-metric units of measure. except for temperatures, which shall be in Degrees C

The report shall be printed single sided on 8 1/2" x 11" size paper and bound in a lightweight folder with the MANUFACTURER and the serial number clearly printed on the cover.

The report shall also be provided in an electronic format using Microsoft Word and/or Adobe Acrobat file formats and sent to FCPUD.

When the tests are completed and again when the field report is submitted the electronic files for the Doble power factor, excitation, and SFRA tests shall be combined with the ones from and factory tests and sent to FCPUD in the format that can be read by the Doble test programs.

As a minimum, the report shall include:

- Assembly checklist.

- Dew point measurements.

- Power factor and single phase excitation tests in Doble format including all readings.

- SFRA traces with comparisons to the factory tests.

- All tests required in these specifications including a checklist of the functional and control tests required in these specifications.

- All tests and checklists performed by MANUFACTURER as part of their own processes.

- If applicable, oil tests from each tanker.

- Oil tests for transformer and LTC.

- If applicable, vacuum processing log.

- If applicable, Leak Down (Leak Up) test results.

- Statement describing all problems and description of resolution and corrections.

Photographic record of the assembly of the transformer from digital images taken by high-resolution, 12 megapixel or higher, digital camera shall be submitted.

- The camera and associated equipment used to take the photographs shall be approved by FCPUD.

- All digital images shall be provided to FCPUD using a method approved by FCPUD (email, download site, Thumb Drive, etc.).

Final Acceptance

Final acceptance of the transformer shall be by FCPUD or FCPUD's representative after the transformer is assembled, vacuum filled, and field tested. This acceptance is not dependent on who (FCPUD or MANUFACTURER) performs the final field testing.

OTHER REQUIREMENTS

Correspondence And Meetings

All correspondence, drawings and instruction books shall be sent to the person listed in the Data Form.

The MANUFACTURER shall inform FCPUD in writing of the address for sending official correspondence and the contact information for the MANUFACTURER's project manager for the Contract.

MANUFACTURER shall keep FCPUD informed in writing of contact information for the MANUFACTURER's project manager and field service personnel, updated as necessary throughout the duration of this Contract.

Periodic progress meetings may be scheduled over the course of the Work, as mutually agreed by FCPUD and MANUFACTURER.

The MANUFACTURER shall participate in planned and unplanned meetings with FCPUD to properly coordinate the Work.

The MANUFACTURER shall prepare notes of each meeting and submit them to FCPUD for review and comment within five days of the meeting.

Drawings

The MANUFACTURER shall furnish engineering drawings that are sufficient for design and construction of the foundations for the transformer and determine conduit and power supply needs within ten (10) weeks after receipt of order. All the information shall be in English and in standard non-metric units of measure. The following information must be furnished:

Tank bottom dimensions within $\pm 4''$.

Heights $\pm 4''$.

Base to cover $\pm 4''$.

Base to bushing terminals $\pm 5''$.

Location of bushings from centerlines of tank $\pm 4''$.

Weights, $\pm 5\%$, with and without oil.

Location of control cabinets from the tank centerline within $\pm 3''$.

Location and size of FCPUD conduit entrance to the control cabinet.

Power (kVA), voltage, and amperage requirements of the cooling equipment, LTC, controls, cabinet heaters, and all auxiliary equipment including recommended supply wire size in enough detail that FCPUD can determine power supply needs.

The number and size of wires that FCPUD must supply with controls, alarms, and monitoring system in enough detail for the size of the incoming conduits to be determined.

The MANUFACTURER shall furnish one (1) complete set of full-size drawings (ANSI C) plus electronic files (pdf) for approval.

The MANUFACTURER shall furnish in pdf format and AutoCAD DWG format (Release 2020) drawings for approval.

Partial sets are not acceptable unless approved by FCPUD.

The electronic files shall be submitted using a method approved by FCPUD (email, download site, USB Thumb Drive, etc.).

MANUFACTURER shall provide approval drawings until all drawings are approved by FCPUD (may require multiple rounds).

The drawings shall be readable when printed on 11" x 17" sheets.

The outline approval drawings shall be submitted to FCPUD within twelve (12) weeks from the date of the Purchase Order.

The remaining approval drawings shall be submitted to FCPUD within sixteen (16) weeks from the date of the Purchase Order.

The approval drawings shall include as a minimum the following:

Outline drawings of the transformer packaged for shipping and separate outline drawings of the fully assembled transformer for service including the following:

Elevations of each side

Plan of base and top

Dimensions (including untanking envelopes)

Dimensioned location of all parts and accessories including bushings, surge arresters, radiators, and connection points of the completely assembled and in operating condition.

Dimensioned location of centers of gravity (in three dimensions) of the transformer completely assembled, with oil and without oil.

Weights (shipping and completely assembled)

Accuracy of weights shall be stated on the outline drawing and nameplate.

d.5 Volumes

Items to be removed for shipment shall be identified with weight information provided.

Shipping restrictions shall be noted on the transformer outline drawing. For example, "Transformer not designed for rail shipment".

Minimum clearances from live parts for required BIL rating using a radius with an arc from each live part.

A dashed line showing the top of the core and coil assembly and the horizontal centerline of the bottom bushing connector shall be shown on any side view where the bushings are bottom connected.

Parts and accessories shall be identified on a Bill of Material. The Bill of material shall include complete description and Original Equipment Manufacturer (OEM) name and catalog number. Transformer manufacturer substituting their part number for OEM parts or equipment is not acceptable.

The voltage rating, HP, and CFM ratings shall be included in the Bill of Material for fans.

e. Main Tank Oil Level Table

- e.1 A drawing containing the main tank and/or conservator oil level shall be provided to allow FCPUD to determine the distance to the oil level below the top flange for the following conditions:
 - High level alarm (if applicable).
 - Level for the maximum top oil temperature as defined in these specifications.
 - Level for the worst case overload as defined in these specifications.
 - Normal operation
 - Cold start
 - First low level alarm
 - Second low level alarm (if applicable)
 - Critically low oil level (alarm or trip as defined in these specifications)
 - Highest live part including bushing minimum oil level (note limiting factor)
 - e.2 A formula for calculating the distance from the top of the main tank and/or conservator to the top of the oil level for varying oil temperatures shall also be provided on this drawing so that FCPUD may verify measurements or extend the table if necessary.
 - f. LTC Oil Level Table (if applicable)
 - f.1 A drawing containing the LTC oil level shall be provided to allow FCPUD to determine the distance to the oil level for the following conditions:
 - High level alarm (if applicable).
 - Normal operation
 - Cold start
 - First low level alarm
 - Critically low oil level (alarm or trip as defined in these specifications)
 - Highest live part including bushing minimum oil level (note limiting factor)
- Transformer internal core and coil assembly drawings and lead arrangement drawings including the following:
- Bushing pockets (fully dimensioned sectional and top views of the bushing pockets with and without bushings installed.)
 - Flanges
 - Current transformer pockets
 - All minimum clearances
 - Internal lead routing and support drawings
- A detail shall be provided that shows the oil level at the following:
- 25 Degrees C
 - Maximum during normal operation
 - Maximum during overload operation
 - Minimum at cold start
 - Alarm
 - Critical alarm/tripping
- Detailed 3D color drawings of the transformer internal layout and details. The intent of this is to receive the parametric model drawings that are generated as part of the transformer design using ProE or similar program.
- Nameplate drawings.

Drawing showing the location of all valves with a description for each valve and valve position during normal operation.

Conduit and piping drawings showing conduit and piping details and material.

Gasket Information Drawings or information shall be provided showing gasket dimensions and materials to allow FCPUD to purchase or field fabricate replacement gaskets.

Bushing outline drawings showing physical and electrical parameters.

These drawings shall be the original drawing from the supplier.

Redrafting drawings with the transformer manufacturer's nameplate applied are not acceptable.

On drawings showing multiple ratings, the rating being supplied shall be marked with an arrow.

Arrester outline drawings showing physical and electrical parameters.

These drawings shall be the original drawing from the supplier.

Redrafting drawings with the transformer manufacturer's nameplate applied are not acceptable.

Cut sheets for sudden pressure relays, temperature gauges, pressure relief devices, bushing connectors, electronic temperature monitor (if supplied), monitoring devices, seal-in relays, communication devices, Buchholz relay, gas detection relay, Sergi valve, and any other devices requested by FCPUD.

Connection diagrams showing where external FCPUD cable connections are provided.

Complete set of control and alarm schematics including LTC.

Complete set of wiring diagrams showing all internal control wiring including LTC.

The wiring diagrams shall show next to each terminal the destination by device name and terminal number where the wire is landed.

Wiring lists and drawing grid location with wire names methods are not acceptable.

Control cabinet layout and section views of control cabinet devices and terminal blocks.

Current transformer characteristic curves including secondary excitation, ratio correction factor for all current transformers, including LTC current transformers.

FCPUD requires fifteen (15) working days after the receipt of approval drawings to review and return the approval drawings to the factory.

The MANUFACTURER shall not start actual construction until all issues are resolved on the drawing approval process.

FCPUD will have final approval of the format and content of the final drawings.

The MANUFACTURER shall furnish in pdf format and AutoCAD DWG format (Release 2020) one (1) set of "Approved for Construction" for all drawings when the drawing approval process is completed.

The electronic files shall be submitted using a method approved by FCPUD (email, download site, USB Thumb Drive, etc.).

These drawings shall be submitted to FCPUD within twenty (20) weeks from the date of the Purchase Order or prior to construction, whichever is earlier.

The MANUFACTURER shall stamp “CERTIFIED FOR CONSTRUCTION” and the current date on these drawings.

The MANUFACTURER shall furnish in pdf format and AutoCAD DWG format (Release 2020) one (1) set of “As-Built” for all drawings prior to shipment of the transformer.

The electronic files shall be submitted using a method approved by FCPUD (email, download site, USB Thumb Drive, etc.).

Translation programs and drawing attributes will not be allowed for schematics, wiring diagrams, and any other drawings that FCPUD may need to edit in the future.

The MANUFACTURER shall stamp “AS-BUILT” and the current date on these drawings.

Instruction manuals covering installation, operation, and maintenance procedures of the transformer shall be provided.

The Instruction manual shall include instruction books for all accessories and third party equipment including but not limited to bushings, arresters, DETC and/or LTC, oil temperature indicators, pressure relief devices, rapid pressure rise relay, gas accumulation indicator, oil level indicator, conservator, breather, radiator, radiator valve, fan with motor, upper filter valve, lower filter valve, DGA monitoring system, etc.

The MANUFACTURER shall provide a total of four (4) identical complete instruction manuals, including one (1) shipped with the transformer.

Each instruction manual shall include a copy of the Certified Test Report.

The instruction manual shall include the stamped Seismic Analysis Report, when one is specified in the Data Form.

With the exception of drawings, the contents of each instruction manual shall be printed on 8 ½” x 11” paper and bound in heavy duty three-ring binders suitable for reference and filing with the particular model supplied clearly noted on documents that apply to more than one (1) type or model.

Each set of the instruction manuals shall include a spare parts list detailing the manufacturer, catalog numbers, price, and ordering information.

Each instruction manual shall have a complete set of “as-built” drawings including the internal core and coil assembly drawings and lead arrangement drawings included in the binder on 11” x 17” sheets.

The color drawings showing the 3D parametric solid model shall be included with each instruction manual.

The MANUFACTURER shall stamp “AS BUILT” and current date on all drawings included in the instruction manual.

If revisions to the “as built” drawings are necessary, the MANUFACTURER shall pack the latest copy of the “as built” drawings with the transformer and shall send the revised drawings within two (2) weeks after shipment of the transformer.

The complete instruction manuals with all inclusions shall be submitted to FCPUD no later than when the transformer is shipped.

At least one complete set of installation, operation, and maintenance instruction books including the drawings shall be printed on waterproof media with indelible inks so that emergency use during inclement weather does not destroy the documentation.

This is to be the set shipped with the transformer.

The MANUFACTURER shall ship this material in weatherproof packaging.

Prior to shipping, the MANUFACTURER shall provide one (1) USB Thumb Drive or other digital media approved by FCPUD in the instruction manual pouch of each instruction book.

The digital media shall include a complete set of “as-built” drawings, the complete instruction manual, and any available photographs.

The drawings shall be in AutoCAD .DWG format (Release 2020) and pdf format.

Any text documents shall be in Microsoft Word format.

The Instruction Manuals shall be in Adobe pdf format.

The 3D parametric modeling drawings shall be converted to picture files using a JPG format.

Translation programs and attributes will not be allowed for schematics, wiring diagrams, and any other drawings that FCPUD may need to edit in the future.

Design Review

FCPUD will conduct a design review, in accordance with this specification and CIGRE 529, when the design and the layout drawings have been completed.

The MANUFACTURER shall not start the manufacture of the transformer until the design review is complete and FCPUD has given written concurrence that the design review has been successfully completed.

The design review shall be included in the purchase price of the transformer.

The design review will be completed approximately three (3) weeks after the design review package including design review data sheets and nameplate and outline approval drawings have been submitted to FCPUD.

See Attachment for the Design Review and Quality Assurance Plan.

The meeting shall be scheduled with the MANUFACTURER as soon as possible after the award of contract.

The MANUFACTURER shall submit all items of the transformer design for review by FCPUD and FCPUD’s Application Engineer and Project Engineer.

The MANUFACTURER shall prepare notes of the design review meeting and submit them to FCPUD for review and comment within five days of the meeting.

This meeting may be conducted at the manufacturing facility or virtually at FCPUD’s option.

The date and time of the meeting will be mutually agreed to between the MANUFACTURER and FCPUD.

When the design review meeting is held, the MANUFACTURER shall have the appropriate technical personnel available to answer questions.

The design review meeting will be scheduled for one continuous day.

The MANUFACTURER shall ensure that all design details including coils, magnetic circuit, short circuit stresses and strengths, lead and cable sizes, temperature rise calculations, cooling equipment, and hot spot temperature calculations have been completed prior to the design review.

The MANUFACTURER will be expected to furnish the following during the design review:

Average Winding Rises for all Windings at the OA and maximum forced cooled ratings.

Top and bottom oil rises for the OA and maximum forced cooled ratings.

Calculated hot spot rises for each winding at the OA and maximum forced cooled ratings.

The MANUFACTURER is to provide calculated thermal data as stated in subsections a through c above for the specified overload cycle.

The hot spot rises must be calculated using maximum localized losses, oil flow patterns, and insulation on the conductors. Allowances will not be allowed.

FCPUD will approve the methods used for calculating the winding losses used during the temperature tests at the time of the design review.

The MANUFACTURER shall be prepared to discuss the methods used to calculate the transformer hot spot temperatures during the design review.

The hot spot temperatures shall be calculated using one of the methods identified in C57.12.00-2021, Clause 5.11.1.1.

Calculations using the hottest spot allowance are not acceptable.

The MANUFACTURER shall be prepared to discuss the gasket and gasket retention system during the design review.

The MANUFACTURER shall be prepared to discuss leak rates and durability of the gaskets.

Leakage Flux Loss and Heating Analysis: The MANUFACTURER is expected to have analysis programs and calculation methods to determine the leakage fields at different points in the design and the resulting losses and temperatures.

The heating in the core, tie plates, core frames, tank walls, lead connections, etc. will be studied at the design review.

The MANUFACTURER shall calculate the short circuit forces and stresses that are generated from the leakage magnetic fields.

The MANUFACTURER is expected to produce documentation that supports the calculation methods, i.e. model tests, tests on full-size transformers, and experience in service.

Inputs and outputs from a short circuit forces program for nominal and tap extremes of the No-Load tap changer.

The program must be identified and approved by the FCPUD.

Manufacturer's "in-house" programs shall not be accepted without commercially available data demonstrating methods and specific safety margins.

Elongation of one (1) winding shall not be accepted in-lieu of an offset of one (1) winding.

In the Andersen Program, the LV winding shall have the negative (-1) current. The additional to static forces, the dynamic forces calculations are desired.

The coil winding sheets delineating the turns and spacers.

The MANUFACTURER shall provide substantiating data for the stress criteria used in this design.

For core form transformers the inner windings shall be analyzed for forced and free buckling stresses.

The bending stress between radial spacers and axial spacers are to be provided.

The compressive stress in radial spacers is to be calculated.

Stresses shall not exceed the limits specified in IEC 60076-5 Annex A.

The coil drying and sizing processes are to be provided.

The transformer is to be processed such that it remains tight during transportation, operation in service, and after repeated faults in service.

The distribution of transient voltages in the windings shall be provided.

The calculations are to be made with a technique that considers both the capacitive and inductive elements of the electrical network.

Voltages within the windings, between windings, and from winding to ground are to be calculated.

The switching surge voltages for the BSL test voltages specified shall be calculated for all windings.

The maximum voltage in each winding for the test voltages specified shall be provided at design review.

The dielectric stress between windings, at the winding ends, and at the lead exits shall be calculated.

MANUFACTURER is expected to demonstrate that the stress margins meet the requirements of these specifications.

As part of the design review meeting, the MANUFACTURER shall provide their design information, including but not limited to the following:

Core

General configuration and dimension.

Calculation of the core loss and excitation current.

Calculation of the temperature in the core.

Grounding of core.

Method of tightening the core.

Core and magnetic leakage flux plots.

Windings

Winding configurations, dimensions, and construction.

Detail of cooling spacers.

Load losses and thermal characteristics.

Winding thermal study and plot.

The final pressure on the windings and how it is derived shall be provided.

MANUFACTURER shall include the calculations showing the pressure on each winding resulting from the amount of force applied per phase in the final pressing operation.

The calculation details shall be provided and enough information to confirm the calculations.

Lead Structure Data

Calculation of % Impedance

Calculation for X/R ratio (nominal and tap extremes)

Accuracy of X/R calculations

Insulation Analysis

Winding arrangement and test voltage per leg.

Impulse distribution.

Electric Field Analysis.

Insulation/oil stress data.

Review of Short Circuit Forces

Short circuit currents for each failure mode.

Short circuit mechanical forces under worst case.

Short circuit study.

Review of Flux Shielding, Core, and Clamp structure, Tank Walls, Tank Base and Tank Cover.

Thermal Data

Thermal calculations.

Cooling data (fan SCFM and fan curves).

Review of overload condition.

Tank thermal study and gradient plot.

Heat load released at full load.

Seismic Analysis Report, if required in the Data Form

Review of Outline and Control Schematic Drawing

Minimum Clearance Between Phase to Phase and Phase to Ground, Between Internal Parts and Critical Internal Parts to Ground

Inspection and Test Program

Warranty

The MANUFACTURER shall provide a five (5) year warranty, including the internal and external paint finish, against all manufacturing and design defects in the equipment.

During the warranty period, the MANUFACTURER shall be responsible for every occurrence to repair or replace at his sole expense, including in-and-out expenses (including, but not limited to, removal of oil, disassembly, transportation to the repair facility, moving to the rail siding and loading on the railroad car or trailer as applicable, transportation back to the foundation or storage location, re-assembly of the unit, oil filling, and field testing), any transformer or equipment considered to be part of the transformer that does not meet this Specification and/or is found to be defective or fails as a result of defective material or workmanship. Costs of special, indirect, or consequential damages will be excluded.

This fully inclusive warranty shall be in addition to (and not in lieu of) the Manufacturer's standard warranty.

Each Bidder is to PROVIDE IN PROPOSAL the cost adder for this fully inclusive warranty and enter it on their bid form.

The MANUFACTURER warrants that the items, at time of delivery, shall conform to FCPUD's specifications, the requirements of this Order, approved sample or samples, if any, are free from defects in design, material, and workmanship, ARE MERCHANTABLE, AND WILL BE FIT AND SUFFICIENT FOR THE PURPOSE INTENDED. MANUFACTURER SPECIFICALLY WARRANTS THAT TO THE EXTENT KNOWN, COULD REASONABLY EXPECT TO KNOW, OR HAS BEEN INFORMED OF THE PARTICULAR PURPOSE FOR WHICH THE ITEMS ARE TO BE USED, THE ITEMS SHALL BE SUITABLE FOR SUCH PURPOSE. At FCPUD's option, the MANUFACTURER shall promptly either repair or replace defective items after receipt of FCPUD's written notice of a defect, or shall immediately refund all monies paid therefore.

The MANUFACTURER or MANUFACTURER's representative shall place a sticker inside the control cabinet door indicating the date when the warranty period ends.

This label shall be placed after the transformer has been delivered to the Delivery Location point.

If the MANUFACTURER requires a factory representative to be on-site to supervise the assembly and vacuum filling of the transformer to validate the warranty, the cost of the representative shall be included in the transformer purchase price.

Safety Data Sheets and Waste Reduction Notification

The MANUFACTURER shall furnish safety Data Forms (SDS) in accordance with OSHA 1910.1200 on all chemicals and hazardous materials specifying generic and trade name of product, product specification, full hazard information including receiving and storage hazards, instructions and special equipment needed for handling.

Information on approved containers and instructions for the disposal of said material is also required.

SDS shall be furnished with each shipment of chemicals and hazardous materials.

Service Bulletins

Service Bulletins shall be provided to FCPUD.

The MANUFACTURER shall be responsible for providing any and all service bulletins/advisories on the transformer provided and all associated ancillary equipment after delivery.

This is to be an ongoing process provided by the MANUFACTURER to keep FCPUD informed of any mechanical and/or electrical problems, which may cause breakdown or failure of the equipment, or more importantly, jeopardize personnel working near the equipment.

This service shall continue beyond the standard warranty period and any fee for this service shall be included in the purchase price of the transformer.

This correspondence shall be sent to the person/address indicated in the Data Form.

ADDITIONAL REQUIREMENTS BASED ON THE DATA FORM

If “none” is specified in the Data Form for the LTC

All LTC requirements are removed from this specification.

All testing that requires the LTC to be in any other position than “N” or “Neutral” are removed from this specification including using 1R for the load losses.

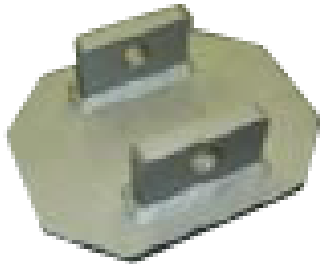
If “no” is specified in the Data Form for the Remote I/O and/or Automation/Communications Devices

All alarms shall be wired to terminal blocks in the main control cabinet

All analog outputs shall be wired to terminal blocks in the main control cabinet

All contacts for customer use shall be wired to terminal blocks in the main control cabinet.

FCPUDFCPUDFCPUDFCPUDFCPUDFCPUDATTACHMENT A – FALL PROTECTION MOUNTING PLATE



WELD-ON MOUNTING PLATE

Unplated mild steel construction.
8510816

Weight: 11.6 lbs (5.3 kg)

ATTACHMENT B – DESIGN AND QUALITY ASSURANCE REVIEW PLAN

Review Design

The following information outlines the process that will be followed during the design review and subsequent Quality Assurance Reviews.

The manufacturer is requested to provide the following information prior to the meeting. This information should be tabulated and submitted to the COA as soon as possible.

Winding layout with the type of windings noted and the insulation clearances between windings and to ground.

Calculated radial and axial short circuit stresses.

Winding Layout

Arrangement of windings.

Type windings used.

Conductor configurations in each winding.

Tap windings and location of taps in windings. Load and de-energized.

Location and design of tap winding or tap section.

Construction of tap leads and attachment to winding.

Conductor configuration

Insulation Clearances and Configuration.

Electrostatic shielding in windings

Insulation clearances.

Between windings

Between windings and ground.

Geometry of insulation

Conductor insulation type and thicknesses in each winding.

Transient voltage distribution

Use of Metal Oxide protection across windings if any.

Review of calculation methods.

Calculated voltages.

Within windings.

Induced voltages in other windings.

Acceptance criteria for these voltages.

Coil Conductor Sizes and Calculated Load Losses

Transposition in windings.

Calculated load losses.

Review of calculation method.

Expected calculated vs. test variation.

Calculation of leakage fields.

Describe fields computation methods used.

Outline of analysis method used for calculation of leakage losses and heating in coils, connections and leads.

Calculated temperature rises in winding components subject to leakage flux heating.

Connections

Leads.

1.3.5 Control of circulating currents

1.3.6 Leakage reactance.

Calculated values between all winding combinations.

Expected variation calculated vs. test.

Variation with tap position.

Paralleling information.

Core Configuration and Materials.

Core geometry, method of stacking, and gaps.

Design induction.

Ventilation of core.

Core material.

Supplier

Grade

Acceptable slitting and shearing burrs.

Core grounding.

Calculated no load losses and exciting current at 100 and 110% voltage. Calculations to meet the 110% excitation at no load and 105% overvoltage with full load and 0.8 power factor on the loaded winding.

Leakage flux heating considerations in core. Core hot spot temperature at worst- case excitation and the method of calculating the temperature.

Internal Core and Winding Support Structures.

Outline of construction.

Review of heating problems in lockplates, core surface, and frames.

Internal Leads, Connections, and Bushing Clearances.

Design, routing, and support of leads to tap changers and bushings.

Design, routing, and support of connections between windings.

Review of induced and transient voltages between leads and to ground.

Tabulation of voltage stresses.

Withstand voltages compared to stresses.

Clearances from lower end of bushings to ground and to other live parts.

Lower bushing shields and insulation.

External clearances between bushings-conformance with ANSI/IEEE.

Tap Changers.

Type and manufacturer of load tap changer.

Rating as related to contact life and maintenance.

Expected contact life including definition of contact life.

Maintenance requirements.

De-energized tap changer type and manufacturer.

Location in winding.

Expected contact life including definition of contact life.

1.7 Short Circuit Design

Calculated stresses in windings compared to allowed stresses. Include any special considerations for the Tertiary.

Review of method used to calculate leakage fields, forces, and stresses.

Review criteria for short circuit withstand values including data from full size transformer and model tests.

Frame and support design and calculated forces on support members compared to allowed.

Density of pressboard used in barriers, spacers, and end insulation.

Winding processing and compression during drying operations.

Control of winding tightness during core building.

Final clamping of windings.

Short circuit performance in service.

1.8 Cooling

Calculated winding and oil rises.

Hot spot rises and the calculated values for each winding.

Oil flow patterns in windings.

Calculation methods for determining hot spots. It is expected that the method will include oil flow, localized losses, and insulation thicknesses.

Calculated hot spots in windings and leads.

Review of all winding hot spots.

Leads to bushings and between windings.

Tap leads across windings and to tap changers.

Heat exchangers and fans used. Discussion of leaks.

Cleaning requirements in service.

Service record of proposed heat exchangers and fans.

Tank Design and Oil Preservation.

Tank

A. Construction

Tank design and welding procedures to prevent leaks.

B. Shielding of tank (if any).

Oil preservation system.

Gaskets

A. Gasket groove design.

B. Gasket materials.

Weights And Dimensions

System Operating Aspects

Review Of Proposed Layout Of Transformer and Accessories

Test Program

Review of requirements.

Test plans for the transformers.

Accuracy of loss measurements. Accuracy specified must be justified.

Temperature tests.

Partial discharge testing and acceptance criteria.

Gas in oil testing and acceptance criteria.

Check points during testing.

Review of Test Department problems.

Test Floor failure record for the past 5 years. Written data is required.

Review Remaining Questions Or Exceptions

Review Specification And Resolution Of Any Questions Or Exceptions.

Preparation For Shipment, Field Installation, And Processing With Emphasis On Simplification

Dryness at time of shipment and method used to determine dryness.

Expected dryness when received at site and method for determining.

Instructions for installation.

Processing required.

Oil characteristics after filling.

Special Design Issues

This will include the discussion of maintenance required in service and actions taken by the manufacturer to reduce maintenance costs.

Quality Assurance Program

Special check points.

Experience Record In Service

In service problem and failure history for the past 5 years. Written data is required.

Closing

Develop Action List with Schedule and Completion of Open Items.

Appendix B – Build America Buy America Requirements
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Term 7. National Environmental Policy Act (“NEPA”) Requirements

DOE must comply with the National Environmental Policy Act (“NEPA”), 42 USC §§ 4321 et seq., and implementing regulations at 40 CFR Parts 1500 et seq. and 10 CFR Part 1021, prior to authorizing the expenditure of Federal funds. The Recipient is thereby only authorized to use Federal funds in compliance with the NEPA determination referenced in Term 4. The authorized activities are subject to any conditions listed in the NEPA determination, which are hereby incorporated into this Award. Federal funding has only been obligated for award activities and locations that are included in the NEPA determination or decision incorporated by reference in Term 4. Questions about the permissibility of Federal funding on activities not included in the NEPA determination prior to DOE’s issuance of a final NEPA decision for those activities must be directed to the Grants and Agreements Officer. Undertaking unauthorized activities may jeopardize Federal involvement in the Award.

Term 8. Build America Buy America Requirements for Infrastructure Projects

Buy America Preference. Recipients of an award of Federal financial assistance from a program for infrastructure are hereby notified that none of the funds provided under this award may be used for an infrastructure project unless:

(1) All iron and steel used in the project are produced in the United States—this means all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States;

(2) All manufactured products used in the project are produced in the United States— this means the manufactured product was manufactured in the United States; and the cost of the components of the manufactured product that are mined, produced, or manufactured in the United States is greater than 55 percent of the total cost of all components of the manufactured product, unless another standard that meets or exceeds this standard has been established under applicable law or regulation for determining the minimum amount of domestic content of the manufactured product; and

(3) All construction materials are manufactured in the United States—this means that all manufacturing processes for the construction material occurred in the United States. The construction material standards are listed below.

Incorporation into an infrastructure project. The Buy America Preference only applies to articles, materials, and supplies that are consumed in, incorporated into, or affixed to an infrastructure project. As such, it does not apply to tools, equipment, and supplies, such as temporary scaffolding, brought to the construction site and removed at or before the completion of the infrastructure project. Nor does a Buy America Preference apply to equipment and furnishings, such as movable chairs, desks, and portable computer equipment, that are used at or within the finished infrastructure project, but are not an integral part of the structure or permanently affixed to the infrastructure project.

Categorization of articles, materials, and supplies. An article, material, or supply should only be classified into one of the following categories: (i) Iron or steel products; (ii) 15 Manufactured products; (iii) Construction materials; or (iv) Section 70917(c) materials. An article, material, or supply should not be considered to fall into multiple categories. In some cases, an article, material, or supply may not fall under any of the categories listed in this paragraph. The classification of an article, material, or supply as falling into one of the categories listed in this paragraph must be made based on its status at the time it is brought to the work site for incorporation into an infrastructure project. In general, the work site is the location of the infrastructure project at which the iron, steel, manufactured products, and construction materials will be incorporated.

Application of the Buy America Preference by category. An article, material, or supply incorporated into an infrastructure project must meet the Buy America Preference for only the single category in which it is classified.

Determining the cost of components for manufactured products. In determining whether the cost of components for manufactured products is greater than 55 percent of the total cost of all components, use the following instructions:

(a) For components purchased by the manufacturer, the acquisition cost, including transportation costs to the place of incorporation into the manufactured product (whether or not such costs are paid to a domestic firm), and any applicable duty (whether or not a duty-free entry certificate is issued); or

(b) For components manufactured by the manufacturer, all costs associated with the manufacture of the component, including transportation costs as described in paragraph (a), plus allocable overhead costs, but excluding profit. Cost of components does not include any costs associated with the manufacture of the manufactured product.

Construction material standards. The Buy America Preference applies to the following construction materials incorporated into infrastructure projects. Each construction material is followed by a standard for the material to be considered “produced in the United States.” Except as specifically provided, only a single standard should be applied to a single construction material.

(1) Non-ferrous metals. All manufacturing processes, from initial smelting or melting through final shaping, coating, and assembly, occurred in the United States.

(2) Plastic and polymer-based products. All manufacturing processes, from initial combination of constituent plastic or polymer-based inputs, or, where applicable, constituent composite materials, until the item is in its final form, occurred in the United States.

(3) Glass. All manufacturing processes, from initial batching and melting of raw materials through annealing, cooling, and cutting, occurred in the United States.

(4) Fiber optic cable (including drop cable). All manufacturing processes, from the initial ribboning (if applicable), through buffering, fiber stranding and jacketing, occurred in the United States. All manufacturing processes also include the standards for glass and optical fiber, but not for non-ferrous metals, plastic and polymer-based products, or any others.

(5) Optical fiber. All manufacturing processes, from the initial preform fabrication stage through the completion of the draw, occurred in the United States.

(6) Lumber. All manufacturing processes, from initial debarking through treatment and planning, occurred in the United States.

(7) Drywall. All manufacturing processes, from initial blending of mined or synthetic gypsum plaster and additives through cutting and drying of sandwiched panels, occurred in the United States.

(8) Engineered wood. All manufacturing processes from the initial combination of constituent materials until the wood product is in its final form, occurred in the United States.

Waivers

When necessary, recipients may apply for, and the agency may grant, a waiver from these requirements. The agency should notify the recipient for information on the process for requesting a waiver from these requirements.

When the Federal agency has made a determination that one of the following exceptions applies, the

awarding official may waive the application of the Buy America Preference in any case in which the agency determines that:

- (1) applying the Buy America Preference would be inconsistent with the public interest;
- (2) the types of iron, steel, manufactured products, or construction materials are not produced in the United States in sufficient and reasonably available quantities or of a satisfactory quality; or
- (3) the inclusion of iron, steel, manufactured products, or construction materials produced in the United States will increase the cost of the overall project by more than 25 percent.

A request to waive the application of the Buy America Preference must be in writing. The agency will provide instructions on the format, contents, and supporting materials required for any waiver request. Waiver requests are subject to public comment periods of no less than 15 days and must be reviewed by the Made in America Office.

There may be instances where an award qualifies, in whole or in part, for an existing waiver described at <https://www.energy.gov/management/doe-buy-america-requirement-waiver-requests>.

Definitions

“Buy America Preference” means the “domestic content procurement preference” set forth in section 70914 of the Build America, Buy America Act, which requires the head of each Federal agency to ensure that none of the funds made available for a Federal award for an infrastructure project may be obligated unless all of the iron, steel, manufactured products, and construction materials incorporated into the project are produced in the United States.

“Construction materials” means articles, materials, or supplies that consist of only one of the items listed in paragraph (1) of this definition, except as provided in paragraph (2) of this definition. To the extent one of the items listed in paragraph (1) contains as inputs other items listed in paragraph (1), it is nonetheless a construction material.

(1) The listed items are: (i) Non-ferrous metals; (ii) Plastic and polymer-based products (including polyvinylchloride, composite building materials, and polymers used in fiber optic cables); (iii) Glass (including optic glass); (iv) Fiber optic cable (including drop cable); (v) Optical fiber; (vi) Lumber; (vii) Engineered wood; and (viii) Drywall.

(2) Minor additions of articles, materials, supplies, or binding agents to a construction material do not change the categorization of the construction material.

“Infrastructure” means public infrastructure projects in the United States, which includes, at a minimum, the structures, facilities, and equipment for roads, highways, and bridges; public transportation; dams, ports, harbors, and other maritime facilities; intercity passenger and freight railroads; freight and intermodal facilities; airports; water systems, including drinking water and wastewater systems; electrical transmission facilities and systems; utilities; broadband infrastructure; and buildings and real property; and structures, facilities, and equipment that generate, transport, and distribute energy including electric vehicle (EV) charging.

“Infrastructure project” means any activity related to the construction, alteration, maintenance, or repair of infrastructure in the United States regardless of whether infrastructure is the primary purpose of the project. See also paragraphs (c) and (d) of 2 CFR 184.4.

“Iron or steel products” means articles, materials, or supplies that consist wholly or predominantly of iron or steel or a combination of both.

“Manufactured products” means:

(1) Articles, materials, or supplies that have been: (i) Processed into a specific form and shape; or (ii) Combined with other articles, materials, or supplies to create a product with different properties than the individual articles, materials, or supplies.

(2) If an item is classified as an iron or steel product, a construction material, or a Section 70917(c) material under 2 CFR 184.4(e) and the definitions set forth in 2 CFR 184.3, then it is not a manufactured product. However, an article, material, or supply classified as a manufactured product under 2 CFR 184.4(e) and paragraph (1) of this definition may include components that are construction materials, iron or steel products, or Section 70917(c) materials.

“Predominantly of iron or steel or a combination of both” means that the cost of the iron and steel content exceeds 50 percent of the total cost of all its components. The cost of iron and steel is the cost of the iron or steel mill products (such as bar, billet, slab, wire, plate, or sheet), castings, or forgings utilized in the manufacture of the product and a good faith estimate of the cost of iron or steel components.

“Section 70917(c) materials” means cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives. See Section 70917(c) of the Build America, Buy America Act