Allen&Hoshall
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Specifications and
Contract Documents

BRIGHTRIDGE

30/40/50//56 MVA, 69:13 kV

POWER TRANSFORMER
With OLTC

Allen&Hoshall
engineering since 1915

Engineers • Planners
8331 E. Walker Springs Lane, Suite 102
Knoxville, TN 37923

PROJECT 81023.8

MARCH 2026

BRIGHTRIDGE

JOHNSON CITY, TENNESSEE

DOCUMENT 00002
CERTIFICATIONS

The Plans and Specifications covered by these Contract Documents were prepared under the supervision and direction of the undersigned Registered Engineers and/or Architects, whose seals are affixed below.

Joe W. Nims P.E.
Electrical Engineer

END OF DOCUMENT

DOCUMENT 00003
CONTENTS

DIVISIONS 0 and 1 - CONTRACT DOCUMENTS AND GENERAL REQUIREMENTS

DIVISION 16 - ELECTRICAL

END OF DOCUMENT

DOCUMENT 00021
INVITATION TO BIDDERS

Sealed proposals for one (1) 30/40/50//56 MVA, 69:13 kV Power Transformer with OLTC for BrightRidge (Owner) will be received by email until 1:00 PM EDT on May 5, 2026, and immediately thereafter will be opened, and publicly read.

Proposals shall be sent in PDF document format by email to **SealedBids@brightridge.com**.

See Document 00102 – INSTRUCTIONS TO BIDDERS, for detailed submission instructions.

No Bidder may withdraw a bid for a period of thirty (30) days after the date set for opening of bids.

By: Jeff Dykes
CEO

END OF DOCUMENT

DOCUMENT 00102
INSTRUCTIONS TO BIDDERS

Each Bidder shall carefully examine the site of the work to be acquainted with working conditions and all difficulties that may be involved therein, and shall carefully examine all drawings, specifications, and other contract documents to be familiar with all of the requirements, terms, and conditions thereof. Any information relating to the work furnished by the Owner or others, or failure to make these examinations shall in no way relieve any Bidder from the responsibility of fulfilling all of the terms of the contract.

The Proposal provides for quotation of a price for one or more bid items, which may be lump sum bid prices, alternate bid prices or a combination thereof. No payment will be made for items not set up in the Proposal, unless otherwise provided by contract amendment. All Bidders are cautioned that they should include in the prices quoted for the various bid items all necessary allowances for the performance of all the work required for the satisfactory completion of the Project.

Bidder is cautioned to verify the completeness of this specification package as listed in Document 00003 - CONTENTS.

Bidder will submit the completed Document 00302 - PROPOSAL and all the supporting documents specified by email to **SealedBids@brightridge.com**.

BRIGHTRIDGE REQUIREMENTS FOR A DIGITAL BID SUBMISSION:

1. Bids should be clearly identified as:

   Bid Enclosed and Your Company Name
   Allen & Hoshall Project Number 81023.8
   Name: Brightridge Power Transformer
   Due: May 5, 2026, at 1:00 PM EST

2. Send an email with an attached PDF of the digital bid including all required documents to: SEALEDBIDS@BRIGHTRIDGE.COM. Documents may be combined and sent as one PDF and cannot exceed 50MB in size. An automatic delivery receipt is sent indicating that the bid email has been delivered to sealedbids@brightridge.com

3. BrightRidge reserves the right to reject any or all bids and to waive any informalities or technicalities therein.

4. **Send a SEPARATE EMAIL**, indicating that you have submitted a digital bid and include "Sealed Bid for Power Transformer" in the subject line to: PURCHASING@BRIGHTRIDGE.COM. **Do not attach a copy of your bid to this email!**

5. No fax or physically delivered sealed bids will be accepted. Bids must be digital.

6. Direct any questions about the bid submission process to the purchasing department at 423-952-5161 or 423-952-5000.

The Engineer for this project is:

	Allen & Hoshall Engineers Planners	
STREET:	8331 E. Walker Springs Lane, Suite 102 Knoxville, Tennessee 37923	
PHONE:	(865) 693-7881	
CONTACT:	Joe Nims, PE	jnims@allenhoshall.com
ALTERNATE:	Charles Dykes	cdykes@allenhoshall.com

The Engineer will represent the Owner in all matters pertaining to this project, including but not limited to, answering technical questions of prospective bidders, recommendation of awards, acceptance of shop drawings and similar documents, and approval of invoices prior to payment by the Owner.

CHECKLIST FOR BIDDERS - Submit Document 00302 - PROPOSAL and all supporting documents as specified:

DOCUMENT 00102:	Bid Envelope Information: Enter on sealed bid envelope
DOCUMENT 00210:	Iran Divestment Act Certification
DOCUMENT 00302:	Bid Price
DOCUMENT 00302:	Guaranteed Losses
DOCUMENT 00302:	Auxiliary Losses
DOCUMENT 00302:	LTC Design Data
DOCUMENT 00302:	Place of Manufacture
DOCUMENT 00302:	Warranty Extension Adder
DOCUMENT 00302:	Surety Bond Adder
DOCUMENT 00302:	Shipping Lead Time
DOCUMENT 00302:	Shipping Method
DOCUMENT 00302:	Shop Drawing Schedule
DOCUMENT 00302:	Field Assembly Representative
DOCUMENT 00302:	Field Assembly and Testing Schedule
DOCUMENT 00302:	Labor Contract Expiration Date
DOCUMENT 00302:	Required Submittal Data
DOCUMENT 00302:	Addenda (if any)
DOCUMENT 00302:	Exceptions to the Specifications (if any)
DOCUMENT 00302:	Signature

END OF DOCUMENT

DOCUMENT 00210
IRAN DIVESTMENT ACT CERTIFICATION

(must be attached to bid form upon submission)

1. By submission of this bid, each bidder and each person signing on behalf of an bidder certifies, and in the case of a joint bid each party thereto certifies as to its own organization, under penalty of perjury, that to the best of its knowledge and belief that each bidder is not on the list created pursuant to TCA 12-12-106 in reference to the Iran Divestment Act.

2. This act prohibits a person or other entity identified on the list from bidding or contracting with a local government and shall make any contract entered into with these persons or entities void.

3. The State of Tennessee list can be found at:

   https://www.tn.gov/generalservices/procurement/central-procurement-office--cpo-/library-/public-information-library.html

The undersigned hereby certifies that he/she is authorized by the vendor or bidder to certify that his/her company is not on the list of prohibited bidders as discussed above.

Company Name: _____

Contractor's Authorized Agent: _____
(Printed Name)

Contractor's Authorized Agent: _____
(Signature)

Date:_____

END OF DOCUMENT

DOCUMENT 00302
BID FORM

Date: May 5, 2026

To: BrightRidge
2600 Boones Creek Road
Johnson City, TN 37615

Gentlemen:

The undersigned, hereinafter called the "Materialman", hereby proposes to sell and deliver to BrightRidge, hereinafter called the "Owner", upon the terms and conditions herein stated, the material specified in the attached Specifications dated March 2026, for the following sum:

BASE BID:

ITEM	QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
1	1	Power Transformer 30 MVA, 68.8-13.09 kV	$_____	$_____
2	1	Spare H Bushing	$_____	$_____
3	1	Spare X Bushing	$_____	$_____

The Guaranteed Evaluated Losses are calculated as outlined in Section 16320 - SUBSTATION POWER TRANSFORMER and Section 16320D – DATA SHEET. The guaranteed losses per unit for the BASE BID are as follows:

No Load Losses	Load Losses, ONAN rating (75°C)		Guaranteed Total Losses
Rated Voltage (20°C)	LTC @ Neutral	LTC @ 15 Raise	(excluding auxiliary losses)
_____ kW	_____ kW	_____ kW	_____ kW, per unit

Auxiliary Losses:		
First Step of Forced Cooling	Second Step of Forced Cooling	Total Auxiliary Losses
_____ kW	_____ kW	_____ kW, per unit

The LTC mechanism being proposed is a type _____(resistive or reactive), manufactured by _____ with a maximum current rating of _____ A.

The coil construction of the tap winding is a _____ (helical, etc.) and is _____ (fully or partially) distributed.

If a series transformer is proposed, windings have a _____(circular or rectangular) construction. The excited winding has a rated voltage of _____ V.

If a reactance-type LTC is proposed, loading on the power transformer is limited to _____ percent of its maximum rating if the LTC mechanism stops in a mid-tap position. Other limitations should be discussed as part of the manufacturer's response.
If a reactance-type LTC is proposed, the preventative autotransformer (PA) uses _____ (circular or rectangular) construction. If rectangular construction is proposed, details of the manufacturer's PA design should be a part of the proposal.

The place of manufacture for the BASE BID is _____.

OPTIONAL ADDERS WITH PRICING:

The Owner requests an adder for a **4-year extension** to the warranty specified in Section 16320 SUBSTATION POWER TRANSFORMER. During this additional 4-year period, the Materialman's responsibilities are identical to those specified in Section 16320 except that transportation, removal and installation is excluded. The **BASE BID** price **ADDER** per unit is $_____.

The **BASE BID** price **ADDER** per unit to provide a 100% surety bond is $_____.

PROJECT LOCATION AND SCHEDULE:

Destination: Brightridge Electric
2600 Boones Creek Rd
Johnson City, TN 37615

Delivery Constraints: Shipments arriving after 2:00 p.m. on weekdays (Monday through Thursday) or arriving on weekends or holidays shall not be offloaded until the next working day and the Materialman shall be responsible for any demurrage.

Site Conditions: The transformer will be delivered and off-loaded to a concrete pad in the Owner's material yard. Materialman is responsible for assessing and including an appropriate delivery method in its BID.

Materialman's shipment lead time is _____ weeks.

Materialman will provide transportation to the Destination by _____ (e.g., truck, rail, ocean vessel).

The Materialman shall provide shop drawings, as specified in Section 01341 – SHOP DRAWINGS, _____ weeks after receipt of order.

The Materialman shall provide "FOR CONSTRUCTION" drawings **at least 6 weeks prior to shipping**.

Field Assembly, when required, will be performed by field service representatives from _____ (supply name of Field Service Firm).

Field Assembly and Testing Completion: _____ weeks after delivery.

LABOR RELATIONS:

The nearest labor contract expiration date associated with the design, manufacture, delivery, or installation of the transformer is _____.

GENERAL:

In submitting this BID FORM, the Materialman agrees as follows:

The prices set forth herein **do not include any** sums which are or may be payable by the Materialman on account of taxes imposed by any taxing authority upon the sale, purchase, or use of the equipment. If any such tax is applicable to the sale, purchase, or use of the equipment, the amount thereof shall be added to the purchase price and paid by the Owner. The **Owner is exempt from Tennessee Sales and Use Taxes (§ TCA 67-6-209(e)**.

The Materialman agrees to the terms and conditions of Document 00531 - MATERIALS CONTRACT.

The prices set forth herein are firm if accepted by the Owner within the period specified in Document 00021 - INVITATION TO BIDDERS and shall include the cost of:

1. Delivery to the Destination.
2. Offloading onto an Owner furnished concrete pad.
3. Assembly, if any, of bushings, radiators and/or equipment shipped separately from the main body of the transformer. This includes the cost of a crane, and other tools required to complete this assembly.
4. Field Service Representative for inspection, testing, and certification.
5. All other labor or other costs to provide the Owner with transformer filled with insulating liquid and ready for external connection.

The Evaluated Losses are guaranteed by the Materialman. If transformer test losses exceed the guaranteed losses, the Contract Amount will be adjusted as described in Section 16320 - SUBSTATION POWER TRANSFORMER.

DELIVERY AND INSTALLATION:

The transformer(s) shall be delivered to the Destination during the Delivery Period specified above. The Delivery Period defines the time during the project schedule from completion of the concrete pad until other project tasks could make the pad inaccessible. Delivery outside the specified Delivery Period could result in liquidated damages being assessed. Field assembly shall be completed on or before the Field Assembly Completion Date.

The Materialman shall be responsible for securing all permits required for shipping to the Destination and shall be responsible for any damages to road and utilities or other damages caused by the Materialman or his Delivery Agent during shipment to Destination.

Notice of Shipment - The Materialman shall notify the Owner and Engineer at the following times:

1. 10 days prior to shipment.
2. 24 hours prior to shipment.
3. 24 hours prior to delivery.

Failure to provide notice shall result in Materialman being responsible for any demurrage charges resulting from the unavailability of equipment to unload equipment.

The Materialman agrees that all requests for time extensions shall be in writing, and that only such time extensions as are granted by the Owner in writing shall be considered.

Time is of the essence in order for the Owner to comply with established construction schedules. Should the Materialman fail to complete the terms of this BID FORM by the Completion Date, after all time extensions granted by the Owner have been added, then in that event the Owner shall have and is hereby given the right to deduct and retain out of such monies which may then be due, or which may become due and payable to the Materialman, the DAMAGE AMOUNT per calendar day as liquidated damages for each and every day that Certification is delayed beyond the Completion Date. The Materialman and Owner agree that liquidated damages are for costs associated with project delay and not as a penalty and that proof of such losses or damages shall not be required. The DAMAGE AMOUNT shall be $250 per day, not to exceed five percent (5%) of the purchase price of the unit.

EVALUATION OF BIDS:

In order to determine the lowest responsive and responsible Vendor, the Owner will consider, in addition to the price quoted on the BID FORM, the following:

1. Evaluated Losses.
2. Stated exceptions to the specifications.
3. Method of delivery.
4. Warranty.
5. Delivery time.
6. Work history on previous projects.
7. Qualifications of the Field Service Representatives or Field Service Firm.

The prices submitted for spare parts will not be used in the evaluation.

The Materialman shall submit responses on this BID FORM with all blank spaces completed. Each completed BID FORM should also include a copy of the required attachments.

BID ATTACHMENTS:

Additional information and drawings shall be attached to and become a part of this BID FORM including, but not be limited to, the following:

1. Outline Drawings.
2. Transformer Dimensions, Weights.
3. Transformer Insulating Liquid Capacity (Tank & Total).
4. Impedance.
5. Regulation Value.
6. Load Tap Changer Data.
7. Sound Levels at All Ratings.

8. Qualifications of the Materialman's Field Services Representative.
9. A schedule of field tests, if different from those specified in Section 16320.
10. Complete listing of transformers of proposed design and rating of this manufacturer that have been short-circuit tested. The listing shall include all units tested and designated as development test or test required by customer specification. Test results, winding type and winding material shall be included. Unsuccessful tests shall be explained with appropriate comments as to design changes and subsequent testing and results.

Failure to submit evaluation data as specified can lead to bid rejection.

TITLE AND RISK OF LOSS:

Title of each equipment item shall pass to the Owner when all of the following have occurred:

1. Delivery and placement of equipment onto foundation at location specified.
2. Satisfactory inspection for in-transit damage.
    a. For transportation that includes a maritime vessel, the equipment and all impact recorders must be inspected for damage before and after each transport segment.
3. Satisfactory installation and field test by the Materialman's Field Services Representative.
    a. For transportation that includes a maritime vessel, additional testing is required for each transport segment. See Section 16320 – SUBSTATION POWER TRANSFORMER, Article 1.08.
4. Certification that the unit is ready to place in service.
5. Acceptance by the Owner following completion of Item 4.
6. Payment: See Document 00531 - MATERIALS CONTRACT, Article II Payment.

The Materialman acknowledges that he has received the following Addenda (insert Addenda number(s) and date(s) or NONE):

ADDENDUM NUMBER	DATE
_____	_____
_____	_____

EXCEPTIONS: Any and all exceptions that the Materialman takes to the attached specifications shall be itemized on this BID FORM. All items or exceptions not listed on this BID FORM will be deemed in full compliance with these specifications. Detailed description of the exceptions may be provided elsewhere in the bid materials. The Bidder shall indicate to which specification sections and paragraphs the exceptions apply or indicate no exceptions.

Specification Section Associated with EXCEPTION	Description of Exception

It is understood by the undersigned that the Owner retains the privilege of accepting or rejecting all or any part of this BID FORM and to waive any informalities or technicalities therein.

MATERIALMAN:_____

BY:_____ TITLE:_____

MAILING ADDRESS: DATE:_____

_____ TELEPHONE:_____

_____ FAX:_____

_____ E-MAIL:_____

STREET ADDRESS:

_____

_____

_____

OVERNIGHT SHIPMENT ADDRESS:

_____

_____

_____

PRINCIPAL CONTACT_____ TELEPHONE:_____

E-MAIL:_____

ALTERNATE CONTACT_____ TELEPHONE:_____

E-MAIL:_____

END OF DOCUMENT

DOCUMENT 00531
MATERIALS CONTRACT

AGREEMENT made as of _____, 2026 between BrightRidge (hereinafter called the "Owner"), an Energy Authority organized and existing under the laws of the State of Tennessee, and _____(hereinafter called the "Materialman"), a corporation organized and existing under the laws of _____.

WHEREAS the Owner and the Materialman desire to enter into this contract for the furnishing of materials, supplies and equipment (hereinafter called "Materials") for the Project,

NOW THEREFORE, in consideration of the mutual undertakings herein contained, the parties hereto agree as follows:

ARTICLE I - GENERAL

SECTION 1. The Materialman agrees to sell and deliver to the Owner and the Owner agrees to purchase and receive from the Materialman the following Materials in accordance with the provisions of the Table of Contents, Invitation to Bidders, Bidding Instructions, Materialman's Proposal, General Conditions, Supplementary Conditions, Specifications, and other items, attached hereto and made part hereof:

ITEM	QUANTITY	DESCRIPTION	CONTRACT PRICE
1	1	68.8-13.09 kV, 30 MVA Power Transformer with OLTC	$ _____
2	1	Spare 350 kV BIL Bushing for Item 1	$ _____
3	1	Spare 150 kV BIL Bushing for Item 1	$ _____
Total Contract Price			**$**_____

ARTICLE II – PAYMENT

At each payment milestone, as detailed below, the Materialman shall submit to the Engineer a detailed invoice. After verifying the amount is correct, the invoice will be forwarded to the Owner with a recommendation for payment. Owner shall, within 30 days after receipt thereof, pay Materialman the recommended amount. The final invoice shall not be submitted for payment until the equipment has been assembled and fully tested by the Materialman and certified ready for energization. The Owner will promptly pay the amount due less any sum Owner is entitled to set off, including but not limited to liquidated damages to which the Owner is entitled.

PAYMENT MILESTONE	PERCENT DUE
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

ARTICLE III - DEFECTIVE MATERIALS AND WORKMANSHIP

SECTION 1. All materials furnished hereunder shall be subject to the inspection, tests, and approval of the Owner and the Materialman shall furnish all information required concerning the nature or source of any Materials and provide adequate facilities for testing and inspecting the Materials at the Plant of the Materialman.

SECTION 2. The materials furnished hereunder shall become the property of the Owner when delivery at the specified location is made; no transit damage is noted after delivery; Materialman has satisfactorily installed, tested and certified the materials are ready to be placed in service; Owner has accepted installation and field tests completed by Materialman; and payment, as defined in Article II, has been made. The Owner may reject any such materials as do not comply with the Specifications for materials and warranties of the Materialman and manufacturers and any defective materials either before or after incorporation of such materials into the Project; provided such rejection is made in accordance with Warranty requirements of the attached technical section of this Specification. Upon any such rejection, the Materialman shall replace the rejected Materials with Materials complying with the Specifications for Materials and warranties at the original delivery destination(s). The Owner shall return the rejected materials at the same destination(s). In the event of the failure of the Materialman to replace rejected Materials, the Owner may make such replacement, and the cost and expense thereof shall be paid by and recoverable from the Materialman.

ARTICLE IV - MISCELLANEOUS

SECTION 1. All manufacturers' guarantees of Materials shall be transferred and assigned to the Owner upon delivery of any Materials and before payment is made for such Materials. Such guaranties shall be in addition to those required of the Materialman by other provisions of this contract.

SECTION 2. The Materialman shall hold harmless and indemnify the Owner, its agents, and employees, from any and all claims, suits, and proceedings for infringement of any patent or patents covering Materials purchased hereunder. The Materialman shall defend any suit or proceeding brought against the Owner, its agents, or employees, based upon a claim that the materials or any part thereof constitute an infringement of any patent, or if the Materialman shall fail to defend such suit or proceeding, the Owner may do so, and the Materialman shall make reimbursement for the expense of such litigation. If the Materials, or any part thereof, are held to constitute infringement and the use thereof is enjoined the Materialman shall, at its own expense, either procure for the Owner the right to continue to use the Materials, or such part thereof, or shall replace the Materials, or such part thereof, with non-infringing materials.

SECTION 3. Simultaneously with the final payment to the Materialman, as provided herein, the Materialman shall deliver to the Owner duplicate original releases of lien of subcontractors, if any.

SECTION 4. In the event that any of the provisions of this contract are violated by the Materialman or by any of the Materialman's subcontractors, the Owner may serve a written notice of intention to terminate such contract upon the Materialman, which notice shall specify the reasons therefor. Unless within ten (10) days after the serving of such notice upon the Materialman such violation shall cease and an arrangement for the correction thereof satisfactory to the Owner be made, this contract shall, upon the expiration of the said ten days, cease and terminate. In the event of any such termination, the Owner may purchase the Materials necessary for complete performance of this contract for the account and at the expense of the Materialman, and the Materialman shall be liable to the Owner for any excess cost occasioned thereby. The foregoing shall be in addition to every right or remedy now or hereafter existing at law or in equity or by statute.

SECTION 5. Each and all of the covenants and agreements contained herein shall extend to and be binding upon the successors and assigns of the parties hereto. However, the Materialman shall not assign this contract or any part thereof or enter into any contract with any person, firm, or corporation for the performance of the Materialman's obligations hereunder, or any part thereof, without the approval in writing, of the Owner.

Signed subject to incorporation of Materialman’s Quotation as part of this Materials Contract.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed by their duly authorized representatives all as of the day and year first above written.

Owner: BrightRidge	Materialman:
Signed: _____	Signed: _____
Type/Print: _____	Type/Print: _____
Title: _____	Title: _____

END OF DOCUMENT

DOCUMENT 00711
GENERAL CONDITIONS

TABLE OF CONTENTS

DOCUMENT 00711
GENERAL CONDITIONS

1. DEFINITIONS

A. The word "Owner" means the person(s), or organization, or municipality to which the Proposal is addressed.

B. The words "Engineer", "Architect", "Engineer/Architect" mean ALLEN & HOSHALL, Engineers, Planners.

C. The word “Materialman”, “Contractor”, or “Bidder” means the successful Bidder to whom the contract is awarded.

D. The words "install", "furnish", "provide", or words of like import mean the Materialman shall install, furnish, or provide, and similarly the words "approved", "authorized", "required", "satisfactory", "acceptable", or words of like import mean approved by, authorized by, required by, satisfactory to, or acceptable to the Engineer/Architect, unless otherwise expressly stated.

E. The words "indicated", "shown", "detailed", or "scheduled" mean indicated, shown, detailed, or scheduled on the contract documents, specifications, or drawings, unless otherwise expressly stated.

F. The word "work" means the labor, materials, equipment, supplies, and services to be furnished under the contract, and the performing of all duties and obligations required by the contract documents.

G. The word "submit" means the Materialman shall submit to the Engineer/Architect for approval, unless otherwise expressly stated.

H. The word "provide" means the Materialman shall furnish and install, complete and ready for use, unless otherwise expressly stated.

I. The word "selected" means selected by the Engineer/Architect, unless otherwise expressly stated.

2. ENGINEER/ARCHITECT'S DECISION

A. The Engineer/Architect shall in all cases determine the amount, quality, acceptability, and fitness of the several kinds of finished work and materials which are to be paid for hereunder, and shall decide all questions which may arise as to fulfillment of this contract on the part of the Materialman, and the Engineer/Architect’s interpretation of the contract and the Engineer/Architect’s determination and decision thereon shall be final and conclusive; such determinations and decisions, in case any question arises, shall be a condition precedent to the Materialman’s right to receive any money hereunder. The Engineer/Architect shall have the right to correct all clerical, mathematical, or minor errors or omissions in the specifications when such corrections are necessary for the proper coordination of the contract documents.

3. DRAWINGS AND SPECIFICATIONS

A. The drawings accompanying these specifications and forming a part thereof are listed elsewhere and together with the specifications they cover the work to be performed under the Contract. The Materialman and each Subcontractor employed on this work shall carefully examine all contract drawings and read all specifications. They will be bound by all things therein affecting their special work no matter under what heading they may appear.

B. The drawings and specifications are mutually explanatory and supplementary, and all features covered in one and not in the other shall have the same force and effect as though covered in both. In the event of any conflicts between the drawings and specifications, the Engineer/Architect's decision shall govern. Should any error, discrepancy, or variance be discovered in the drawings or specifications, the Materialman (or Subcontractor, as the case may be) shall immediately notify the Engineer/Architect before beginning the work and submit the question to the Engineer/Architect for his interpretation and decision. The Engineer/Architect will be governed by overall meaning of the documents.

C. No deviations from the drawings and specifications shall be made without the Engineer/Architect's prior written approval.

D. The GENERAL CONDITIONS and the SUPPLEMENTARY CONDITIONS shall apply to each and every division and/or section of the Technical Specifications, as fully as if quoted verbatim therein.

4. STANDARD PUBLICATIONS

A. Wherever in these documents reference is made to standard specifications, standards, codes, or other standard publications, such as "ASTM" (American Society for Testing and Materials), "AASHTO" (American Association of State Highway and Transportation Officials), "ANSI" (American National Standards Institute), "AWWA" (American Waterworks Association), "ACI" (American Concrete Institute), "AISC" (American Institute of Steel Construction), "AWS" (American Welding Society), Federal Specifications, "NEC" (National Electrical Code), or others, in all cases the latest published editions of such referenced standard publications in effect at the time of receipt of bids shall apply.

5. STANDARD EQUIPMENT AND EQUIPMENT INSTALLATION

A. Except where special equipment is required, it is the general intent of the Technical Specifications that manufacturers' standard equipment shall be furnished, and minor variations from the Technical Specifications to accommodate manufacturers' standard equipment will be permissible, provided that the proposed equipment complies substantially with the Technical Specifications, and that it will accomplish the required results, all to the Engineer/Architect's satisfaction.

1. In addition to the requirements specified in the Technical Specifications, each item of equipment shall have all features and accessories as standard with its manufacturer and/or required for a complete operational unit.

6. STANDARDS FOR MATERIALS

A. All materials shall be new. Used or salvaged materials shall not be considered unless specifically authorized by the Engineer/Architect.

7. PATENTS

A. The Materialman shall hold and save harmless the Owner and its officers, agents, servants, and employees from liability of any patented or unpatented invention, process, article, or appliance manufactured or used in the performance of the contract, including its use by the Owner, unless otherwise specifically stipulated in the Contract Documents.

8. CONTRACT SECURITY

A. The Materialman shall furnish a surety bond in an amount equal to at least 100 percent of the contract price as security for the faithful performance of this contract and for the payment of all persons performing labor and furnishing materials in connection therewith. The surety shall be a bonding company or companies legally authorized to do business in the State in which the work is located.

B. The Owner shall have the right to waive the surety bond requirements, in which case the Materialman shall reduce his bid price in the amount of the Materialman's cost for such security.

9. SUBCONTRACTING

A. The Materialman shall not award any subcontract to any Subcontractor without the Engineer/Architect's prior approval. Only those Subcontractors of proven ability whose reputation is known to the Engineer/Architect for executing first-class work, will be approved. The Engineer/Architect's approval will not be given until the Materialman submits to the Engineer/Architect an itemized written statement designating the name of each Subcontractor, and the amount of each subcontract. This statement shall also designate the items of the contract which the Materialman proposes to execute directly with his own organization. The amount of these items, combined with the amounts of the various subcontract proposals, shall correspond to the contract price for the entire project. The contract will not be signed until all subcontracts have been approved.

B. The Materialman shall be as fully responsible to the Owner for the acts and omissions of his Subcontractors, and of persons either directly or indirectly employed by them, as he is for the acts and omissions of persons directly employed by him.

C. The Materialman shall cause appropriate provisions to be inserted in all subcontracts relative to the work to bind Subcontractors to the Materialman by the terms of the General Provisions and other Contract Documents insofar as applicable to the work of Subcontractors and give the Materialman the same power as regards terminating any subcontract that the Owner may exercise over the Materialman under any provisions of the Contract Documents.

D. Nothing contained in this contract shall create any contractual relation between any Subcontractor and the Owner. It is specifically pointed out that the contractual relationship shall exist between the Owner and the Materialman only. It is the Materialman's duty, in his own interest, to enter into sub-contract agreements in strict

accordance with all provisions of the Contract Documents. The failure of the Materialman to make the proper agreements with his Subcontractors and suppliers shall in no way relieve the Materialman of his responsibilities and obligations to the Owner.

E. The Materialman and all Subcontractors for the various branches of work employed on the project shall cooperate fully with each other to facilitate the progress of the work, and to avoid all interferences between the various parts of the work.

F. Whenever his work is in progress, each Subcontractor shall have present at the job site a Job Superintendent, foreman, or other duly authorized agent with authority to control the Subcontractor's work. This duly authorized agent shall meet with the approval of the Engineer/Architect and the Owner. The Owner reserves the right to remove from the project the Subcontractor's agent or any other employee of the Subcontractor, if, in the Engineer/Architects or Owners judgement, such removal is necessary to protect the Owner's interest.

10. LIQUIDATED DAMAGES

A. If so stated in the PROPOSAL, the time of completion of the construction is of the essence of the contract and should the Materialman neglect, refuse, or fail to complete the work to be done under the contract within the time stated in the PROPOSAL, after all extensions of time granted by the Owner have been added, then in that event the Owner shall have and is hereby given the right to deduct and retain out of such monies which may then be due, or which may become due and payable to the Materialman for the work to be done under this contract, the amount stated in the PROPOSAL per calendar day for each and every day that the work is delayed in its completion beyond the specified time. The amount stated in the PROPOSAL will be held by the Owner to pay Engineering, Architectural, and legal fees and other costs occasioned by the delay in completion of construction.

11. NOTICES AND SERVICE THEREOF

A. All notices, demands, requests, instructions, approvals, and claims shall be in writing.

B. Each notice to or demand upon the Materialman shall be sufficiently given if delivered at the office of the Materialman shown by him in the Bid (or at such other office as the Materialman may from time to time designate to the Owner in writing), or if deposited in the United States mail in a sealed postage-prepaid envelope, or if delivered with charges prepaid to any telegraph company for transmission, in each case addressed to such office.

C. Unless otherwise specified in writing to the Materialman, all papers required to be delivered to the Owner shall be delivered to the Engineer/Architect, and each notice to or demand upon the Owner shall be sufficiently given if delivered to the Engineer/Architect's office, or if deposited in the United States mail in a sealed postage-prepaid envelope, or delivered with charges prepaid to any telegraph company for transmission, in each case addressed to the Engineer/Architect, or to such other representative of the Owner or to such other address as the Owner may subsequently specify in writing to the Materialman for such purposes.

D. Each such notice or demand shall be deemed to have been given or made as of the time of actual delivery, or (in the case of mailing) when it should have been received in due course of post, or (in case of telegrams) at the time of actual receipt, as the case may be.

12. RIGHTS OF THE OWNER TO TERMINATE CONTRACT

A. If the Materialman should be adjudged bankrupt, or if he should make a general assignment for the benefit of his creditors, or if a receiver should be appointed for the Materialman or any of his property, or if he should persistently or repeatedly refuse or fail to supply enough properly skilled workmen or proper material, or if he should refuse or fail to make prompt payment to persons supplying labor or material for the work under the Contract, or persistently disregard instructions or fail to observe or perform any provisions of the Owner's instructions, or fail to observe or perform any provisions of the Contract Documents, or otherwise be guilty of a substantial violation of any provision of the Contract Documents, then the Owner may by at least five days prior written notice to the Materialman without prejudice to any other rights or remedies of the Owner in the premises, terminate the Materialman's right to proceed with the work. The foregoing provisions are in addition to, and not in limitation of, the rights of the Owner under all other provisions of the Contract Documents.

13. ASSIGNMENT OF CONTRACT

A. The Materialman shall not assign the whole or any part of this contract or any monies due or to become due hereunder without the Owner's written consent. In case the Materialman assigns all or any part of any monies due or to become due under this contract, the instrument of assignment shall contain a clause substantially to the effect that it is agreed that the right of the assignee in and to any monies due or to become due to the Materialman shall be subject to prior liens of all persons, firms, and corporations for services rendered or materials supplied for the performance of the work called for in this contract.

14. WARRANTY

A. All material furnished by the Materialman, covered by the drawings and specifications and official modifications thereof, shall be warranted by the Materialman for a period of one year from the date of acceptance by the Owner. All necessary repairs required during this period due to defective workmanship or material shall be made promptly by the Materialman at his facilities or at the customer's site, whichever is best, without cost to the Owner, including all costs for transportation in both directions between the manufacturer's facilities and the delivery site, including Owners costs for removal and installation, at times convenient to the Owner.

B. After the beginning of the warranty period, the Materialman shall not be responsible for lubrication, filter servicing, adjusting of belts and other items normally requiring periodic adjustments, cleaning out strainers, and other normal maintenance operations, all of which shall be the Owner's responsibility.

C. The Engineer/Architect shall have the sole right to establish the beginning of the warranty period for all portions of the project, and if so stated in the SUPPLEMENTARY CONDITIONS or the TECHNICAL SPECIFICATIONS, the guarantee period shall not begin until a trial run has been completed with satisfactory operation for the period of time stated in the SUPPLEMENTARY CONDITIONS or the TECHNICAL SPECIFICATIONS.

15. MODIFICATIONS TO GENERAL CONDITIONS

A. Modifications to these GENERAL CONDITIONS, if any, shall be as specified in SUPPLEMENTARY CONDITIONS.

END OF DOCUMENT

DOCUMENT 00811
SUPPLEMENTARY CONDITIONS TO DOCUMENT 00711

7. PATENTS

1. Delete Paragraph A and insert in its place:

   A. The Materialman shall hold harmless and indemnify the Owner, its agents, and employees, from any and all claims, suits, and proceedings for infringement of any patent or patents covering Materials purchased hereunder. The Materialman shall defend any suit or proceeding brought against the Owner, its agents, or employees, based upon a claim that the materials or any part thereof constitute an infringement of any patent, or if the Materialman shall fail to defend such suit or proceeding, the Owner may do so, and the Materialman shall make reimbursement for the expense of such litigation. If the Materials, or any part thereof, are held to constitute infringement and the use thereof is enjoined the Materialman shall, at its own expense, either procure for the Owner the right to continue to use the Materials, or such part thereof, or shall replace the Materials, or such part thereof, with non-infringing materials.

8. CONTRACT SECURITY

1. Delete phrase in Paragraph B ", in which case the Materialman shall reduce his bid price in the amount of the Materialman's cost for such security."

12. RIGHTS OF THE OWNER TO TERMINATE CONTRACT

1. Paragraph A, ninth line delete "five" and substitute "ten" therefore.

14. BASIC WARRANTY

1. The length of warranty shall be as established in the appropriate technical sections of the Contract Documents and Specifications.

2. Bids will not be accepted from a Materialman that does not provide a Bid Price Adder for the 4-year warranty extension.

15.MODIFICATIONS TO GENERAL CONDITIONS

1. Add new paragraphs immediately after Paragraph A which is to be read as follows:

   B. Prior to Execution of the Contract, the liability insurance shall be provided with the following as to limits of coverage and certain other special provisions (if any):

      1. Workers' Compensation - In accordance with the laws of the State.

2. Contractor shall provide Comprehensive General Liability insurance, written on a Job Site Basis and name the Owner and Engineer as additionally insured, as follows on an Occurrence Form:

General Liability -	General Aggregate:	$1,000,000	
	Completed Operations:	$1,000,000	
	Property Damage:	$1,000,000	each occurrence
	Personal Injury:	$1,000,000	annual aggregate
	Each Occurrence:	$1,000,000	
Auto Liability -	Combined Single Limit:	$1,000,000	
	Bodily Injury and	$ 500,000	each person
	Property Damage:	$ 500,000	each accident
		$1,000,000	annual aggregate
Umbrella Liability -	Aggregate:	$3,000,000	
	Each Occurrence:	$3,000,000	

C. Materialman shall be responsible for ascertaining that each carrier has obtained transit insurance for all stages of transportation and for all countries through which the transformer passes. Coverage shall be in an amount at least equal to the contract price.

END OF DOCUMENT

DOCUMENT 00900
ADDENDA

1. INTERPRETATIONS - ADDENDA

A. Interpretations and Addenda for questions concerning the meaning or intent of the Contract Documents and response to these will be made through the issuing of Addenda.

B. All Addenda are incorporated, by reference, into the Contract. Failure of any Bidder or sub-bidder to receive any addenda shall not relieve the Bidder of any obligation with respect to their Bid.

C. All Addenda and modifications to the Contract Documents shall be inserted and indexed numerically in this location behind this page and coordinated as instructed in each Addendum.

END OF DOCUMENT

SECTION 01040
PROJECT COORDINATION

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Coordination

B. Project Representatives and Addresses

1.02 COORDINATION

A. All work, submittals, and testing shall be coordinated with the Work listed in the Contract Documents to assure efficient progress of the Project Construction.

1.03 PROJECT REPRESENTATIVES AND ADDRESS

A. Owner: BrightRidge

MAIL: P.O. Box 1636, Johnson City, TN 37605
STREET: 2600 Boones Creek Road
Johnson City, TN 37615

PHONE: 423-952-5027

Contact: Russ Foster, Substation & Power Equipment Supervisor
Alternate: Sam Ford, Chief Engineering & Technology Officer

B. Engineer: Allen & Hoshall
Engineers | Planners

STREET: 8331 E. Walker Springs Lane, Suite 102
Knoxville, Tennessee 37923

PHONE: (865) 693-7881

Contact:	Joe Nims, PE	e-mail: jnims@allenhoshall.com
Alternate:	Charles Dykes	e-mail: cdykes@allenhoshall.com

C. All correspondence to the Owner shall be addressed as in Article 1.03, A.

D. All correspondence, submittals, shop drawings, test reports, instruction manuals, operation manuals and any other pertinent Project materials shall be addressed to the Engineer as in Article 1.03, B.

E. Forward a copy of all correspondence addressed to the Owner to the Engineer.

F. Notify Owner and Engineer of the Primary Project Representative, Alternate Project Representative, mailing address, package delivery address, phone number (normal working hours), phone number (after working hours) and email address.

G. All correspondence, submittals or other items associated with the Contract shall be identified by the Project Owner and Project name as listed in the Contract Documents.

PART 2. PRODUCTS

(NOT USED)

PART 3. EXECUTION

(NOT USED)

END OF SECTION

SECTION 01090
REFERENCE STANDARDS

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Quality Assurance

B. Schedule of References

1.02 QUALITY ASSURANCE

A. Comply with the latest revision of the standard for all equipment, materials, and labor, except when more rigid requirements are specified or are required by applicable codes.

B. Request clarification from Engineer before proceeding, should specified reference standards conflict with Contract Documents.

1.03 SCHEDULE OF REFERENCE

A. Documents and/or Standards from the following agencies may be referenced in the Contract Documents:

AA	Aluminum Association
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CRSI	Concrete Reinforcing Steel Institute
CSI	Construction Specifications Institute
EEI	Edison Electric Institute
EPA	Environmental Protection Agency
ICEA	Insulated Cable Engineers' Association

IEEE	Institute of Electrical and Electronics Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
SSPC	Steel Structures Painting Council
RUS	Rural Utility Service
UL	Underwriters' Laboratories, Inc.

END OF DOCUMENT

SECTION 01301
SUBMITTALS

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Submittal Procedures

B. Submittal Schedule

1.02 RELATED SECTIONS

A. DIVISIONS 0 and 1 - CONTRACT DOCUMENTS, and GENERAL REQUIREMENTS: These shall apply to all work included in this section.

B. Section 01040 - PROJECT COORDINATION

C. Section 01341 - SHOP DRAWINGS

D. Section 01721 - PROJECT RECORD DOCUMENTS

1.03 SUBMITTAL PROCEDURES

A. Transmit each submittal with a transmittal letter or Engineer accepted form.

B. Submit shop drawings as specified in Section 01341 - SHOP DRAWINGS

C. Identify BrightRidge Transformer, pertinent drawing sheet and detail number(s), and specification section number, as appropriate.

D. Schedule submittals to expedite the project and deliver to Engineer with copy of transmittal letter to Owner's representative as identified in Section 01040 - PROJECT COORDINATION. Coordinate submission of related items.

E. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of the completed Work.

F. Provide space for Engineer’s review stamps.

G. Revise and resubmit submittals as required, identify all changes made since previous submittal.

1.04 SUBMITTAL SCHEDULE

A. Provide a submittal schedule indicating review dates and return dates required to maintain the project schedule.

1.05 SUBMITTAL MATRIX

A. The following matrix shows the types of submittals required under each section of the technical specifications. Details can be found in the appropriate technical sections.

Section Number	Bill of Materials	Shop Drawings	Product Data	Calculations	Certifications	Photographs	MIX Design	Test Reports	O&M Manuals
16320		X	X	X		X		X	X
16327		X	X						X

END OF SECTION

SECTION 01341
SHOP DRAWINGS

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Shop Drawing submittals.

B. Final/Record/As-Built Drawings are specified in Section 01721 - PROJECT RECORD DOCUMENTS

1.02 RELATED SECTIONS

A. DIVISIONS 0 and 1 - CONTRACT DOCUMENTS, and GENERAL REQUIREMENTS: These shall apply to all work included in this section.

B. Section 01301 - SUBMITTALS

C. Section 01721 - PROJECT RECORD DOCUMENTS

1.03 SHOP DRAWINGS

A. Shop drawings shall include fabrication, erection, layout, and setting drawings; material lists; manufacturer's catalog sheets and/or descriptive data for materials and equipment showing dimensions, performance characteristics, and capacities; wiring and control diagrams; electrical characteristics, and capacities; and other pertinent information as required to obtain approval of the items involved.

B. Drawings shall be presented in a clear and thorough manner.

1. Details shall be identified by reference to sheet and detail numbers shown on Contract Drawings and Specification Sections.

C. Minimum sheet size: 8½" x 11".

D. Maximum sheet size: 22" x 34"

1.04 PRODUCT DATA

A. Preparation:

1. Clearly mark each copy to identify pertinent products or models.

2. Show performance characteristics and capacities.

3. Show dimensions and clearances required.

B. Manufacturer's standard schematic drawings and diagrams:

1. Modify drawings and diagrams to delete information which is not applicable to the

Work.

2. Supplement standard information to provide information specifically applicable to the Work.

1.05 MATERIALMAN RESPONSIBILITIES

A. Designate in the submittal schedules, the dates for submission and the dates that reviewed Shop Drawings and product data will be required to maintain delivery schedule.

B. Review Shop Drawings and Product Data prior to submission. Materialman shall allocate 10 business days (excluding holidays) to the project schedule for the Engineer's initial review. Additional time may be necessary for resubmissions.

C. Determine and verify:

1. Catalog numbers and similar data.

2. Conformance with specifications

D. Coordinate each submittal with requirements of the Work and of Contract Documents.

E. Notify the Engineer in writing (include e-mail), in advance of submission, of any deviations in the submittals from requirements of the Contract Documents. Materialman requested deviations may require additional supporting documentation before the Engineer acts on the request.

F. Begin no fabrication or work which required submittals until return of submittals with satisfactory review.

1.06 SUBMISSION REQUIREMENTS

A. Make submittals promptly in accordance with the approved schedule.

B. Number of submittals required:

1. Shop Drawings: Submit one (1) copy of electronic data files of all drawings prepared for the project. Electronic data files shall be either a Design Web Format (.DWF) or a Portable Document Format (PDF) format. Raster based scans (.TIF, .PCX, or .GIF) files of manual drawings are not acceptable.

2. Product Data: Submit one electronic (1) copy of product data of all items for which product data is specified in other sections. Electronic data files shall be in a PDF format.

3. Shop Drawings and Product Data can be provided on electronic storage media or via e-mail. When submittal data is delivered via e-mail, it is the Materialman's responsibility to verify receipt by the Engineer.

C. Submittals shall contain:

1. Submittal identification number. Submittals shall be numbered consecutively. Re-

submittals shall use the same submittal number with an alphabetic suffix added.

2. The date of submission and the dates of any previous submissions.

3. The Owner's name, project title and number.

4. Contract identification.

5. Identification of the project, with the specification section number.

6. Relation to adjacent or critical features of the work or materials.

7. Applicable standards, such as ASTM or Federal Specification numbers.

8. Identification of deviations from Contract Documents.

9. Identification of revisions on resubmittals.

10. A 3"x 3" blank space for Materialman and Engineer stamps.

1.07 RETURN FOR RESUBMISSION

A. The Engineer will return for resubmission all shop drawings submitted without the above specified approval and certification which in the Engineers opinion contain numerous discrepancies, have not been checked, or do not meet the requirements for submission.

1.08 REVIEW OF SUBMITTALS

A. The Engineer will review, mark and date all submitted shop drawings. One (1) electronic set will be returned to the Materialman. When submittal data is returned via e-mail, it is the Engineer's responsibility to verify receipt by the Materialman. Materialman shall make corrections and changes as indicated.

B. Resubmit shop drawings as specified above, until satisfactory review has been obtained. Corrections and/or changes indicated on shop drawings by Engineer/Owner shall not be considered as an extra work order.

C. After satisfactory "Review" or "Furnish as Corrected" has been obtained for all shop drawings, a set of shop drawings marked "FOR CONSTRUCTION" shall be furnished to the Engineer in the format specified in Article 1.06 above. Materialman shall provide "FOR CONSTRUCTION" drawings within 21 days of receipt of the Engineer's satisfactory review of all shop drawings.

D. Review of shop drawings by the Engineer will be general only, and such review will not relieve the Materialman of responsibility for accuracy of such shop drawings, proper fitting, coordination, construction of work, and furnishing materials required by the Specifications but not indicated on shop drawings. Review of shop drawings shall not be construed as approving departures from the Specifications.

1.09 ENGINEER DUTIES

A. Review submittals with reasonable promptness and in accordance with schedule.

B. Affix stamp and initials or signature, and indicate requirements for resubmittal, or satisfactory review of submittal.

C. Return submittals to Materialman for distribution, or for resubmission.

PART 2. PRODUCTS

(NOT USED)

PART 3. EXECUTION

(NOT USED)

END OF SECTION

SECTION 01721
PROJECT RECORD DOCUMENTS

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Final “As-Built” record drawings

B. Factory test results

C. Operation/Maintenance manuals

1.02 RELATED SECTIONS

A. DIVISIONS 0 and 1 - CONTRACT DOCUMENTS, and GENERAL REQUIREMENTS: These shall apply to all work included in this document.

B. Other requirements affecting Project Record Documents may appear in pertinent other Sections of these Specifications.

1.03 SUBMITTALS

A. Comply with pertinent provisions of GENERAL CONDITIONS and Section 01301 - SUBMITTALS.

B. Prior to submitting a request for final payment, submit the final Project Record Documents to the Engineer for approval.

1.04 MATERIALMAN RESPONSIBILITIES

A. The Materialman shall provide final "As-Built" record drawings of the work with all revisions incorporated.

B. The Materialman shall provide factory test results, as applicable, for all material furnished.

C. The Materialman shall provide complete operation and maintenance manuals for all equipment furnished.

PART 2. PRODUCTS

(NOT USED)

PART 3. EXECUTION

3.01 FINAL DRAWINGS

A. At completion of the project, the Materialman shall incorporate all revisions into the shop drawings to provide a complete set of final drawings. The drawings shall be marked as "Final-As Constructed".

B. One (1) copy of electronic data files of all drawings prepared for the project shall be sent by email. Format shall be AutoCAD (.DWG) files and Portable Document Format (.PDF).

3.02 FACTORY TEST RESULTS

A. The Materialman shall provide, as a minimum, results for all routine or production tests required by the industry standards referenced in the technical sections.

B. The Materialman shall also provide results for any non-routine tests specified in the technical sections.

C. When required in the technical sections, required test results shall be forwarded to the Engineer prior to shipping.

D. Engineer shall have two (2) weeks to review factory test results before shipping.

3.03 OPERATION AND MAINTENANCE MANUALS

A. Shipped Equipment. The Materialman shall provide a complete set of the Operation, Maintenance and Instruction Manuals covering all equipment furnished for the project in each unit shipped.

B. Owner's Records. For each unit, two (2) complete set(s) of Operation, Maintenance and Instruction Manuals covering all equipment furnished for the project shall be sent to the Owner at the address in SECTION 01040 - PROJECT COORDINATION.

C. Engineer's Records. For each unit, one (1) complete set of Operation, Maintenance and Instruction Manuals covering all equipment furnished for the project shall be sent to the Engineer at the address in SECTION 01040 - PROJECT COORDINATION.

D. Each complete set includes One (1) printed copy and One (1) electronic copy.

E. Contents of Manuals

1. Table of Contents and index tabs.
2. Description of the equipment.
3. Operating instructions.
4. Installation instructions including rigging and lifting details.
5. Maintenance instructions.
6. Instruction manuals for installation, operation, and maintenance of each accessory device, including oil filling procedures.
7. Assembly drawings.
8. Parts lists.
9. List of recommended spare parts.

10. List of maintenance tools furnished with the equipment.
11. Nameplate information and shop order numbers for each item of equipment and component part.
12. Final As-Constructed shop drawings.
13. Photographs (if required in specifications).
14. Certified factory test results.

F. Format

1. All Manuals shall be bound in an ultra-heavy duty, three-ring binder of suitable size for the material to be inserted.

2. USB Flash Drives containing electronic data files shall be placed in poly sleeve three-ring binder page and inserted in manual binder.

3. Instruction manuals for microprocessor-based relays/controls shall be provided in:

   a. The relay/control manufacturers' original binding or
   b. A three-ring binder produced by the Materialman with dividers identical to the relay/control manufacturers' manual.

4. All information bound shall be 8½" x 11" or accordion folded to this size.

5. Page dividers with plastic reinforced holes and tabs shall be used to organize Operations and Maintenance Manuals.

6. Binder cover and edge inserts shall contain Owner's name, project title, date, and subject matter of the manual.

G. Organization

1. Table of Contents shall list all information contained.

2. Contact information for all major equipment suppliers, Materialman, and subcontractors.

3.04 FINAL SUBMITTAL

A. All Record Documents, including final drawings and Operation, Maintenance and Instruction Manuals shall be submitted to the Engineer prior to submitting final payment request.

3.05 CHANGES SUBSEQUENT TO ACCEPTANCE

A. The Materialman has no responsibility for recording changes in the Work subsequent to Final Completion, except for changes resulting from work performed under Warranty.

END OF SECTION

SECTION 16320
SUBSTATION POWER TRANSFORMER
TABLE OF CONTENTS

SECTION 16320
SUBSTATION POWER TRANSFORMER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification section in conjunction with Section 16320D - DATA SHEET - SUBSTATION POWER TRANSFORMER includes the fabrication and delivery of substation power transformer(s), as required to meet the **Materialman's** obligations, as stated in the proposal section of these specifications.

B. This specification includes two-winding transformers, three-winding transformers, and autotransformers.

1.02 RELATED SECTIONS

A. DIVISIONS 0 and 1 - PROPOSAL DOCUMENTS, MATERIALS CONTRACT AND GENERAL REQUIREMENTS: These shall apply to all work included in this section.

B. Section 01301 - SUBMITTALS

C. Section 01341 - SHOP DRAWINGS

D. Section 01721 - PROJECT RECORD DRAWINGS

E. Section 16320D - DATA SHEET - SUBSTATION POWER TRANSFORMER

F. Section 16327 – ON-LOAD TAP CHANGER

1.03 REFERENCE STANDARDS

A. Published Specifications, standards, tests, or recommended methods of trade, industry, or governmental organizations apply to work in this section where cited in Section 01090 - REFERENCE STANDARDS and in the listing below. For dated references only the edition cited applies. For undated references, the latest edition of the referenced document applies.

1. IEEE C57.12.00 – IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

2. IEEE C57.12.10 - IEEE Standard Requirements for Liquid-Immersed Power Transformers.

3. IEEE C57.12.28 - IEEE Standard Pad-Mounted Equipment-Enclosure Integrity.

4. IEEE 57.12.70 – IEEE Standard Terminal Markings and Connections for Distribution and Power Transformers.

5. IEEE C57.12.90 - IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

6. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers.

7. IEEE C57.19.00 - IEEE Standard General Requirements and Test Procedures for Power Apparatus Bushings.

8. IEEE C57.19.01 - IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.

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

10. IEEE C57.93 - IEEE Guide for Installation and Maintenance of Liquid-Immersed Power Transformers.

11. IEEE C57.98 - IEEE Guide for Transformer Impulse Tests.

12. IEEE C57.106 - IEEE Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment.

13. IEEE C57.119 - IEEE Recommended Practice for Performing Temperature Rise Tests on Liquid-Immersed Power Transformers at Loads Beyond Nameplate Ratings.

14. IEEE C57.147 – IEEE Guide for Acceptance and Maintenance of Natural Ester Insulating Liquid in Transformers.

15. IEEE C57.148 - IEEE Standard for Control Cabinets for Power Transformers.

16. IEEE C62.11 - IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV).

17. IEEE Standard 693 - IEEE Recommended Practice for Seismic Design of Substations, 2018.

18. NEMA No. TR-1 - Transformers, Regulators, and Reactors.

1.04 SERVICE CONDITIONS AND SYSTEM DESCRIPTION

A. Service conditions and a system description are shown in the DATA SHEET.

1.05 PERFORMANCE REQUIREMENTS

A. Loss Evaluation

1. The formulas used to calculate the Evaluated Losses and Total Evaluated Cost are shown in the DATA SHEET.

2. Losses provided by the **Materialman** on the BID FORM will be used to calculate the Equivalent Load Losses and the Total Evaluated Cost. The Total Evaluated Cost will be a part of the bid evaluation.

3. Guaranteed Total Losses are the sum of No-Load Losses and Equivalent Load Losses. The reference temperature for No-Load Losses is 20°C. The referenced temperature for the Equivalent Load Losses will be the nameplate average winding

temperature rise at the base ONAN rating plus 20°C (75°C for 55°C transformers and 85°C for 65°C transformers).

4. Equivalent Load Losses shall be calculated at the ONAN rating of the transformer unless different load conditions are specified in the DATA SHEET.

5. Equivalent Load Losses shall be calculated with the H-Winding de-energized tap changer in the rated voltage tap position unless a different tap is specified in the DATA SHEET.

6. For two-winding transformers **without** On-Load Tap Changers (OLTCs), the Equivalent Load Losses are equal to the **Materialman's** quoted load losses.

7. For two-winding transformers with OLTC transformers, the Equivalent Load Losses are the average of the measured load losses with the OLTC in the neutral and 15 Raise positions.

8. For three-winding or autotransformers with stabilizing windings or an unloaded tertiary, the Equivalent Load Losses are equal to the **Materialman's** quoted load losses.

9. For three-winding or autotransformers with a loaded tertiary winding, the Equivalent Load Losses will be calculated using the **Materialman's** quoted load losses for each pair of windings (i.e., H-X, H-Y and X-Y) and converted to an equivalent wye. Load losses will be calculated for each winding based on the loading condition specified in the DATA SHEET. The Equivalent Load Losses are the arithmetic sum of each winding's calculated load losses at the specified loading condition.

10. All units will be evaluated independently.

B. Loss Guarantee

1. The Guaranteed Total Evaluated Losses are calculated using the Evaluated Losses formula in the DATA SHEET and losses provided by the **Materialman** on the BID FORM.

2. Test methods described in the latest revision of IEEE Standard C57.12.90 are acceptable for no-load loss and load loss measurements.

3. Tolerances for transformer losses or **Materialman's** test system, as allowed in the latest revision of IEEE C57.12.00, **do not** apply for the calculation of loss penalty.

4. Should the tested Evaluated Losses exceed the Guaranteed Total Evaluated Losses, a loss penalty shall be computed. The penalty will be the difference between the actual Evaluated Losses and the Guaranteed Evaluated Losses. In no case shall a unit price be increased for loss costs less than guaranteed. The final payment shall be reduced by the amount of the penalty calculated by the Engineer. The Engineer will certify final payment by the **Owner**.

1.06 SUBMITTALS

A. Shop drawings shall be submitted for approval in accordance with Section 01301 -

SUBMITTALS and Section 01341 - SHOP DRAWINGS.

B. Submittals shall consist of, but not limited to, the following:

1. Transformer Outline Dimension Drawing with Weights. The drawing shall show all four sides and the top. The drawing shall also indicate the center of gravity of the unit for shipping and installation purposes.
2. Outline and Nameplate drawings for Bushings and Surge Arresters
3. Current Transformer manufacturer's nameplate data, typical excitation, and ratio correction factor curves shall be included for each type of CT.
4. Control Cabinet Layout Drawings.
5. Control Schematics.
6. Control Wiring Connection Diagrams.
7. Control Cabinet nameplate schedule.
8. Nameplate Drawing.
9. Certified seismic qualification tests and analyses, in accordance with IEEE Std. 693-2018.
10. Details of Seller's solution to tank rupture mitigation, Section 16320 Article 2.03 J.
11. Temperature Rise Calculations.
12. Winding and Main Core Characteristics Tables.
13. Lead interconnection method and certification process.
14. Cutsheets for conduit bodies and product used to protect RMC threads.
15. Preliminary programming of microprocessor-based monitor (if applicable).
16. Factory Test Plan, Factory Test Schedule, and blank copy of Field Report.
17. Digital photographic images (submitted before factory testing).
18. Preliminary Factory Test Reports (for Engineer's approval).
19. Thermographic photos.
20. Final Factory Certified Test Report.
21. Final Programming of electronic winding temperature indicator (if applicable).
22. Installation Instructions.
23. Operating Instructions.
24. Refiner's Certificate that mineral oil meets ASTM D3487, if applicable.
25. Installation Field Test Report (preliminary plan and final results).

C. Final Drawings, Manuals, and Test Reports shall be provided **prior** to shipment in accordance with Section 01721 - PROJECT RECORD DOCUMENTS.

1.07 PHOTOGRAPHS

A. Core and Coil Photographs. Color photographs shall be provided for each unit (one set of both printed and digital copies for each instruction manual) in accordance with Section 01721 - PROJECT RECORD DOCUMENTS. Photographic prints shall be at least 8 x 10 inches in size with a minimum 300 dpi resolution. Digital images shall be in a jpeg format. The resolution of the digital images shall be compatible with the printing specifications, with a minimum resolution of 12 Megapixels. All photographs shall be identified with **Materialman's** name and unit serial number. In addition, digital copies shall be forwarded to the Engineer as submittals at the appropriate time. The following images shall be provided:

1. Core and individual coils before the coils are landed. Images shall show general construction (e.g., keyed spacers, bands) and taps, if applicable.

2. Core and coil assembly prior to tanking. Five views shall be provided including each

quadrant and from above.

3. Core and coil assembly after tanking.

4. **Digital copies of the images in items 1, 2, and 3 above shall be forwarded to the Engineer for approval prior to tanking of the core and coils**.

B. Fully Assembled Transformer.

1. Five views of both visible-light and thermal images shall be provided including each quadrant and from above.

2. Nameplate photo after engraving/stamping impedance data.

3. **Digital copies of the images in items 1 and 2 above shall be forwarded to the Engineer with the Preliminary Factory Test Reports**.

C. Thermographic Images.

1. Thermographic Instrument Requirements

a. Infrared thermal imaging systems shall detect emitted radiation and convert detected radiation to a real-time visual signal on a monitor screen. Imagery shall be multi-color. Non-imaging radiometers, visual infrared thermometers, and non-imaging line scanners are not sufficient.
b. Spectral Range: the infrared imaging system shall operate within a spectral range from 2 to 14 µm.
c. Spatial Resolution: Infrared imaging system must have resolution sufficient to provide clear imagery of inspected components. It is recommended that the infrared thermal imaging system have a detector that has a minimum of 320 x 240 pixels.
d. Thermal Sensitivity: The infrared thermal imaging system shall have a thermal sensitivity (NETD) of 0.1°C (100 mK) or less at 30°C.

2. Thermographic Documentation. The **Materialman** shall provide documentation for all infrared inspections. The following information will be included in a written report to the Engineer:

a. The manufacturer, model and serial number of the infrared equipment used.
b. The date(s) of the inspection and when the report was prepared.
c. When using Delta T criteria, the surface temperature of the hottest point(s) and of a defined reference and their temperature difference shall be reported.
d. When using absolute temperature criteria, the surface temperature of the hottest point(s) and the standard temperature(s) referenced.
e. Thermographic images shall be taken as specified in Article 3.01, Paragraph E.6.a.

1.08 SHIPPING

A. Transformer(s) shall be shipped filled with insulating liquid or dry air in an upright position. If shipped without insulating liquid, the transformer shall be liquid filled under vacuum after delivery as detailed in **Materialman's** installation procedures and

directives. For maritime shipments, the transformer shall be equipped with two make-up bottles of dry gas. During transport, the valve of one gas bottle valve shall be open while the second valve shall be closed in case additional gas is needed due to leakage.

B. Internal shipping braces (if applicable) shall be painted red to clearly indicate it is to be removed at the destination prior to final assembly and energization.

C. Upon delivery all necessary certifications shall be given to **Owner** stating the insulating liquid has no detectable levels of PCBs (<2.0 ppm).

D. Transformer(s) and associated equipment shall be shipped with a digital 3-axis impact recorder attached, regardless of mode of transportation. Impact recorders shall provide data on the magnitude of axial, transverse, and vertical forces on transformer during transit. The impact recorder shall record acceleration-time histories with accelerations up to 10g and frequency bands between 1 and 250 Hz. For maritime transportation, the impact recorder should include inclination and angle measurements. The impact recorder shall be able to operate in temperatures from -20°C to 60°C.

1. A minimum of two digital impact recorders shall be installed on the tank exterior for shipment. Impact recorders shall be mounted to a sufficiently rigid structure at the centerline of the longitudinal ends of the transformer tank. No damping material shall be allowed between the impact recorders and the tank.
2. Impact recorders should be mounted so that they are not exposed to possible sources of damage during transport.
3. Adhesive impact warning labels shall be placed on crated items (e.g., bushings, radiators).
4. When the mode of transportation includes rail or maritime vessels, the impact recorders shall be checked at each transloading location for unusual impacts or accelerations during the shipping period. Impact recorder batteries shall also be checked at each transloading location to verify a sufficient state of charge to the next location.
5. **Materialman** shall review the impact recorder's record to determine the extent of inspection and tests at each location.
6. After the transformer is unloaded at its final destination, the impact recorders shall be retrieved and returned by the **Materialman's representative**.
7. Impact recorder data shall be provided to the **Owner** and Engineer in a format usable by Microsoft Excel. If on-line monitoring is available, the **Materialman** shall provide all necessary information for the **Owner** and Engineer to access the on-line data.

E. For transportation that includes a maritime vessel, bushings removed for shipment shall be replaced by test bushings. The test bushings shall be mounted on the cover plate and have gaskets to maintain pressure during transportation. The test bushings shall have mechanical protection when not in use. With the transformer prepared for shipping, a base line SFRA will be performed at the factory.

F. For transportation that includes a maritime vessel, testing and inspection shall be conducted after each transport segment including, but not limited to:

1. Visual inspection. The transformer shall be visually checked for leaks, tank external marks and scratches, sheared off parts, bent plates or beams and other signs of

rough handling. If the tank pressure is zero, the dew point of the shipping gas shall be recorded. Unacceptable dew points shall be reported to Owner .

2. Impact recorder data analysis. Data shall be interrogated from the impact recorder. If acceleration limits have been exceeded, the Materialman shall determine what steps are appropriate before the next transportation segment begins.
3. Core/frame insulation resistance. Insulation resistance measurements shall be performed to detect damage to core/frame insulation.
4. SFRA. Subsequent SFRA tests shall be conducted in conformance to IEEE C57.150 Clause 9.72 to determine if unacceptable movement has occurred during transportation.
5. Transportation reports. Materialman shall provide the Owner with a summary report of all testing and visual inspections.

G. For transportation that includes a maritime vessel, the **Owner** reserves the right to hire an independent consultant/inspector to review and approve the **Materialman's** transportation plan. All expected costs associated with the independent consultant/inspector shall be added to the evaluated cost of **Materialman's** proposal.

1.09 WARRANTY

E. All materials, insulating liquids, and equipment supplied under this specification shall be new and warranted to the **Owner** against failure due to design or to defects in workmanship for a period of one (1) year after the transformer is first energized by **Owner** or one and one-half (1-1/2) years from date of delivery, whichever occurs first. Should any failure to conform to this warranty appear within the specified time, the **Materialman** shall correct such non-conformity at their facilities or at the substation site, whichever is best, all at no cost to the **Owner** and including all costs for transportation in both directions between the **Materialman's** facilities and the delivery site, including **Owner's** costs for removal and installation.

PART 2 PRODUCTS

2.01 MATERIALMEN

A. Approved **Materialmen** are shown in the DATA SHEET.

B. The **Materialmen** shall include in the BID FORM the most immediate date a labor contract associated with the design, manufacture, delivery, or installation of the transformer is set to expire.

2.02 GENERAL LOADING AND RATINGS

A. Transformer Ratings. Each transformer and all associated components and accessories shall be as specified in the DATA SHEET.

B. Thermal Performance and Required Data.

1. Without exceeding normal loss of life as defined in IEEE C57.91, the transformer shall be constructed for continuous operation at its maximum rated kVA capacity with the ambient conditions stated in the DATA SHEET. At the same ambient conditions with an equivalent load before peak of 70 percent of the maximum

nameplate, the transformer shall be capable of serving an 8-hour peak load of 110 percent of the maximum nameplate without additional loss of life.

2. The current carrying capability of the unit shall only be limited by the capacity of the core and windings. Accessory components shall not limit the maximum kVA rating.

3. **Materialman** shall submit the following chart of thermal calculations for review. Assume transformer is connected for temperature rise tests.

Thermal Quantities	55°C Average Winding Rise									65°C		
	ONAN			ONAF-1			ONAF-2			ONAF-2		
	H	X	Y	H	X	Y	H	X	Y	H	X	Y
Bottom Oil Rise												
Top Oil Rise												
Hottest-Spot Rise												
Average Winding Rise												
Winding Resistance												
Main Core Hottest-Spot Rise												
No-Load Losses (kW)												
Load Losses (kW)												

Notes: Temperature Rises are above ambient in °C.
Tertiary or Y-Winding data (as applicable).

C. Seismic Requirements.

1. The power transformer(s) shall be qualified according to IEEE 693-2018, "Recommended Practice for Seismic Design of Substations" (Annex D) and meet the requirements of the qualification level specified in the DATA SHEET.

2. The **Materialman** shall provide sufficient loading details on the Outline Drawing to design the concrete foundation. This shall include the recommended anchorage using a bolted design.

D. Short Circuit Strength Requirements.

1. The transformer(s) covered by this specification shall meet the electrical and mechanical withstand requirements given in the latest revision of IEEE C57.12.00 when tested according to IEEE C57.12.90.

2.03 COMPONENTS

A. General. Materials supplied as part of the specified power transformer(s) shall be new, of good quality and stored, protected, assembled, used, connected, applied, cleaned, and conditioned in accordance with the original manufacturer's instructions.

B. Core and Coils.

1. Complete core and coil assembly shall be removable from transformer tank for all needed repairs.

2. Locking devices shall be provided for all nuts, bolts, and clamps to deter any

loosening during shipping or normal operation.

3. All windings shall be constructed of individual insulated rectangular magnet wire or continuously transposed cable (CTC) and shall be of a disk or helical design.

4. Autotransformer windings shall be fully distributed and designed for the control of short-circuit forces for a fault at the transformer terminals.

5. Winding Insulation Levels: Power transformers shall be manufactured and tested to meet Class II dielectric insulation levels regardless of the high-voltage winding's rated voltage. The insulation package shall be provided by Weidmann. Insulation levels for the phase and neutral end (where applicable) of each winding are specified in the DATA SHEET.

6. The surface moisture content of the solid insulation at delivery, determined by the dew point temperature of the shipping gas, shall be no greater than 0.5% moisture by dry weight.

7. Additional requirements for windings associated with on-load tap changing are contained in Section 16327 ON-LOAD TAP CHANGER – EQUIPMENT AND CONTROLS when specified in the DATA SHEET.

8. Stabilizing Winding (when applicable).

    a. The stabilizing winding (when applicable) shall be assigned a thermal rating based on specifications in the DATA SHEET.
    b. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) then shorted and grounded externally, the **Materialman** shall provide:

        1) A removable link between the bushings of suitably sized flexible braid or laminated conductor. The selected link shall not damage the bushings due to thermal expansion and contraction between -20°C and 105°C.
        2) A 2-hole grounding pad shall be welded to the tank adjacent to the bushings.
        3) A suitable sized flexible lead between the 2-hole grounding pad and one of the bushings.

9. **Materialman** shall submit the following charts of winding characteristics for review.

Characteristic	H-Winding	X-Winding	Y-Winding	Regulating Winding
Winding Type				
Turn Conductor(s)				
Conductor Insulation				
Max. Current Density				

Notes: (1) Description of disc windings shall include the total number of sections.
(2) Turn conductor(s) description should include the strand dimensions, number of strands and if the conductor(s) are part of a CTC, and material (Cu/Al).

(3) Tertiary or Y-Winding and Regulating Winding data (as applicable).

Characteristic	H-Winding		X-Winding				Y-Winding
Turns	Tap 1		N				
	Tap 2		1R		9R		
	Tap 3		2R		10R		
	Tap 4		3R		11R		
	Tap 5		4R		12R		
			5R		13R		
			6R		14R		
			7R		15R		
			8R		16R		

Notes: (1) OLTC, Tertiary or Y-Winding data (as applicable).

Winding	Series Transformer (where applicable)			
	Winding Type	Turn Conductor(s)	Conductor Insulation	Max. Current Density
Exciting				
Series				

10. Lead interconnections. **Materialman** shall submit the method(s) used to interconnect the winding exit leads to the cables in the lead structure (e.g., crimped, bolted, etc.). Additionally, the **Materialman** shall submit the method used to certify the quality of the interconnection.

11. All leads shall be clamped with blocks. Ties and tie-wraps shall not be used.

12. The core shall be of cruciform, step-lap construction with mitered joints using high grade grain-oriented silicon steel having high permeability and low hysteresis loss. Laminations shall be free of burrs after fabrication and insulated with a suitable coating.

13. Insulation between core and core clamps shall be a high-temperature material with a minimum thermal class of 130°C.

14. Core cooling ducts, when used, shall not use cellulose materials to form the duct.

15. Each separate core shall be single point grounded. The core ground connection shall be external to the transformer tank. Individual core ground leads shall be brought to the tank cover with separate insulated leads and exit the transformer tank through a separate suitable bushing. For cores with a cooling duct, each section shall have a separate lead. Leads from each section may be connected internally near the tank cover or brought through as a separate lead. Each lead and bushing shall be labeled to indicate its origin. The Core Ground bushing(s) and ground

connection(s) shall be protected in an enclosure mounted on the main tank's cover.

The sides of the core ground enclosure shall be welded to the main tank's cover with an overlapping enclosure cover that has a mineral oil-resistance gasket. The enclosure cover shall either be hinged with a latch or secured with bolts. If secured with bolts, a minimum of four bolts shall be used and the holes shall be outside the perimeter of the gasket and any gasket grooves or retainers. The enclosure cover shall be marked as 'Core Ground' and include indication of its origin (e.g., Main, Series, PA). A detail of the core ground enclosure shall be included on the Outline Drawing.

16. **Materialman** shall submit the following chart of core characteristics for review.

Main Core Characteristics								
Steel Grade	Construction (1)(2)	Leg		Window		Flux Density %Rated Voltage		Weight
		Diameter	Area	Height	Width	100%	110%	

Notes: (1) Details of joint construction, cooling ducts (including insulating material), coatings, and banding should be included.
(2) Details of material handling used to minimize, detect, and define burrs.
(3) State if core frame is insulated from the tank. If the core frame is insulated, detail how core frame is single-point grounded.

C. De-energized Tap Changer (DETC) and Dual Voltage Switches (DVS).

1. A hand operated, Category 2 DETC fully compliant with C57.131-2012 shall be provided for the H-Winding.

2. Tap positions shall be as specified in the DATA SHEET.

3. The operating handle shall be located between 36 and 60 inches above the base to allow personnel to change tap settings from the ground. Access to the operating handle shall not be blocked by radiators, cabinets, junction boxes, conduits, or other devices. Tap setting indicator will be clearly visible to the operator. Provisions shall be made to padlock the operating handle.

4. The DETC shall have silver plating on the movable copper contacts and shall be capable of passing a functional life test as specified in C57.157.

5. Dual Voltage Switches, when applicable, shall meet the same requirements as the DETC.

6. An identification nameplate shall be located adjacent to each operating handle.

D. Instrumentation and Control.

1. All instruments and gauges shall be scaled in °C for temperature and pounds per square inch (psi) for pressure.

2. When instrumentation and gauge electrical leads are provided by the instrument and gauge manufacturer, the leads shall be insulated for 600V, stranded copper

(Class C or better) and be #14 AWG, minimum. For gauge leads, #16 AWG will be accepted when the gauge manufacturer does not offer #14 AWG as an option.

3. Transformer(s) shall be equipped with a Liquid Level Indicator (LLI) gauge as specified in the DATA SHEET.

4. Transformer(s) shall be equipped with a Winding Temperature Indicators (WTI), a Liquid Temperature Indicators (LTI) and/or an Electronic Transformer Monitor (ETM) as specified in the DATA SHEET. Fan controls schematics are specified in Article 2.03 Paragraph K.1 of this specification. Contact ratings shall be compatible with the specified use. Alarm and trip temperature set points shall be adjustable with setting points determined by the Materialman. Alarm function shall not coincide with fan operation. The fans shall be operated in a fashion to achieve the cooling class specified in the DATA SHEET.

5. Pressure-Vacuum gauge with scale range of plus or minus 10 psi. This may be integrally part of the insulating liquid preservation system.

6. Pressure Relief Device (PRD) mechanically operated with signal indicator visible from the ground. The PRD shall be MESSKO MPREC or an approved equivalent. One (1) set of isolated, Form C alarm contacts shall be provided for remote annunciation.

7. A sudden pressure relay system shall consist of a sudden pressure relay (63) connected to an auxiliary seal-in relay (63X).

    a. The sudden pressure relay (63) shall be ABB part number 8524A42G02.
    b. The auxiliary seal-in relay (63X) shall be Qualitrol model 909-300-01 or 909-300-02 (for classified locations). The seal-in relay's Form C alarm contacts shall be used for annunciation. The seal-in relay's Form A tripping contact shall be used in the protection scheme.

8. Auxiliary relays used to provide the required alarm and trip output contacts shall be mounted such that vibration from other devices will not cause a mis-operation of the auxiliary relays. Auxiliary relays shall not be mounted adjacent to contactors used for fan control or auxiliary power to the transformer. The **Materialman** shall illustrate mounting and shock isolation methods on shop drawings.

    a. Auxiliary relays shall be designated using IEEE C37.2 Suffix X. For example, an auxiliary relay used with a winding temperature trip shall be designated 49TX.

9. Leads for alarm and trip circuits shall be pre-wired to terminal blocks for external connection. These terminal blocks shall be marked to identify leads and shall be mounted in the main control cabinet.

10. Contacts identified in the DATA SHEET as Trip Contacts shall be rated as specified in C37.90-1989 (5A continuous, 30A for 200ms).

E. Control Cabinet.

1. The Control Cabinet shall meet the specifications detailed IEEE C57.148. Optional items and specifications that are different from C57.148 are detailed here or

tabulated in the DATA SHEET in the format shown in Annex B of C57.148. Unless otherwise indicated, the term control cabinet refers to the transformer main or primary control cabinet.

2. All devices within the control cabinet shall have nameplates attached with screws suitable for the application or as approved by the Engineer. The nameplates shall be black phenolic with a white core. The **Materialman** shall submit a nameplate schedule for the Engineer's approval.

3. Control cabinet doors shall not have viewing windows unless specified in the DATA SHEET.

4. Control cabinet doors shall be capable of being opened and secured at a minimum of a 105-degree position. Swing panels shall be opened and secured at a minimum of a 90-degree position. **Materialman** shall detail on the Control Cabinet Layout drawings both the door(s) and swing panel(s) in the opened and secured position. This detail shall include items mounted on the inside of the cabinet door(s) (e.g., instruction manual pockets, latching mechanism) and items on the swing panel that extend beyond surface (e.g., test switches, instrumentation).

5. Wiring.

   a. All terminal wiring, except for euro-style connectors, shall have pressure grip solderless lugs of the **uninsulated** ring-type terminals. Spade lugs will not be permitted. **Wiring Drawing notes shall state the wiring terminal requirements**.
   b. Relays and controls using euro-style connectors shall use ferrule or blade style terminals: SEL Order # 915900365 (14 AWG single conductor ferrule), 915900366 (16 AWG dual conductor ferrule), 915900368 (14-16 AWG single conductor blade).
   c. Suitable grommets and cable/conductor protection shall be used at locations of cable/conductor contact with edges, corners, and openings of the control cabinet.
   d. No splices are allowed (except in CT outlet or junction box) within the control, current transformer, or instrument wiring leads. All connections shall utilize terminal blocks located in the control cabinet or junction boxes. Splices or ring-type terminals are allowed at the Bushing CT outlet or junction box.
   e. All alarm and trip contacts shall be wired to terminal blocks located in the control cabinet for connection to external alarm and trip circuits except alarm and trip contacts used to actuate auxiliary relays.
   f. Control, alarm, and trip-circuit terminal blocks shall be arranged in a vertical or rectangular configuration similar to Figure A.3 in C57.148.
   g. For every ten (10) used terminals, two (2) spare terminals shall be provided.

E. Bushings.

1. Bushings rated above 110 kV BIL shall be condenser core Oil-Air bushings. Bushing type shall be either Oil Impregnated Paper (OIP) or Resin Impregnated Paper (RIP) as specified in the DATA SHEET. All bushings shall be manufactured and tested in accordance with IEEE C57.19.00 and C57.19.01. Where applicable, the nameplate shall state that oil has no detectable levels of PCBs (<2.0 ppm).

2. The transformer shall be designed to accommodate the maximum bushing

dimensions listed in IEEE C57.19.01.

3. All mounting hardware shall be stainless steel (300 Series) with silicon bronze nuts. The **Materialman's** application should address potential galling.

4. All dimensions for bushings shall be shown on submittal drawings.

5. Bushing ratings and location shall be as shown in the DATA SHEET.

6. Bushing terminals shall be as specified in the DATA SHEET.

7. When an Air Terminal Chamber (ATC) is specified on DATA SHEET, the phase bushings shall be inside the ATC while the neutral bushing shall be on the cover.

G. Nameplates.

1. Nameplates shall [be made of 316L stainless steel and] contain all information for Nameplate C, set forth in IEEE Standard C57.12.00 and the following information:

   a. State the insulating liquid conforms to ASTM D3487 Type II.
   b. When appropriate, state that windings are fully insulated (not graded or reduced insulation level).
   c. State the maximum loading at an average ambient of 0°C.
   d. When applicable, the voltage and continuous thermal duty of the stabilizing winding shall be included on the nameplate.

2. A seismic qualification identification plate shall be designed and attached to the equipment to last its service life. The plate shall follow the format shown in IEEE 693-2018 A.7. The seismic qualification identification plate shall be mounted below the transformer's main nameplate.

H. Grounding.

1. Core Grounding is specified in Article 2.03, Paragraph B.15.

2. Tank Grounding. 2-hole grounding pads shall be welded on all four corners of the tank, 6 inches above the base, for grounding of transformer with bolt type connectors for connection to 1/0 AWG to 4/0 AWG stranded copper conductor. The connectors shall be included.

3. Neutral Grounding. When the neutral bushing's mounting location is not specified to be on the Sidewall or when the neutral is not impedance grounded, clamps suitable for one vertically mounted 2-inch Schedule 80 PVC conduit (**Owner** supplied) shall be furnished. The clamps shall be equally spaced (with spacings between 36 and 60 inches) and below each neutral bushing. When the neutral bushing is impedance grounded, the neutral shall be protected by a surge arrester.

4. Air terminal chamber (when specified in DATA SHEET) shall be equipped with 24"x2"x0.375" copper ground bus. Ground bus shall be drilled at one end for the installation of one (1) 2-hole NEMA pad. The **Materialman** shall provide a 4/0 copper conductor from the NEMA 2-hole pad to a grounding pad located on the tank wall near the ATC. Ground bus shall be located to provide unimpeded installation of

power cable shield ground conductors and surge arrester grounding. The **Materialman** shall provide and install arrester grounding jumpers and required connectors.

5. Surge Arrester Grounding.

    a. When the phase bushings are cover-mounted, 2-hole grounding pads shall be welded at the top of the transformer tank walls for grounding the surge arresters. Three of these pads shall be located approximately three inches (3") from the top of the tank in Segment 1 (when an ATC is not specified). Three additional pads shall be located approximately three inches (3") from the top of the tank in Segment 3.
    b. When a neutral bushing is cover-mounted and protected by a surge arrester, a fourth 2-hole pad shall be welded at the top of the transformer tank wall for grounding of the surge arrester. This pad shall be located approximately three inches (3") for the top of the tank in the segment nearest the neutral surge arrester.
    c. When an ATC is specified, a grounding pad for each surge arrester shall be provided inside ATC and connected to the ATC's ground bus with a 4/0 copper conductor. The connectors shall be included.
    d. **Materialman** shall also provide a bolt type connector (conductor range 1/0 AWG to 4/0 AWG kcmil) for each grounding pad to connect the surge arresters' ground terminal with a stranded copper conductor.

6. Power Cable Shield Grounding – When an ATC is specified in the DATA SHEET

7. Control Cabinet Grounding - All control wiring ground connections shall be at the control cabinet's ground bus bar.

I. Insulating Liquid Preservation System.

1. The transformer shall be equipped with a positive pressure, inert gas preservation system consisting of the following:

    a. A standard, commercially available supply cylinder (Linde Size K or approved equivalent) with control valve. Equipment shall be compatible with US-DOT Standards.
    b. Three stage pressure reducers.
    c. Pressure relief valve.
    d. Run-fill valve.
    e. Oil sump.
    f. Gauges indicating transformer tank pressure and supply cylinder pressure.
    g. Pressure switches indicating low tank pressure, high tank pressure and low cylinder pressure. All alarm contacts shall be wired to terminal blocks located in control cabinet mounted for connection to external alarm circuits. Form C contacts shall be provided for each alarm. T**he Materialman shall indicate on the schematic drawings the contact position in the normal operating condition.**
    h. All instruments and gauges shall be scaled in °C for temperature and pounds per square inch (psi) for pressure.
    i. Piping and valves necessary to control the flow of gas to and from the transformer tank.
    j. The complete preservation system, including inert gas cylinder, shall be

enclosed in a weatherproof cabinet mounted on the main body of the transformer.

k. The nitrogen furnished with the preservation system shall be Type III as specified in ASTM D1933 (Standard Specification for Nitrogen Gas as an Electrical Insulating Material).

2. The nitrogen cabinet shall be mounted at least 4 inches above the base.

J. Tank.

1. Tank shall be suitable for full vacuum filling and remain intact for static pressures related to normal operations (e.g., energization, through faults).

2. Cover shall be fabricated (e.g., sloped or domed) to hinder water accumulation. At least two circular manholes shall be included to provide access to the interior. Manholes, handholes, and all other openings in the tank cover that employ gaskets shall be raised at least 0.75 inches above the cover surface to prevent moisture accumulation around the gasket joints.

3. Metal surfaces to which gaskets are applied shall be finished smooth, seamless, and shall be designed with sufficient rigidity to assure proper compression of the gaskets. Machine grooves shall be provided so that over-compression of the gaskets cannot occur. Mounting bolts shall be external to the gasket. Gaskets shall be of nitrile rubber or Viton®.

4. All corners on tank walls shall be formed with hydraulic press brake with welded vertical joints located at vertical intersection of sheet steel plates away from the vertical preformed corners of the tank.

5. The transformer cover shall be welded to a flange on the main tank. Gasket material shall be placed on the flange so that the cover can be removed and re-welded without damage to the core and coils.

6. Rupture Mitigation: Tank shall be designed to assure the predicted failure point will be the top of the transformer to minimize the loss of insulating liquid. The energy containment requirement is an Arc Energy of 2000 kJ (69 kV and below) and 4000 kJ (above 69 kV).

7. When bushings are mounted on the cover, the tank design shall allow removal/replacement of current transformers without removal of the tank cover.

8. Jacking pads shall be provided for lifting complete transformer assembly. Pulling eyes for pulling complete transformer assembly shall also be provided.

9. Conduits

a. All circuits for forced-air cooling devices, temperature indication, alarms, current transformers, and the power supply for cooling devices shall be installed in galvanized steel Rigid Metal Conduit (RMC) securely fastened to the transformer. All RMC shall be connected to cooling devices, instruments, shock-mounted cabinets (when applicable) and other devices, with liquid proof flexible conduit. All conduit fittings shall have weatherproof, mineral oil-resistant gaskets. As far as practical, all conduits shall be grouped in one

general location. Conduits, conduit bodies and conduit fittings shall meet applicable ANSI/NEMA/UL standards. There shall not be any type of exposed wire or cable on the transformer except as approved by the Engineer.

b. Where a conduit is cut and threaded, the length of the thread shall be one thread short to prevent the conduit from butting inside the coupling.
c. Where junction boxes are used, they shall be NEMA Type 4X, constructed of 0.080" aluminum, with continuously welded seams, continuous hinged cover with a mineral oil-resistance gasket, stainless steel clamps and screws. The junction box shall be E-Box series AN4X, or as approved by Engineer.
d. Tank brace bands, which normally only contain atmospheric air, may be used in lieu of conduit if adequate wiring supports and handholes (with covers) are provided.
e. Use of adequately designed and protected power cables in lieu of flexible conduit for connection to cooling fan motors is acceptable.

K. Auxiliary Cooling Equipment.

1. Control of Auxiliary Cooling Equipment.

a. The Cooling Control Circuit shall be provided as shown in C57.148 Figure A.6 (when a traditional winding temperature gauge is specified) or Figure A.7 (when a microprocessor-based transformer monitor or ETM is specified).

2. Fans

a. Automatically controlled fans shall give continuous forced cooling to deliver the specified ONAF/ONAF capacity (at the specified ambient conditions and average winding temperature rises) in the DATA SHEET.
b. All fan motors shall be totally enclosed and weatherproof; sealed and permanently lubricated ball bearings; individually protected and rated for 55°C ambient temperature, continuous operation.
c. All fan motors shall be connected in the circuit through weatherproof plug-in fittings for easy removal of any fan without disturbing the others.
d. All cooling fans shall be equipped with OSHA-compliant guards over the fan blades.
e. Status of each stage of cooling shall be provided for SCADA monitoring or as an input to a transformer monitor.

3. Radiators

a. Radiators shall be detachable with shut-off valves located on transformer tank.
b. Exterior surfaces of the radiators shall be galvanized or painted stainless steel.
c. Radiator drain and vent fittings shall be provided for all radiator units.
d. Oil tight covers shall be provided for use when radiators are detached.
e. Lifting eyes shall be provided with each detachable radiator/cooling unit.

L. Supply Voltages.

1. Supply Voltages furnished by the **Owner** are specified in the DATA SHEET.

M. Air Terminal Chamber (ATC). (when specified in the DATA SHEET)

1. The ATC shall be weatherproof and have hinged access doors complete with handle-type, 3-point, latching mechanism and provisions for padlocking in a closed

position. The ATC shall be furnished with stainless steel bug screens and fine mesh filters at all ventilating openings. Louvers shall be installed over these openings to prevent rain from entering the cabinet.

2. The bottom plate of the ATC shall have a removable, gasketed blank face to allow field drilling for the cable entrance conduits. The blank face shall be sized to accommodate the cable entrance conduits specified in the DATA SHEET.

3. The ATC shall be sized to accommodate the size and number of cables specified in the DATA SHEET. Consideration shall be given to the cable's minimum bending radius (20 times cable diameter) and the cable weight applied to the bushing terminal. Bushing terminals shall be braced, if necessary, to support the cable's weight and forces applied by cable bending. The **Materialman** shall supply all necessary insulators and supports to accomplish support of the bushing terminals. If the **Materialman** proposes to use the bushings to support all cable weight and bending forces, information necessary to substantiate this practice shall be provided.

4. Surge Arresters shall be mounted in the air terminal chamber adjacent to the X-Winding bushings in a location that will not interfere with power cable installation. **Materialman** to provide and install surge arrester to bushing terminal jumper and required connectors. Arrester jumper connection at the bushing terminal shall not interfere with phase conductor installation in any way. Jumpers shall be minimum of 2 AWG copper.

5. Minimum Clearances inside the ATC will be as specified in IEEE C57.12.00 Table 11 and NEMA TR-1. For convenience, these values are partially reproduced below:

BIL (kV)	Minimum Clearances (inches)	
	Live Parts to Ground	Live Parts Phase to Phase
110	6	6-1/2
150	8	9

N. Current Transformers.

1. All relay class bushing current transformers (BCT) shall be 5 lead, multi-ratio type with fully distributed windings with a minimum continuous current rating factor of 2.0. CT Circuit Designation, Ratio, Accuracy Class, and location shall be as indicated in the DATA SHEET.

2. Revenue metering bushing current transformers, when specified in the DATA SHEET, shall be provided with the Ratio, Accuracy Class and location indicated and with the following additional requirements:

   a. Four (4) copies of the Certified Test Report (CTR) shall be provided for each metering BCT supplied. Tests on prototypes or similar units are not acceptable.
   b. The CTR shall include a ratio and phase-angle test on each ratio of each CT. Tests shall be made at 10 percent and 100 percent current for each burden and accuracy class specified.
   c. Revenue metering current transformers shall have a minimum continuous current factor of 2.0.

3. Bushing Current Transformer Wiring:

   a. All BCT leads shall be pre-wired to 6-pole/circuit, shorting-type, terminal blocks in the control cabinet. From these terminal blocks, leads will be pre-wired to GE 6-pole PK-2 test blocks. The ratio and connection (wye or delta) will be formed at the shorting-type terminal blocks. Therefore, for a three-phase transformer, one 6-pole PK-2 block will be required for each three-phase BCT circuit. A 4-pole PK-2 test block should be used for BCT circuits that are not three-phase. PK-2 test blocks shall be mounted on a swing panel inside the control cabinet

   b. BCT wiring to the shorting-type, terminal blocks for each BCT circuit shall be organized as shown below (modified as applicable to the actual BCT specified in the DATA SHEET). Each BCT shall have a separate 6-pole/circuit, shorting-type terminal block.

	OUTER-MOST		MIDDLE		INNER-MOST		OUTER-MOST		INNER-MOST				OUTER-MOST		INNER-MOST
PHASE A	H1-3		H1-2		H1-1		X1-2		X1-1		LCT-1		Y1-2		Y1-1
	1Z1		1Y1		1X1		4Y1		4X1		4U1		9Y1		9X1
	1Z2		1Y2		1X2		4Y2		4X2		4U2		9Y2		9X2
	1Z3		1Y3		1X3		4Y3		4X3		4U3		9Y3		9X3
	1Z4		1Y4		1X4		4Y4		4X4		4U4		9Y4		9X4
	1Z5		1Y5		1X5		4Y5		4X5		4U5		9Y5		9X5
	1ZG		1YG		1XG		4YG		4XG		4UG		9YG		9XG
PHASE B	H2-3		H2-2		H2-1		X2-2		X2-1		WCT-1		Y2-2		Y2-1
	2Z1		2Y1		2X1		5Y1		5X1		5W1		10Y1		10X1
	2Z2		2Y2		2X2		5Y2		5X2		5W2		10Y2		10X2
	2Z3		2Y3		2X3		5Y3		5X3		5W2		10Y3		10X3
	2Z4		2Y4		2X4		5Y4		5X4		5W2		10Y4		10X4
	2Z5		2Y5		2X5		5Y5		5X5		5W2		10Y5		10X5
	2ZG		2YG		2XG		5YG		5XG		5W2		10YG		10XG
PHASE C	H3-3		H1-2		H3-1		X3-2		X3-1				Y3-2		Y3-1
	3Z1		3Y1		3X1		6Y1		6X1				11Y1		11X1
	3Z2		3Y2		3X2		6Y2		6X2				11Y2		11X2
	3Z3		3Y3		3X3		6Y3		6X3				11Y3		11X3
	3Z4		3Y4		3X4		6Y4		6X4				11Y4		11X4
	3Z5		3Y5		3X5		6Y5		6X5				11Y5		11X5
	3ZG		3YG		3XG		6YG		6XG				11YG		11XG
NEUTRAL	H0-3		H0-2		H0-1		X0-2 or H0X0-2		X0-1 or H0X0-1				Y0-2		Y0-1
	8Z1		8Y1		8X1		7Y1		7X1				12Y1		12X1
	8Z2		8Y2		8X2		7Y2		7X2				12Y2		12X2
	8Z3		8Y3		8X3		7Y3		7X3				12Y3		12X3
	8Z4		8Y4		8X4		7Y4		7X4				12Y4		12X4
	8Z5		8Y5		8X5		7Y5		7X5				12Y5		12X5
	8ZG		8YG		8XG		7YG		7XG				12YG		12XG

Wiring Duct | Wiring Duct | Wiring Duct | Wiring Duct | Wiring Duct | Wiring Duct

Note: Z is the outermost CT for 3 CTs per bushing. Y is the outermost CT for 2 CTs per bushing.

Each shorting-type terminal block shall be marked to identify CT associated with the terminal block (e.g., H1-1) and the terminal designations shown on the terminal block's marking strip. For example, the 6 pole/circuit, shorting-type terminal block for CT-H1-3 shall have a phenolic nameplate mounted above the terminal block. The terminal block marking strip shall list the corresponding terminal numbers as shown below:

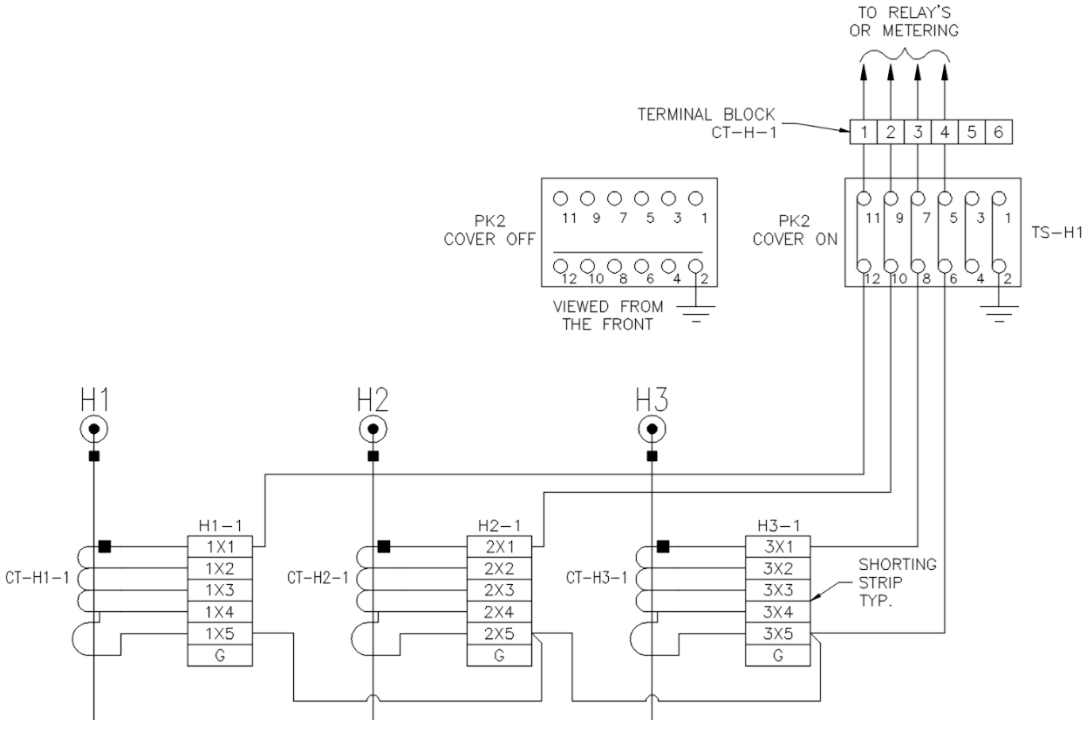
H1-3

1Z1
1Z2
1Z3
1Z4
1Z5
1ZG

c. Incoming BCT wiring to the PK-2 test blocks shall be terminated on the bottom of the block and the outgoing (relay/meter/customer) wiring shall be terminated on the top of the block. For three-phase BCT circuits, the H1 or X1 polarity lead shall be on left as viewed from the front of the panel. PK-2 test blocks shall be designated TS-WP (where W is the winding associated with the CT and P is the CT's position).

d. Wiring from PK-2 test blocks to terminal blocks for external connection shall be provided. One 6-point, non-shorting-type, terminal block shall be supplied for each three-phase BCT circuit. Single-phase BCT circuits from the same winding can share 6-point, non-shorting-type, terminal blocks. Each three-phase terminal block shall be named using the CT circuit designation (CT Function)-(Winding)-(CT Position). For example, the three-phase relay/metering BCT circuit located in Position 1 of the X-Winding would be designated CT-X-1. For an X-Winding neutral CT in Position 2, the terminal block designation would be CT-X0-2.

e. An example showing the specified three-phase BCT circuit is shown below:



f. Phenolic nameplates adjacent to the PK-2 block shall identify the BCT circuit as follows:

TS-WP where W is the winding and P is the position.

For example, the PK-2 block nameplate for the CT circuit illustrated above would be:

TS-H1

For PK-2 blocks associated with winding temperature CTs, the nameplate is the winding and the letter W for WCT. For example, the PK-2 associated with WCT-X2-1 would be:

TS-XW

O. Surge Arresters.

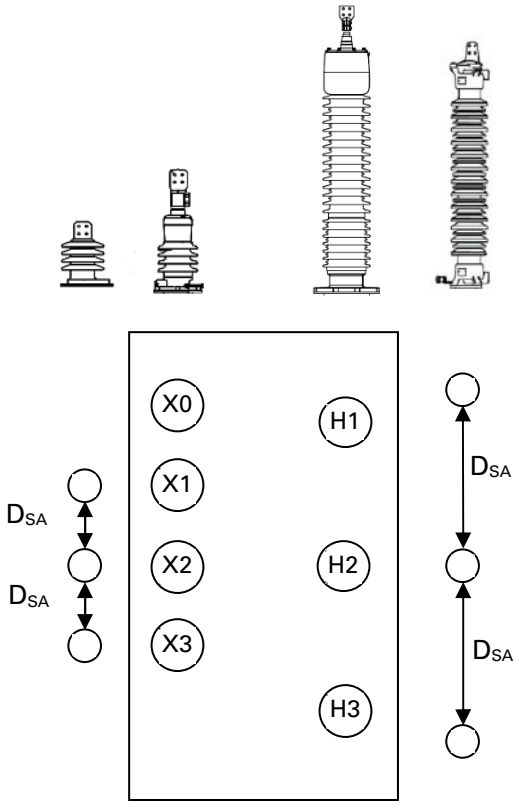
1. Surge arresters shall be installed for each winding or as shown in the DATA SHEET and shall meet all requirements of IEEE Standard C62.11.

2. Ratings for each class of surge arrester shall be as shown in the DATA SHEET.

3. Surge arrester terminals shall be as shown in the DATA SHEET.

4. Surge arrester mounting brackets shall be designed and fabricated to position surge arrester terminals at approximately 12 inches below the corresponding bushing terminal. When this requirement would place the surge arrester's base below the main tank's cover, the mounting bracket shall be designed and fabricated to locate the surge arrester's base at the same elevation as the main tank's cover. This requirement does not apply to arresters located in the air terminal chamber.

5. The mounting brackets shall have the minimum center-to-center clearances illustrated below but shall be not less than the bushing center-to-center spacing.



	25 kV and below	46 kV	69 kV	115 kV	161 kV
D_{SA} (inches)	24	40	46	50	66

6. When a surge arrester protects a winding neutral, an additional mounting bracket shall be provided.

7. For three-winding transformers where the X_2 bushing is not located on the centerline of Segments 1 and 3, the orientation of the surge arresters may need to be shifted to match the substation X-Winding bus. Details of any necessary moves will be provided during the Engineer's Shop Drawing review (See Section 01341 - SHOP DRAWINGS).
8. Surge Arresters shall be located inside the Air Terminal Chamber (when specified in DATA SHEET).

P. Insulating Liquids.

1. Acceptable Insulating Liquids are specified in the DATA SHEET.

2. All insulating liquid supplied with the transformer shall be tested for polychlorinated biphenyls (PCBs) by ASTM D4059 or EPA 8082 and shall contain no detectable levels (<2.0 ppm) of PCBs.
3. Mineral oil, when specified, shall be unused and meet all requirements of Type II as detailed in ASTM D3487 and testing limits of ANSI/IEEE C57.106 for new oil. Content of the oxidation inhibitor DBPC (2-6-ditertiary-butyl para-cresol) shall not be less than 0.3% by mass.

4. Natural ester liquids, when specified, shall be unused and meet all the requirements of ASTM D6871 - 03 and C57.147 for new liquids. Envirotemp® FR3 manufactured by Cargill and Biotemp® manufactured by ABB are approved for use.

5. The **Materialman** shall demonstrate the insulating liquid is non-corrosive when tested according to ASTM D1275B. Results of this modified test shall be included with the **Materialman's** Field Test Report.

Q. On-Load Tap Changer (OLTC)

1. When specified in the DATA SHEET, the **Materialman** should refer to Section 16327 ON-LOAD TAP CHANGER for the technical requirements for the On-Load Tap Changer's mechanism, controls, and associated windings.

2.04 PAINTING AND FINISHES

A. All steel parts, except galvanized or stainless (if used), shall have a coating system that meets or exceeds the coating system requirements of ANSI C57.12.28 –1999 (including salt spray test).

B. The complete transformer shall be painted the color specified in the DATA SHEET. The paint film shall be uniform in color and free from blisters, sags, flaking and peeling. Galvanized and stainless-steel surfaces (e.g., conduits, etc.) shall not be painted. Use of other colors, such as "silver" to mimic galvanized parts is prohibited.

C. The cover of the main tank shall have a non-skid coating.

D. Exterior surfaces of the radiators shall be galvanized. The **Materialman's** thermal calculations shall allow for the lower emissivity of the radiator's surface finish. The interior radiator surfaces shall not be painted but shall be flushed with mineral oil and sealed to protect against rust before final installation.

E. The interior of tank, control and accessory cabinets shall be painted white semi-gloss. Surfaces that are inaccessible after fabrication shall be protected for the life of the unit.

F. Surfaces composed of corrosion-resistant metal or galvanized steel (including aluminum and stainless-steel junction boxes; conduit bodies and fittings) shall be appropriately masked or covered during the painting process.

G. Painting of Galvanized RMC is only allowed when the **Materialman's** coating system is specified as compatible with galvanized steel by the paint manufacturer and proposed coating system is approved in advance by the Engineer.

H. **Outline Drawing notes shall include instructions for masking the conduits, junction boxes, conduit bodies, and fittings during the painting process unless a coating system is approved in advance.**

I. Galvanized surfaces shall comply with ASTM A123/A123M-02 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. The minimum acceptable coating grade shall be 45.

J. Two (2) one-quart containers of touch-up paint, equivalent in all respects to the original paint applied during fabrication, shall be supplied with the unit upon delivery.

Instructions for applying paint shall be supplied.

2.05 FABRICATION

A. Minimum external clearance between live parts of different phases shall be 24 inches for 25 kV and below, 30 inches for 46 kV and 36 inches for 69 kV. These clearances shall also be maintained between the neutral bushing's stud and the live parts of the closest phase.

B. Bushing spacing shall not compromise bushing flashover characteristics. Bushings located in an air terminal chamber shall be spaced to allow installation of specified power cables with adequate working space.

C. Center of gravity for shipping shall be identified on all sides that are visible without obstruction when the transformer is assembled for shipping. The center of gravity for operations shall be identified on all sides visible without obstruction when the transformer is completely assembled. In no case shall these markings be on less than two sides.

D. All bolts, studs, nuts, and lock washers used to mount radiators, fans, cabinets, junction boxes, accessories and conduit shall be a stainless steel/silicon bronze combination, or an engineer approved. **The Outline Drawing notes shall include a statement that all external hardware shall be stainless steel with silicone bronze nuts.**

E. Galvanized RMC systems shall be installed as detailed in NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC EMT) including:

1. Threading shall be one thread short of the chase to prevent butting of the conduit in a coupling allowing the coupling to cover all of the conduit threads when tightened.

2. Threads shall be protected with an electrically conductive, corrosion resistant compound such as zinc galvanizing or KOPR-Shield.

3. Conduit Bodies and Fittings shall comply with NEMA FB2.10 - Selection and Installation Guidelines for Fittings for Use with Non-Flexible Metallic Conduit or Tubing (Rigid Metal Conduit, Intermediate Metal Conduit, and Electrical Metallic Tubing).

PART 3 EXECUTION

3.01 FACTORY TESTS.

A. The **Materialman** shall submit a factory test plan for the Engineer's approval two weeks prior to the start of the factory tests.

B. The **Owner** shall be notified two weeks prior to performance of factory transformer testing to permit **Owner**'s representative to observe the tests.

C. All factory tests shall be completed with the type of insulating liquid being provided for field installation. Mixing different types of insulating liquids is not permitted.

D. All transformers shall be tested as a Class II transformer in accordance with the latest revision of IEEE C57.12.00, C57.12.90, and C57.98. These tests shall be made for every unit provided under this specification.

E. Required Tests: The **Materialman** shall conduct all tests designated as routine for Class II power transformers in the latest revision of IEEE C57.12.00. Complete testing shall be conducted on all units of the design.

1. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and grounded externally, the following values will be provided on the Certified Test Report (CTR):

    a. The winding resistance of the stabilizing winding shall be measured between the two bushings with the external link removed.
    b. TTR will be performed during manufacturing to confirm design values.
    c. The calculated positive sequence percent impedance between the H-Winding and Y-Winding. The calculated positive sequence percent impedance between the X-Winding and the Y-Winding shall also be provided. The base MVA for these calculated impedances shall be the Y-Winding's thermal rating.

2. Insulation Resistance between windings, each winding to ground and core(s) to ground. Any values less than 1000 Megohms shall be investigated and justified to the Engineer.

3. Insulation Power Factor/Dielectric Loss Test.

    a. Power Factor/Dielectric Loss on all windings. For autotransformers with the corner of the stabilizing winding brought out of the tank, the transformer will be tested as a two-winding transformer. Three-winding transformers with a corner grounded stabilizing winding will be tested as a three-winding transformer. The test set connection to the stabilizing winding will be with Y1-Y2 shorted but not grounded.
    b. Power Factor/Dielectric Loss (or hot collar watts-loss) on all bushings.

4. Single-Phase Excitation shall be performed on all DETC positions of the high voltage winding. Additionally, for transformers with an OLTC, the single-phase excitation shall also be performed with the high voltage winding on the DETC rated tap and the OLTC in every position from 1L to 16R, inclusive.

5. Load Loss and Impedance Voltage Tests.

   a. The equivalent positive sequence resistance and reactance of each pair of windings shall be measured or calculated.
   b. For units with OLTCs, the **Materialman** shall complete the additional tests specified in Table 18 of C57.12.00 for **each unit**. The **Materialman** shall also complete a load loss and impedance voltage test at 15 Raise to verify compliance with guaranteed losses.
   c. Windings designed for series-multiple operation shall be tested on every series-multiple combination.
   d. For three-winding transformers (including autotransformers with a tertiary or stabilizing winding), the following zero-sequence data (resistance and reactance) shall be provided at the base MVA: $\%Z_1N_0$, $\%Z_1N_S$, $\%Z_2N_0$, $\%Z_1$, $\%Z_2$, and $\%Z_3$.
   e. Values for zero-sequence impedance data shall be included in the CTR.

6. Temperature Rise. Temperature rise test shall be performed as described by IEEE C57.12.90 **on each unit** provided under this specification.

   a. During the period of thermal stability at the maximum nameplate MVA and just before the load is cut back to rated current, thermal images shall be taken of the transformer's entirety, including all four segments of the tank wall and the tank cover. The measured temperatures at any point on the tank and cover shall not exceed a 75°C rise above ambient air temperature. A report with all of the thermal images taken shall be provided to the Engineer for review within 24 hours after the temperature rise test has been completed. Each image in the report shall indicate, with a marker, the hottest point on the transformer in the image and shall display the temperature at that location. Any spots above the 75°C rise limit shall also be clearly identified. This section of the CTR shall show side by side visible-light and infrared images. Thermal imaging shall comply with Article 1.07 C.
   b. When a microprocessor-based electronic transformer monitor (ETM) is specified in the DATA SHEET, the entire Control Cabinet's AC/DC auxiliary power and control circuits shall be energized. In addition, the ETM shall be:

      1) Programmed as approved by the Engineer except that data logging/signal profile sampling rate shall be 5 minutes.
      2) Powered up and receiving current from the WT-BCT(s).
      3) The ETM's measurements of load current, ambient temperature and top oil temperature shall be verified to be consistent with the **Materialman's** instrumentation.
      4) During the total loss run for the maximum rating test, the ETM shall control the cooling stages. If the top oil and calculated winding temperatures during this test are less than the settings to turn on stage 2 cooling, the second stage should be turned on manually. For the remainder of this test, the fans should be manually controlled.
      5) When the temperature rise tests are complete, the recorded data shall be retrieved from the ETM and the data file sent with the CTR for approval.

   c. Data from the temperature rise tests included on the CTR shall include the data detailed in IEEE C57.91 Clause 4.4 items a) through k) including the conditions (load ambient temperature, tap, etc.) under which measurements for a)

through g) were made.

d. The CTR shall include the cold-resistance measurements made prior to loading and hot-resistance measurements made after shut down for each load level. The first hot-resistance measurement shall be made within four minutes of shutdown. Hot-resistance measurements shall be tabulated and graphed. Graphed measurements shall also show the cooling curve fitted to the measurements and extrapolated to shut down.

e. The following additional thermal data detailed in C57.119 Clause 9 shall be reported in the CTR.

Time Constants			
Oil (Heat Up)	Winding		
	HV	LV	TV

When an ETM is specified in the DATA SHEET, this thermal data shall be used to update the programming of the ETM before shipping.

f. The total time duration, in hours, required to complete the temperature rise tests shall be included on the CTR with the temperature rise test data.

g. **Materialman** shall state in the CTR the transformer's maximum continuous capacity in MVA at an average ambient of 0°C. The maximum capacity shall be at the combination of connections and taps that give the highest average winding temperature rise. **Materialman** shall note requirement in Article 2.02 Paragraph B that ancillary devices (e.g., OLTC mechanism, DETC, bushing, etc.) shall not limit loading.

7. Audible Sound Emissions. Audible sound tests shall be performed as described by IEEE C57.12.90 **on each unit** provided under this specification as required in the DATA SHEET.

   a. DETC and OLTC (where applicable) tap positions shall be selected to produce the highest sound level.

8. Impulse Test.

   a. Impulse testing shall be as described in IEEE C57.12.90.
   b. Impulse testing is not required for the stabilizing winding (if specified). The corner of the stabilizing winding should be grounded during the impulse tests on other windings.

9. Applied-Voltage Test shall be completed using the test values in Table 4 of IEEE C57.12.00-2022.

   a. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and grounded externally, the applied-voltage test shall be performed on the stabilizing winding at a test level corresponding to winding's rated phase-to-phase voltage.

10. Induced-Voltage Test shall be completed using the test values in Table 4 of IEEE C57.12.00-2022.

a. During the induced-voltage test, the pressure inside the transformer tank shall not be artificially increased by more than 0.5 lbf/in^2.
b. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and grounded externally, the corner of the stabilizing winding should be grounded during the induced-voltage test.
c. The OLTC and DETC tap positions shall be reported on the CTR.
d. The test procedure shall include partial discharge readings at the maximum system voltage prior to the first one-hour test level and at the end of the one-hour level.
e. Partial Discharge test shall be acceptable if the Partial Discharge does not exceed 250 pC or 100 μV. Additionally, during the one-hour test period, levels do not increase by more the 50 pC or 30 μV. Background levels shall be less than 100 pC.
f. In addition to the required tabulated periodic readings, a continuous graph of the test voltage and the partial discharge shall be provided with the CTR if the test equipment has this capability.

11. Dissolved Gas-In-Oil.

a. Before factory tests begin, the transformer's liquid preservation system shall be active, and the main tank sealed as in normal service. The main tank shall not be vented into the atmosphere before the final oil sample is taken. If the normal service seal is broken before the final oil sample is taken, it shall be noted on the CTR including:

1) The circumstances that require breaking the seal.
2) The point in test procedure the seal was broken.
3) The time duration of the broken seal.

If the normal service seal is not broken, the CTR shall state that the main tank was not vented to the atmosphere before the final oil sample was taken.

b. At a minimum, samples will be drawn prior to transformer testing, before temperature rise testing, after the completion of temperature rise testing (no more than 6 hours after load is shut down) and at the completion of dielectric testing.
c. Samples shall be drawn in accordance with ASTM D923 in a container suitable for DGA analysis.
d. Gas generation rates shown below will be used to determine if the transformer passed or failed.

Gas Generation Rates (ppm/hour)			
Gas Component	Acceptable	Marginal	Unacceptable
H_2	< 0.8	0.8 to 1.5	> 1.5
HC	< 0.5	0.5 to 1.0	> 1.0
CO	< 2.0	2.0 to 5.0	> 5.0
CO_2	< 20.0	20.0 to 40.0	> 40.0

HC is the sum of CH_4, C_2H_4, and C_2H_6.

Any detectable levels of acetylene (C_2H_2) shall be unacceptable. The **Materialman** shall report the heat run interval in hours for calculation of the gas generation rates.

12. Sweep Frequency Response, an open-circuit and short-circuit sweep FRA test shall be completed on each unit of the fully assembled transformer. Prior to starting the SFRA tests, the core shall be demagnetized.

    a. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and normally grounded externally, the corner of the stabilizing winding shall be ungrounded during the SFRA tests.
    b. The CTR shall include three separate plots, one plot for each category of open-circuit tests and the short-circuit test. Plots shall be magnitude (dB) versus logarithmic frequency. In addition to the plots, test records shall include all data shown in Clause 6 of C57.149 as "Required."
    c. DETC and OLTC positions during the test shall be recorded. When an OLTC is specified, the tap position shall be 16R.
    d. The Engineer is not a client of the test set equipment manufacturer. However, a data file of the test results shall be provided for future comparison.

13. Bushing Current Transformers.

    a. The CTR shall detail the location of the serial numbers of each BCT provided with that unit.
    b. The BCT manufacturers' certified test report for all BCTs provided with that unit shall be included with the **Materialman's** CTR.
    c. After installation of the bushings, the full winding polarity and ratio of all BCTs shall be verified and reported on CTR.

F. Certified copies of the test data shall be furnished and approved by the Engineer **before the transformer is shipped**.

1. Test data shall include but not be limited to the following:

    a. Data Sheets from all specified tests.
    b. Data Sheets for all other routine tests completed by the Materialman but not specified by the Engineer.
    c. Copies of impulse test oscillographs with necessary scale factors, winding, and data sheet identifications.

2. Unsupported pass or fail statements will not be accepted.

3.02 INSTALLATION

A. The **Materialman** shall take all necessary precautions and use the appropriate safety work methods for installation, assembly and testing as may be specified by the Federal, State, Local, or other appropriate regulatory authority.

B. Inspection on Receipt prior to offloading:

1. Check impact recorder. For trailer mounted impact recorders, inspect the recorder prior to unloading transformer. For transformer tank mounted impact recorders, inspect recorder after transformer is offloaded to transformer pad/foundation. **Records from the impact recorder shall be forwarded to the Engineer as a pdf, spreadsheet, or text document.**

2. Check and record gas pressure and ambient temperature in tank.

C. Offloading

1. The **Materialman** is responsible for offloading the transformer from the heavy haul transporter to the **Owner** furnished concrete foundation. The **Materialman** is also responsible for offloading separately shipped parts, components, and accessories.

2. When the transformer is rail-shipped and a rail siding is not available within the substation, the **Materialman** is responsible for offloading at the rail-siding, transportation to the substation site and the offloading to the **Owner** furnished concrete foundation.

3. When the bushings are removed for shipping, the **Materialman** is responsible for providing instructions to the crews offloading the bushings on the correct orientation of the shipping crates.

D. External Inspection after offloading

1. Check for evidence of hits, scrapes, and abrasions.

2. Check for damage to components (e.g., bushings, gauges, conduits, and valves).

3. Record the condition of the paint.

4. Check that external parts have not become loose and that external compartments remain sealed.

5. Check inside the control cabinets for visible damage, loose parts, foreign matter, and moisture accumulation.

6. For liquid-filled shipping, check for signs of leaks.

E. Internal Inspection after offloading

1. If receiving gas pressure (units shipped gas-filled) are neither positive nor negative, test the dew point temperature of the shipping gas. If dew point temperature indicates the solid insulation surface moisture content is above 0.5%, the insulation must be dried until this requirement is met. The **Materialman** shall provide the installation contractor data to correlate moisture content with dew point temperature.

2. The **Materialman** shall follow OSHA confined space practices and procedures.

3. The transformer **shall not** be opened when the relative humidity exceeds 60 percent, when precipitation is threatening or when the interior of the transformer is appreciably cooler than the ambient.

4. Dry air with a Dew Point of -60°F or better shall be continuously supplied while the transformer is open.

5. Record time the tank seal is broken and reestablished. The amount of time the tank is open to the atmosphere should be limited to 2 hours.

6. The Internal Inspection will include, as a minimum, removal of all shipping blocks

and provide an examination of core, windings, leads and support structures.

7. All tools shall be accounted for both before and after the internal inspection.

F. Assembly of Fittings

1. **Materialman** is responsible for supplying all tools necessary for the final assembly of the transformer. This includes a crane, as needed, to install bushing and radiators.

2. The transformer **shall not** be opened for final assembly when the relative humidity exceeds 60 percent, when precipitation is threatening or when the interior of the transformer is appreciably cooler than the ambient temperature.

3. Bushings and Radiators shall be installed according to transformer and bushing manufacturers' recommendations. This includes tightening the mounting bolts to the bushing manufacturer's recommendations.

4. Damage, touch up and replacement. Care should be used to avoid scratching painted or galvanized surfaces.

   a. If primer is exposed and intact, lightly sand the damaged paint to smooth the rough edges. Next, restore the original thickness with a brush or spray. The paint used for the finish coat shall be the same color and quality as the original.
   b. If any metal becomes exposed, the area must be sanded down to blend the damaged area into the undamaged paint surface. Wipe the area with a commercial safety solvent and then dry. Brush or spray the area with a primer compatible with the surface and finish coat. Apply a finish coat using paint of the same color and quality as the original.
   c. Galvanized surfaces that are damaged during shipping or installation shall be repaired in accordance with ASTM A780-01 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings. Galvanizing repair paint shall have 95 percent zinc by weight. Touch-up of galvanized surfaces with aerosol spray, silver paint, bright paint, Brite Paint, or aluminum paints is not acceptable.
   d. Radiators with holes or dents shall be replaced unless the Engineer has approved a repair plan in advance.
   e. Bushings with chipped or cracked porcelain shall be replaced.

G. Vacuum Filling

1. In cases where the insulating liquid is shipped separately from the transformer, the **Materialman** shall furnish all necessary equipment, parts, and labor to vacuum fill the transformer after installation in the field, as detailed in **Materialman's** installation procedures and directives.

2. If insulating liquid is shipped in totes and needs to be covered to limit exposure to direct sunlight, **Materialman** shall notify **Owner** in advance of delivery.

3. The insulating liquid shall have the following characteristics before being allowed to enter the transformer:

   a. Liquid temperature shall be between 60°C and 80°C.
   b. Water content (ASTM D1533) shall not exceed 10 ppm for mineral oil or 150

ppm for natural ester liquids.
c. Total dissolved combustible gas content shall not exceed 0.5 percent.
d. Dielectric Strength shall exceed 30 kV (ASTM D1816 – 0.04-inch gap).

3.03 FIELD TESTING AFTER INSTALLATION

A. After installation at the specified location, the Materialman shall perform the following tests:

1. Operational checks of all indicating and control devices, fans, and OLTC controls (where applicable).

2. Insulation Resistance between windings, each winding to ground and core(s) to ground.

3. Power Factor/Dielectric Loss on all windings.

4. Power Factor/Dielectric Loss (or hot collar watts-loss) on all bushings.

5. Watts-loss test on all surge arresters.

6. Single-Phase Excitation shall be performed on all DETC positions of the high voltage winding. Additionally, for transformers with an OLTC, the single-phase excitation shall also be performed with the high voltage winding on the DETC rated tap and the OLTC in every position from 1L to 16R, inclusive.

7. Transformer Turns Ratio (TTR) shall be performed for all factory test tap combinations specified in C57.12.00.

8. The Winding Resistance Test shall be made on all windings and at all tap positions (corrected to 75C).

   a. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and grounded externally, the winding resistance of the stabilizing winding shall be measured between the two bushings with the external link removed.

9. Sweep Frequency Response, an open-circuit and short-circuit sweep FRA test shall be completed on each unit of the fully assembled transformer. Core shall be fully de-magnetized before SFRA testing begins.

   a. If the stabilizing winding is brought out of the tank as an open delta (with two bushings) and shorted and normally grounded externally, the corner of the stabilizing winding shall be ungrounded during the SFRA tests.
   b. Test results shall be provided as specified in Article 3.01, Paragraph E.12.

10. Insulating liquid samples shall be retrieved in a suitable container under the provisions of ASTM D923 and shall have the following testing conducted:

    a. Dissolved Gas-in-Oil, D3612.
    b. Dielectric Strength, D1816 (0.04-inch gap).
    c. Power Factor at 25C and 100C, D924.

d. Interfacial Tension, D971.
e. Neutralization Number, D974.
f. Moisture Content, D1533.
g. Oxidation inhibitor content, D2668 (mineral oil only).
h. Fire point, ASTM D92 (natural esters only).
i. Kinematic Viscosity, D445 (natural esters only).
j. PCB Content, D4059.
k. Corrosive Sulfur, D1275B (mineral oil only).

11. Bushing Current Transformers shall be tested in accordance with IEEE C57.13.1 as follows:

    a. Turns ratio.
    b. Insulation Resistance.
    c. Polarity.
    d. Excitation.

B. The **Owner** shall use the following acceptance criteria to determine the suitability of the **Materialman's** installation:

1. Insulation resistance shall not be less than 1000 megohm for the power transformer winding and core measurements.

2. The winding power factor shall not exceed 0.5 percent corrected to 20°C.

3. The bushing power factor and capacitances shall not exceed the nameplate by more than 10.0 percent.

4. The turns ratio shall be within 0.5% of the calculated value.

5. The Winding Resistance, after temperature correction, shall be within 1.0 percent of the factory test values.

6. Mineral oil test results shall meet the criteria in C57.106 for new mineral oil received in new equipment for the voltage class >69 - <230 kV (regardless of the transformer's highest voltage). Natural ester liquid test results shall meet the requirements of same voltage class in C57.147. Total dissolved gases shall be less than 0.5 percent and PCB content shall be less than 2 ppm.

7. Bushing current transformer ratio and excitation tests shall not deviate significantly from the manufacturer's published data. Polarity shall match the power transformer's nameplate. Insulation resistance shall not be less than 100 megohms.

C. **Materialman** shall provide comparison of installation test data and data from factory tests. Deviation from factory test results shall be explained in writing to the Engineer.

3.04 FIELD TEST REPORT

A. The **Materialman** shall provide a blank copy of the Field Report as a part of the submittal procedure. The contents of this Field Report shall require the Engineer's approval.

B. The **Materialman** shall report to the Engineer the conditions found during the external

inspection of the transformer. This should include the following:

1. Maximum impact.
2. Number of impacts greater than 5 G.
3. Number of one-G impacts.
4. Tank Pressure
5. Ambient Temperature.
6. Insulation Temperature and method for determining this value.
7. Dew Point of Shipping Gas.
8. Results of core ground insulation resistance test(s).

In addition, a statement of the overall condition of the tank and accessories noting any damage, leaks or rust shall be included.

C. The **Materialman** shall report to the Engineer the conditions found during the internal inspection of the transformer including:

1. Ambient Temperature.
2. Relative Humidity.
3. Time the transformer is opened.
4. Time the transformer is sealed.

In addition, a statement on the condition of the transformer's internal components noting any damage or rust shall be included.

D. When the transformer is vacuum filled in the field, the **Materialman** shall provide the Engineer with a report detailing the filling process with hourly log of the procedure.

E. The **Materialman** shall report to the Engineer the results of all tests performed after the installation.

END OF SECTION

SECTION 16320D
DATA SHEET
SUBSTATION POWER TRANSFORMER
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PART 1. GENERAL

PART 2. PRODUCTS

PART 3. EXECUTION

(NOT USED)

SECTION 16320D
DATA SHEET
SUBSTATION POWER TRANSFORMER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This Data Sheet includes the design and material data information for the fabrication of the Substation Power Transformer(s), as specified in Section 16320 - SUBSTATION POWER TRANSFORMER. This includes two and three winding transformers as well as auto-transformers.

1.02 SERVICE CONDITIONS

A. Ambient Temperatures: The maximum ambient temperature will not exceed 40°C and the 24-hour average ambient temperature will not exceed 30°C. Additionally, the transformer(s) will not be subjected to liquid temperatures below -20°C.

1. Bushing external terminals and bus connections are designed for a 40°C temperature rise over ambient. This exceeds the usual service conditions in C57.19.00-2004 of a 30°C temperature rise over ambient.

B. Location and Altitude: The transformer(s) will be installed **outdoors** at an elevation of **1700** feet above mean sea level.

C. Environment: The transformer(s) will be located in an area with **Medium** contamination as defined in C57.19.100.

D. Harmonic Load Current: The transformer(s) secondary load current will not exceed a harmonic factor of 0.05 per unit.

E. Operations: The transformer(s) will be used as **step-down** substation power transformer(s).

1. The transformer shall be delivered to the Owner's facility and placed on cross ties. Relocation to its final destination and field assembled at a later date.

2. System Short-Circuit Impedances: IEEE C57.12.00-2021 Table 14

F. Seismic Requirements:

1. **Seismic Qualification Level: Moderate**
2. PGA = 0.24 g
3. Importance Factor (Earthquake) (I_{FE}) = 1.25
   Anchorage = 2.00
4. Site Class: **D**
5. Seismic coefficients:

S_{MS}= 0.60	S_{M1}= 0.25
S_{DS}= 0.40	S_{D1}= 0.17

1.03 EVALUATED LOSSES AND TOTAL EVALUATED COST

A. Loss evaluation and loss guarantee are described in Section 16320 - SUBSTATION POWER TRANSFORMER. The following formula will be used to calculate the Total Evaluated Cost:

Evaluated Losses = $ 9,220/kW x (No-Load Losses) +$ 3,550/kW x (Equivalent Load Losses)

Total Evaluated Cost = Evaluated Losses + Bid Price

PART 2 PRODUCTS

2.01 MATERIALMEN

A. Power transformers manufactured by the following **Materialmen** are acceptable for this proposal:

1. Delta Star East, Lynchburg
2. Delta Star North, Quebec
3. Hitachi, Crystal Springs, MS
4. GE Vernova, Waukesha, WI
5. GE Vernova, Goldsboro, NC
6. Virginia Transformer, Pocatello, ID
7. WEG Transformers USA, Washington, MO

2.02 TRANSFORMER RATING DATA

A. General. The substation power transformer shall have the following ratings.

1. Temperature Rise: The average winding temperature rise above ambient shall not exceed 55°C at the ONAN capacity when tested in accordance with IEEE C57.12.90. An additional capacity of 12% shall be available when the average winding temperature rise is 65°C. The average winding temperature rise above ambient by resistance shall not exceed 65°C and hottest-spot winding temperature rise shall not exceed 80°C.

2. Winding Material: **Copper**

3. Winding Construction: **Round**

4. Insulating Liquid: **Mineral Oil**

5. Audible Sound Levels: The transformer(s) shall be designed to have average sound pressure levels dB (A) not exceeding those listed in Table 1 of NEMA TR1–2013.

B. Type, Cooling Class, Frequency and Phases:

1. Type: **Two-Winding**

2. Cooling Class: **ONAN/ONAF/ONAF**

3. Frequency: 60 Hertz.

4. Phase: **Three-Phase**

5. Stabilizing Winding

   a. A stabilizing winding is not required.

6. Zero-Phase-Sequence Impedance Characteristics.

   a. Is not included in this specification.

B. Apparent Power and Impedance Voltage – BASE BID.

1. The rated BASE BID Apparent Power and Impedance Voltage shall be as detailed in the following table:

Windings	Apparent Power (MVA) At Specified Average Winding Rise over Ambient				%Z
	ONAN	Forced Cooling - ONAF			
		1st Stage	2nd Stage		
	55°C			**65°C**	
H-X	**30**	**40**	**50**	**56**	**8.5**

All impedance voltage values are at the ONAN rating.

2. The allowable tolerance for the impedance(s) specified above shall be **as defined in C57.12.00-2021.**

D. Apparent Power and Impedance Voltage – ALTERNATE BID.

1. Is not included in this specification.

E. Voltage Rating, Connections, Taps, Insulation Levels, and Angular Displacement:

Winding	Voltage	Connection	Grounding	BIL	
				Line	Neutral
H	**68800**	**Delta**	**n/a**	**350**	**n/a**
X	**13090Y/7560**	**Wye**	**Solid**	**110**	**110**

1. Tap Voltages: Manual, DETC on the H-Winding:

   a. 72,400/70,600/68,800/67,000/65,200 Volts.

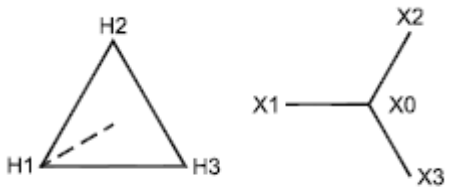
2. Tap Voltages: Manual, DETC or VS on the X-Winding Winding:

   a. None.

3. Tap Voltages: Manual, DETC or VS on the Y-Winding Winding:

   a. none

4. Angular Displacement:



Vector: Dyn1

2.03 INSTRUMENTATION AND CONTROL

A. Liquid Level Indicator (LLI)

1. Transformer(s) shall be equipped with a Liquid Level Indicator (LLI) gauge with dial markings to show 25°C, maximum, minimum, and trip operation levels. The LLI gauge shall be MESSKO MTO. Each LLI shall be magnetically coupled with a six-inch dial and a UV resistance lens. The LLI shall have two sets of isolated Form C contacts for alarm and trip. The alarm contacts shall operate at a low liquid level, but above the critical liquid level. The trip contacts shall operate at the critical liquid level to prevent failures.

B. Liquid Temperature Indicator (LTI) and Control

1. Transformer(s) shall be equipped with a four-switch thermometer responsive and indicative to the top liquid temperature of the transformer. The LTI gauge shall have dial calibrations in degrees centigrade having a temperature pointer and a drag hand indicating the maximum liquid temperature since the last reset. The drag hand shall be resettable from the ground. The LTI gauge shall be MESSKO Compact Series. Switches shall be operated and configured as follows:

	Function	Contacts Required
Switch #1	Future 1st Stage fans	(1) Form A
Switch #2	Future 2nd Stage fans	(1) Form A
Switch #3	High Temperature Alarm	(1) Form C - Owner's use
Switch #4	High Temperature Trip and Annunciation	(1) Form C - Owner's use

The contacts shall be compatible for the specified use (see Section 16320, Article 2.03, Paragraph D.10 for Trip Contacts). Alarm and trip temperature levels shall be adjustable with setting points recommended by the **Materialman**. This gauge will be used as a visual backup to the ETM. Fan contacts shall be wired to control cabinet terminal blocks for future use. The alarm contact shall actuate the auxiliary relay 26AX. The trip contact shall actuate auxiliary relay 26TX.

C. Winding Temperature Indicator (WTI) and Control

1. Transformer(s) shall be equipped with a four-switch thermometer responsive and

indicative of the transformer winding's hottest-spot temperature. The WTI gauge shall have dial calibrations in degrees centigrade having a temperature pointer and a maximum hottest-spot temperature since last reset. The WTI gauge shall be MESSKO Compact Series. Switches shall be operated and configured as follows:

	Function	Contacts Required
Switch #1	Future Control 1st Stage fans	(1) Form A
Switch #2	Future Control 2nd Stage fans	(1) Form A
Switch #3	High Temperature Alarm	(1) Form C - **Owner**'s use
Switch #4	High Temperature Trip and Annunciation	(1) Form C - **Owner**'s use

The contacts shall be compatible for the specified use (see Section 16320, Article 2.03, Paragraph D.10 for Trip Contacts). Alarm and trip temperature levels shall be adjustable with setting points recommended by the **Materialman**. This gauge will be used as a visual backup to the ETM. Fan contacts shall be wired to control cabinet terminal blocks for future use. The alarm contact shall actuate the auxiliary relay 49AX. The trip contact shall actuate auxiliary relay 49TX.

a. For two-winding transformers or three-winding transformers with a stabilizing winding, one (1) WTI gauge shall be provided using load current from the X winding. For three-winding transformers with a tertiary winding, three (3) WTI gauges shall be provided using load currents from each winding.

D. Electronic Transformer Monitor (ETM)

1. A SEL-2414 Transformer Monitor, model # MOT **241421ACA9X743A1130**, shall be used for cooling control and local annunciation. The SEL-2414 shall be mounted on the control cabinet's swing panel at a height between 57 and 63 inches above the base. **The SEL-2414 is not designed for direct sunlight. Materialman will not** provide viewing windows that expose the SEL-2414 to direct sunlight.

a. Inputs to this device shall include the transformer alarms and RTD inputs for main tank top oil, OLTC compartment top oil and ambient temperature. Alarm inputs include sudden pressure, oil levels, and nitrogen pressure, etc. SEL-2414 outputs will be used to control Stage 1 and Stage 2 transformer cooling fans, and to initiate a winding temperature trip timer.
b. The ETM shall be powered by the substation's battery system (see Article 2.03 Paragraph E.5 in this section). Control wiring shall be as follows (No substitutes allowed):

SEL-2414 Outputs (Card A 100)	
OUT101 (A03-A04) NO	Top Oil Trip
OUT102 (A05-A06) NO	Winding Hottest-Spot Trip
OUT103 (A08-A07-A09) NO/NC	**Top Oil Alarm**
IN101 (A10-A11)	**Spare**
IN102 (A12-A11)	**Spare**
SEL-2414 Inputs (Card C 300)	
OUT301 (C01-C02) NC	Winding Hottest-Spot Alarm
OUT302 (C03-C04-C05) NC/NO	Stage 1 Cooling Control (Fail-Safe)
OUT303 (C06-C07-C08) NC/NO	Stage 2 Cooling Control (Fail-Safe)
IN301 (C09-C10)	Stage 1 and Stage 2 Cooling loss of potential

IN302 (C11-C12)	Stage 1 Cooling Status
IN303 (C13-C14)	Stage 2 Cooling Status
IN304 (C15-C16)	OLTC Control self-test alarm (where applicable)
SEL-2414 RTD Inputs (Card D 400)	
RTD1 (D01-D02-D03)	Oil Temperature sensor
RTD2	(Spare)
RTD3 (D07-D08-D09)	Ambient Temperature sensor
RTD4 (D10-D11-D12)	OLTC Oil Temperature sensor (where applicable)
RTD5	(Spare)
RTD6	(Spare)
RTD7	(Spare)
RTD8	(Spare)
RTD9	(Spare)
RTD10	(Spare)
SEL-2414 Voltage and Current Inputs (Card E 500)	
E01-E06: Three-phase **Owner** supplied voltages	
E07-E10: Currents from X winding BCT(s)	
SEL-2414 Current Inputs (Card Z 600)	
IN601 (Z01-Z02)	Pressure Relief Main Tank
IN602 (Z03-Z04)	Sudden Pressure Alarm (63P): Main Tank and OLTC (where applicable)
IN603 (Z05-Z06)	Low Oil Main Tank
IN604 (Z07-Z08)	Low Oil OLTC (where applicable)
IN605 (Z09-Z10)	Gas Pressure High
IN606 (Z11-Z12)	Gas Pressure Low
IN607 (Z13-Z14)	Cylinder Pressure
IN608 (Z15-Z16)	Pressure Relief OLTC Tank Alarm (where applicable)

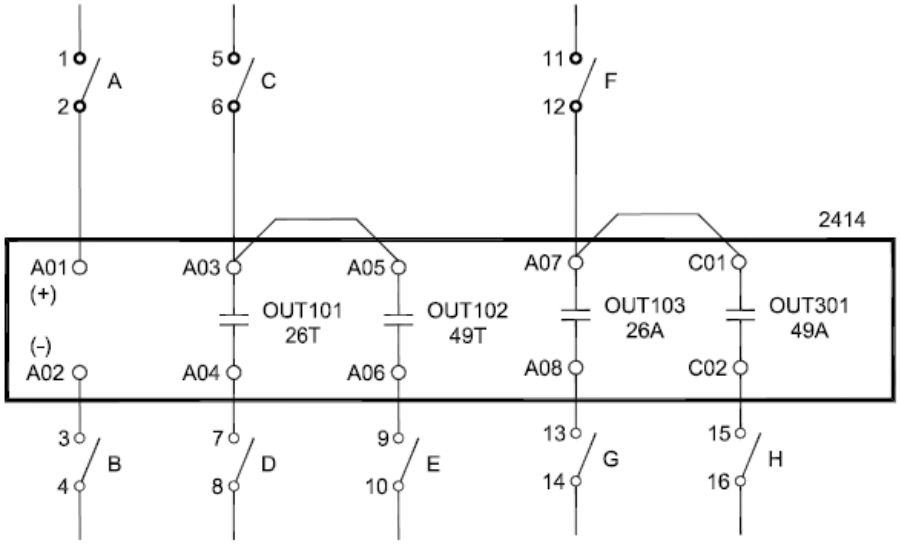
c. ETM Temperature Sensors. Materialman shall provide 100 ohm, 3W, platinum RTD for temperature sensors to be wired directly to the SEL-2414. RTD leads shall not be connected through a terminal block.

d. ETM Programming. A SEL rdb file will be provided to Materialman that defines the Logic, Front Panel and Report settings for the 2414 ETM. Materialman shall provide thermal model settings based on a 55°C average winding rise. Submission of Thermal Data (as required in Section 16320, Article 2.02, Paragraph B.3). The Materialman is responsible for downloading the provided settings prior to the start of Factory Tests. During Factory Temperature Rise Tests, the ETM shall be actively monitoring the transformer being tested (as specified in Section 16320, Paragraph 3.01 E.6) and shall be used to operate transformer cooling stages during the Factory Temperature Rise maximum rating test. **Failure to comply with these requirements shall require the maximum rating test to be repeated with the specified ETM setup.**

e. Current inputs to the SEL-2414 will be supplied from a dedicated single ratio winding temperature bushing current transformer (WCT). For two-winding transformers or three-winding transformers with a stabilizing (or unloaded tertiary) winding, one (1) WCT shall be provided and installed on the X2 bushing. For three-winding transformers with a loaded tertiary winding, three (3) WCTs, one for each winding, shall be provided and installed on the H2, X2 and Y2 bushings. The WCT secondary shall be rated for 5 amperes and have

an accuracy class of at least C100. The WCT primary rating shall equal or exceed the maximum MVA loading of the transformer at an average ambient of 0°C with the OLTC on the neutral position (when applicable). Each WCT shall be wired to a 4-pole, PK-2 test block mounted on the swing panel(s). The WCT shall be terminated on the bottom of the block and the SEL-2414 shall be terminated on the top of the block.

f. Provide an ABB FT-1 test switch to isolate the power supply and all output contacts. This test switch will be designated TS-ETM. FT-1 connections shall be as shown below:



E. Remote Indication.

1. Auxiliary Relays and Contacts, the ETM requires the following auxiliary contacts:

Device	Function	Contacts Required
26AX	Top Oil Alarm	(1) Form C - Owner's use
49AX	Hottest-Spot Alarm	(1) Form C - Owner's use
26TX	Top Oil Temperature Trip	(2) Form C - Owner's use
49TX	Winding Hottest-Spot Trip	(2) Form C - Owner's use
27X	Stage 1 and Stage 2 cooling loss of potential	(1) Form C - Owner's use (1) Form C - ETM Input
63PR-1X	Pressure Relief Main Tank	
63SPX	Sudden Pressure Alarm: Main Tank and OLTC (where applicable)	
71Q-1X	Low Oil Main Tank	
71Q-2X	Low Oil OLTC	
N2X	Gas Pressure High	
	Gas Pressure Low	
	Cylinder Pressure	
63PR-2X	Pressure Relief OLTC Tank Alarm (where applicable)	

1) The contacts shall be compatible for the specified use (see Section 16320,

Article 2.03, Paragraph D.10 for Trip Contacts).

F. Control Cabinet

1. Control Cabinet specifications are organized as shown in C57.148, Annex B.

2. The Control Cabinet shall be in Segment 1 and shall be centered on the tank wall.

3. General User-Specified Options

Options	Y/N	Specify or Comments
Are optional mounting brackets required for gauges or other devices?	N	
Are limiting dimensions specified for the control cabinet?	Y	Equipment mounted in the control cabinet shall be no higher than 72 inches above the base.
Are non-standard materials required for the cabinet construction?	N	
Are non-standard door handles required?	Y	Open & secure at least 105 degrees See Section 16320 Article 2.03 E.4
Are bottom plate dimensions specified?	Y	Bottom plate shall be sized for a minimum of six (6) 2-inch conduits. Location and dimension bottom plate shall be shown on control cabinet layout drawing.
Is a non-standard painting or paint color specified?	Y	Interior shall have a white semi-gloss finish.
Are GFCI outlets specified?	Y	120V, 15 A GFI outlets shall be located inside the cabinet and external to the cabinet. The external outlet shall meet NEC requirements for Wet Locations.
Are non-standard circuit breakers specified?	N	Breakers shall meet NEMA/UL standards.
Are non-standard heater temperature ranges or ambient temperature ranges specified?	Y	240Vac PTC heaters with a fan and a high-recovery mode are required.
Are non-standard user-specified circuit designs required?	N	
Are non-standard optional control circuit components required?	Y	See Section 16320, Article 2.03 K.
Are separate circuit breakers for heaters and lights required?	N	
Is a user-specified type of wiring diagram, terminals, or wire markers required?	Y	CT terminal block designations in Section 16320, Article 2.03 N.3. Control, alarm, and trip-circuit terminal blocks shall use the TB-(X) designation, where X = A, B, C, etc.
Are user-defined terminal block	N	

designations required?		
Are user-defined terminal designations required?	N	
Are wire raceways required?	Y	Raceway fill shall not exceed 40%.
Other non-standard requirements?	Y	Additional wiring requirements are specified in Section 16320, Article 2.03 E.5.

4. Option A: Cabinet Construction

Options	Y/N	Specify or Comments
Standard: NEMA 3	Y	
Other (Specify)	N	

5. Option B: Sheet Metal Thickness

Options	Y/N	Specify or Comments
Standard: C57.148-2020 Clause 5.4	Y	

6. Option C: AC Power Supply and DC Relay Voltages

Options	Y/N	Specify or Comments
AC Standard: 120 V ac, single-phase	N	
AC Other (Specify)	Y	Owner supplied external source shall be 120/240 Vac. PTC heater and Cooling Fans shall be 240V.
DC Standard: 125 V dc	Y	Control devices for DC circuitry shall be able to operate on an ungrounded station battery system
DC Other (Specify)		None

7. Option D: Terminal Blocks

Options	Y/N	Specify or Comments
User-specified optional wiring terminals required?	Y	Control terminal blocks shall be GE type EB-25 or Marathon 1500 Series. Terminals shall be mounted on the back panel. Power Terminal blocks shall be NEMA type solderless box-lug terminals able to accept #12 to 1/0 AWG copper conductors.
User-specified optional CT wiring terminals required?	Y	CT terminal blocks shall be GE type EB-27 or Marathon 1500 Series. Terminals shall be mounted on the back panel.
User-specified or approved alternate CT wiring terminal spacing required?	N	
User-specified optional test switches	Y	All CTs shall be wired to GE type

required?		PK-2 test blocks with auxiliary contacts and jumpers. Three-phase circuits shall be wired to 6-pole test block. All other CT circuits shall be wired to 4-pole test blocks. See Section16320, Article 2.03 N.3 for details. ETM test switch if specified in Article 2.03 of this Section.

8. Option E: Cooling Control Switches

	Y/N	Specify or Comments
Do not include the standard Auto/Off/Manual switch	N	
Do not include the standard manual stage selector switch	Y	
Supply optional lead stage selector switch?	N	
Other	N	

9. Option F: Annunciator

	Y/N	Specify or Comments
Supply optional annunciator	N	

10. Option G: Automatic Transfer Switch (ATS)

	Y/N	Specify or Comments
Supply optional ATS	N	

11. Option H: Dead Front Design

	Y/N	Specify or Comments
Supply optional dead front design	Y	Swing panel(s) shall be provided inside the control cabinet's exterior door(s). Cooling Control Switches, CT circuit PK-2 blocks and OLTC controls (where applicable) shall be mounted on the swing panel(s). Devices mounted on the swing panel(s) shall not prevent the outer door(s) and swing panel(s) from being secured in the open position. Padlocking provisions should not be provided on swing panel(s).

12. Option I: Visible Air Gap

	Y/N	Specify or Comments
Supply optional single switch on AC power supply	N	

Supply optional single switch on DC circuit	N	
Supply optional multiple switches	N	

2.04 TRANSFORMER FEATURES

A. Bushings: Bushings with BIL ratings below 450 kV BIL shall have a Test Tap to measure power factor, capacitance, and partial discharge. Bushings with BIL ratings of 450 kV BIL and above shall have a Voltage Tap. All bushings shall be ANSI #70 light gray.

1. At 25 kV and above, bushings shall be PCORE oil-filled (no substitute). At 69 kV, a type PRC bushing, Catalog Number B-89523-70 shall be provided. The top terminal of all bushings shall be silver plated. Bushing ratings shall be as follows:

Bushing	Voltage Class (kV)	BIL (kV)	Arrangement	
			Location	Mounting
H	**69**	**350**	**Segment 3**	**Cover**
X	**25**	**150**	**Segment 1**	**Cover**
X_0	**25**	**150**	**Segment 1**	**Cover**

2. Terminals/Connectors: All bushings shall have tin plated bronze NEMA 4-hole, NEMA 6-hole pads, or as required when Air Terminal Chamber is specified (see Section 16320).

B. Tank Finish:

1. Paint Color shall be ANSI #70 Light Gray.

C. Air Terminal Chamber (ATC):

1. An ATC is not required.

D. Bushing Current Transformers: Bushing Current Transformers (BCT) to be wired as described in Section 16320 - SUBSTATION POWER TRANSFORMER. CT Circuit Designation, Ratio, Accuracy Class, and location shall be as follows (BCT positions are designated as 1,2,3, etc., with **one (1) being closest to winding** and the highest number being farthest from the winding):

	BCT Circuit Designation	Ratio	Accuracy Class
H-Winding:			
Position 2	**CT-H-2**	**600:5**	**C400**
Position 1	**CT-H-1**	**600:5**	**C400**
X-Winding:			
Position 2	**CT-X-2**	**3000:5**	**C400**
Position 1	**CT-X-1**	**3000:5**	**C400**
Xo Bushing:			
Position 1	**CT-X0-1**	**1200:5**	**C400**

1. CT Circuit Designations are for the entire three-phase or single-phase CT circuit. Individual CTs shall be designated as follows: (CT Function)-(Winding)(Phase)-(CT Position). Where the CT Function types are CT, WCT, and LCT for relay/metering, winding temperature, and LTC control, respectively.

E. Revenue Meter Current Transformers:

1. Are not required.

F. Surge Arresters: All surge arresters supplied with the transformer(s) shall be Ohio Brass station class surge arresters. Surge arresters with an MCOV rating greater than or equal to 29.0 kV shall be type SVN. Surge arresters with an MCOV rating below 29.0 kV shall type EVP with the standard leakage distance. Surge arrester color shall be ANSI #70 Light Gray.

Winding	MCOV (kV)	Terminal
H	**42**	**Galvanized NEMA 4-Hole Pads**
X	**8.4**	**Galvanized NEMA 4-Hole Pads**

1. Surge arresters shall be tank mounted adjacent to the bushings or as required when an Air Terminal Chamber is specified (see Section 16320).

2. X-Winding Surge Arrester terminals shall be machined on both sides to allow connectors to be installed on both sides of the arrester terminal.

G. On-Load Tap Changer:

1. An On-Load Tap Changer and controls shall be supplied in accordance with Section 16327 – ON-LOAD TAP CHANGER.

2.05 ADDITIONAL REQUIREMENTS

A. The following Spare Parts are to be quoted as a separate item on the Bid Form:

1. One (1) spare H and X Bushing.

PART 3 EXECUTION

(NOT USED)

END OF SECTION

SECTION 16327
ON-LOAD TAP CHANGER

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Performance and functional requirements for an On-Load Tap Changer (OLTC).

B. Requirements for OLTC control, instrumentation, and communications.

1.02 RELATED SECTIONS

A. DIVISIONS O and 1 - CONTRACT DOCUMENTS AND GENERAL REQUIREMENTS: These shall apply to all work included in this section.

B. Section 16320 - SUBSTATION POWER TRANSFORMER.

C. Section 16320D - DATA SHEET - SUBSTATION POWER TRANSFORMER.

1.03 REFERENCES

A. Published Specifications, standards, tests, or recommended methods of trade, industry, or governmental organizations apply to work in this section where cited in Section 01090 - REFERENCE STANDARDS and in the listing below.

1. IEEE C57.12.00 – IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

2. IEEE C57.12.10 - IEEEE Standard Requirements for Liquid-Immersed Power Transformers.

3. IEEE C57.131 – IEEE Standard Requirements for Tap Changers.

1.04 SUBMITTALS

A. Shop drawings shall be submitted for approval in accordance with Section 01301 - SUBMITTALS and Section 01341 - SHOP DRAWINGS.

B. Submittals shall consist of, but not limited to, the following:

1. Outline and Details

2. OLTC Nameplate Drawing

3. Schematics and Wiring Diagrams

4. OLTC Operating Instructions

5. Tap Changer Control/Instrumentation Data and Instruction Manuals

C. Final Drawings and Manuals shall be provided prior to shipment in accordance with

Section 01721 - PROJECT RECORD DOCUMENTS.

1.05 WARRANTY

A. The warranty shall be the same as the substation power transformer supplied or Materialman's standard which ever affords greater protection to the Owner.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Waukesha Type UZD
B. Reinhausen Type RMV-II

2.02 COMPONENTS

A. On-Load Tap Changer (OLTC)

1. The OLTC shall be designed, manufactured, and tested to IEEE Standard C57.131 and IEEE Standard C57.12.10.

2. The active part of the OLTC shall be in a separate compartment. There shall be no mixing of insulating liquids between compartments, and each compartment shall have sample and draining provisions independent of the other compartment.

3. The OLTC compartment's insulating liquid shall be Mineral Oil as specified in Section 16320.

4. The preferred physical location of the OLTC is on the tank wall of Segment 2.

5. OLTC shall be the high-speed resistive or vacuum interrupter-reactance type.

6. The OLTC shall not limit the transformer from being loaded in accordance with IEEE Standard C57.91. OLTC taps shall have full rated kVA capacity on taps above normal and a current rating corresponding to full load current at rated voltage on taps below normal voltage.

7. The drive mechanism motor shall be rated 230 Vac and be connected to an Owner supplied 120/240 Vac source.

8. Resistive-type OLTCs shall complete a tap change once started, either electrically or manually. OLTC shall not be capable of remaining in a mid-tap position due to loss of operating voltage during electrical operation or during manual operation. **Manufacturers proposing a reactance-type OLTC shall address the impact of losing control power when the mechanism is in a mid-tap position as part of their proposal.** If the OLTC provided is capable of this condition, an alarm shall be provided for indication.

B. OLTC Features

1. The position indicator shall have drag hands to indicate both the maximum raise and lower position. The reset means for the drag hands may be either electrical or

mechanical. If mechanical reset is used, the reset lever shall be no higher than 72 inches above the base of the transformer.

2. The OLTC's compartment shall be equipped with a mechanical pressure relief device and a magnetic liquid level gauge. Alarm contacts shall be provided for both devices as specified in Section 16320.

3. A dehydrating breather shall be provided for the OLTC's compartment when mineral oil is used as the insulating liquid.

4. An Oil Filtration System shall be provided for arcing-in-oil designs. The Filtration System shall be manufactured by Waukesha Electric Systems or as approved by the Engineer.

5. OLTCs that use arcing-under-oil designs shall have a sudden pressure relay and associated equipment for the OLTC's oil compartment to initiate de-energizing of the power transformer. The sudden pressure relay provided shall be as specified in Section 16320.

6. An operations counter shall be provided to indicate the number of tap changer operations.

7. A neutral position cam operated switch shall be included and wired to the transformer's control cabinet for use with a neutral position light indicator.

C. Windings

1. The tap winding shall be fully distributed and wound on a separate winding cylinder from the high and low voltage windings. Winding conductors shall be copper. Where partially distributed windings are proposed, the tap sections must be arranged symmetrically about the magnetic and electric center of the main windings. **The Materialman must discuss the details of the partially distributed design as part of the Proposal to receive full consideration.**

2. A series transformer, when required, shall be constructed to Class 2 power transformer standards including circular core and coil design using disc or helical type winding construction with all copper conductors.

3. When a reactance-type OLTC is provided, the preventative autotransformer (PA) shall be constructed to Class 2 power transformer standards including circular core and coil design using disc or helical type winding construction with all copper conductors.

   An alternate PA design incorporating a rectangular coil with full height copper strip conductor is acceptable. Windings shall be designed as a 2:1 autotransformer with two windings of equal turns and current carrying capacity. Windings shall be wound in a radially interleaved arrangement. Resulting design shall exhibit essentially zero axial and radial forces during short circuits.

D. Nameplate

1. A separate nameplate shall be attached to the OLTC mechanism providing OLTC data required in C57.131 and including but not limited to:

a Model Number, Type, Serial Number
b Quantity of insulating liquid in compartment(s)
c Instruction Manual Number
d Vacuum capability of barrier between OLTC and transformer main tank

E. Drive Mechanism Enclosure

1. The Drive Mechanism enclosure shall meet the specifications for the Control Cabinet and Wiring detailed in Sections 16320 and 16320D.

F. Controls and Instrumentation

1. All controls required to allow independent or parallel operation with a future transformer bank shall be provided. Parallel operation shall utilize the circulating current method.

2. The OLTC controls required shall include:

a Beckwith model M-2001C Comprehensive Digital Tapchanger Control, Style M-2001C-6SVAA, combined with an M-2270B Adapter Panel, Style M-2270B-SCV.

b Auxiliary CTs as required for the M-2001 control's line drop compensation function shall be provided.

c Beckwith M-0329B back-up control shall be provided.

d Beckwith parallel balancing module M-0115A shall be provided to allow for parallel operation with an identical OLTC transformer. Isolated dry contacts wired to terminal blocks shall be provided to indicate switch position (parallel or independent) for SCADA indication.

e Beckwith AC current relay, Module M-0127A, shall be included in the circulating current circuit of paralleled OLTC transformers to guard against excessive circulating current.

3. To accommodate access to the OLTC control's settings and data logging, one copy of the Beckwith M-2029 "Tap Talk" communications software shall be provided.

4. Tap Position Tracking

a The M-2001 control will keep track of tap position internally.

5. The OLTC controls shall be mounted in the transformer main control cabinet on a hinged, swing-out inner panel for easy access behind the panel. All controls, operations counter, position indicator reset or other devices requiring operation by utility personnel shall be no higher than 72 inches above base of transformer. Additionally, the top of the control shall be at least 4 inches from any other device or raceway. In addition to the controls listed, the following features shall also be included:

a. Remote/Local Switch control to block remote raise, lower, and automatic operations via the SCADA system. The switch shall be a toggle switch and may be part of the adapter panel or separately mounted on the swing panel near the OLTC control.

6. All interconnection wiring between the control modules, current transformers, auxiliary equipment, and field terminal blocks shall be provided to achieve a completely functional automatic voltage regulating control system. Wiring shall meet the specifications listed in Section 16320. Terminations shall include all interconnections between the available input/output functions of the M-2001 including but not limited to the following:

a External sensing voltage input.
b OLTC paralleling connections.
c Self-Test alarm contact outputs.
d User programmable alarm contact input.
e Tap change inhibit contact input.
f Multi-step voltage reduction.
g OLTC tap position transducer output.
h Sensing voltage input.

G. Auxiliary and Control Power

1. Owner-supplied external source(s) are shown in the DATA SHEET. Materialman selected devices shall be rated to operate at the specified voltages.

2. Sensing voltage for the OLTC controls shall be 120 VAC, 1Ø, 60 Hz, and will be supplied by the OWNER.

2.03 FABRICATION

A. Bolted access covers on the OLTC compartment shall be hinged and removable.

B. There shall be a spill lip at the bottom edge of the load tap changer cabinet to prevent insulating liquid spillage when the cabinet is opened for maintenance.

C. OLTC design shall be capable of withstanding full vacuum in the main transformer tank without damage to OLTC compartment or components. If the barrier between the main tank and the OLTC compartment requires an equalizing vacuum, warning signs should be placed near the appropriate main tank fittings and in the instruction manual.

D. When operating the hand crank with the transformer under load is not appropriate, a warning sign should be placed near the hand crank coupling.

PART 3. EXECUTION

(NOT USED)

END OF SECTION