Mount Pleasant Municipal Utilities | **Ameren Missouri (ATXI)**

Mount Pleasant, Iowa | **St. Louis, Missouri.**

BID SPECIFICATION FOR

Skunk River Substation Transformer #1 and #2

PROCUREMENT BID DOCUMENTS

LICENSED PROFESSIONAL ENGINEER
PETER ANTHONY BERGAMINI
P26871
IOWA

I HEREBY CERTIFY THAT THIS ENGINEERING DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF IOWA.

Peter Bergamini 04/02/2025

SIGNATURE DATE

PETER ANTHONY BERGAMINI

LICENSE NUMBER: P26871

MY LICENSE RENEWAL DATE IS DECEMBER 31, 2026.

PAGES OR SHEETS COVERED BY THIS SEAL:

Olsson

Kansas City, Missouri

Prepared by: **Jack Hedgecock**

Peter A. Bergamini P.E.

INVITATION TO BID

Project Buyer: Mount Pleasant Municipal Utilities / Ameren Missouri (ATXI)

Project Name: Skunk River Substation Transformer #1 & #2
30/40/50MVA 345000/69000V (345/69kV) Autotransformer Procurement

Project Location: Adjacent to 1461 Old Hwy #34, Mt. Pleasant, IA 52641. - (NE ¼, Sec 2, T-71-N, R-7-W, Henry Co. IA)
Date: 4/2/2025

Subject: Notice to Bidders - Invitation to Bid for two (2) 345kV/69kV Autotransformers 30/40/50MVA

Dear Bidders,

Mount Pleasant Municipal Utilities / Ameren Missouri (ATXI) invites qualified and experienced bidders to submit their proposals for the supply and delivery of two (2) 345kV/69kV Autotransformers with power ratings of 30/40/50MVA, including associated accessories and services. Delivery MUST include all freight and/or roadway taxes/tariffs and fees. Delivered and offloaded on the transformer pad located at the address indicated above.

Bid Submission Deadline: 5/19/2025 Bid Submission Time: 1 pm CST

We look forward to receiving your proposals and working together to achieve a successful outcome for this project. Should you have any questions or require further information, please contact Jack Hedgecock at jhedgecock2@olsson.com, 319-931-8785.

Sincerely,

Nate Lucas
General Manager
Mount Pleasant Municipal Utilities

Furnishing and Delivery of two (2) 345/69kV Autotransformer 30/40/50 MVA Units

For Mount Pleasant Municipal Utilities / Ameren Missouri (ATXI)

Mt. Pleasant, Iowa 52641

The undersigned agrees to perform the work as specified for the prices as stated:

BIDDER NAME: _____

BIDDER ADDRESS: _____

BIDDER PHONE: _____

BIDDER E-MAIL: _____

BIDDER CONTACT: _____

BASE BID LUMP SUM BID PRICE:

_____Dollars (_____)
(words) (figures)

Iowa Sales Taxes (7% of Base Bid Amount) ADD $_____

Vendor discount for early payment: DEDUCT $_____

TOTAL BID AMOUNT: $_____

NAME (TYPED OR PRINTED): _____

TITLE: _____

BY: _____

(Authorized Individual's Signature)

DEFINITIONS

Whenever the following terms or pronoun in place of them are used in these “Instructions to Bidders”, “Form of Proposal”, “Technical Specifications”, “Contract”, etc.… the intent and meaning shall be interpreted as follows:

Owner/Buyer	Mount Pleasant Municipal Utility (MPMU) / Ameren Missouri (ATXI) Mount Pleasant, Iowa
General Manager	Nate Lucas
Approved Representative	An authorized representative of Owner assigned to make any or all necessary observations of work performed and equipment and/or apparatus furnished by the Bidder.
Bidder/Manufacturer	Any individual, firm, or corporation submitting a Proposal for the work contemplated, acting directly or through a duly authorized representative; or party of the second part of the Contract, acting directly or through a duly authorized representative.
Subcontractor	Any individual, firm, or corporation who contracts with the Bidder to perform part of the latter’s Contract.
Surety	The body, corporate or individual, approved by the Owner, which is bound with and for the Bidder who is primarily liable, and which engages to be responsible for their acceptable performance of the work for which they contracted.
Proposal	The approved, prepared form on which the Bidder is to submit or has submitted his Proposal for the work contemplated.
Plans/Drawings	All Drawings or reproductions of Drawings pertaining to the construction under the Contract.
Technical Specifications	The directions, provisions, and requirements contained herein pertaining to the method and manner of performing the work or to the quantities and qualities of materials to be furnished under the Contract.
Contract	The agreement covering the furnishing of equipment and/or apparatus and the performance of the work. The Contract shall include the “Instructions to Bidders”, “General Conditions”, “Form of Proposal”, “Plans”, “Technical Specifications”, and “Acknowledgements”.
Work	The performance of the project covered by the Specification or the furnishing of labor, machinery, equipment, tools, or any other article or item being purchased by the Owner.
Emergency	A temporary unforeseen occurrence or combination of circumstances which endangers life and property and calls for immediate action or remediation.
Work at Site	Work to be performed, including work normally done on the location of the project.
Bid Documents	Include all sections of the Request for Bids, Form of Proposal, Technical Specifications and Appendices.

The subheadings in these Specifications are intended for convenience or reference only and shall not be considered as having any bearing on the interpretations thereof.

Table of Contents

1. INSTRUCTION TO BIDDERS

1.1. Eligibility: Interested bidders must fulfill the eligibility criteria outlined in the bid documents. Bidders should provide necessary documentation demonstrating their experience, technical capability, financial stability, and compliance with applicable laws and regulations.

1.2. Bid Submission: Bid Form shall be directed to Mr. Nate Lucas, securely sealed and endorsed upon the outside wrapper, “BID FOR FURNISHING AND DELIVERING 345KV AUTOTRANSFORMERS” at 509 North Adams Street, Mount Pleasant, Iowa 52641. Bids dropped off at the MPMU Office will be considered if they are in the possession of Mr. Lucas at the close of the bidding period. Technical submittal data may be submitted electronically any time prior to the close of bids.

1.3.1 Bid Security: To be considered, Bids shall be submitted with a Bid Security conforming with the latest edition of the State of Iowa Public Bidding rules in the amount of five percent (5%) of the base bid amount. Bid should be submitted on the Bid Proposal Form provided. The form may be reconstituted if the contents are duplicated. Failure to submit the required bid security, complete or submit the Bid proposal form, or provide the required technical submittals may result in rejection of proposal.

1.3. Evaluation Criteria: Bids will be evaluated based on factors such as compliance with specifications, price, delivery schedule, past performance, and technical capabilities.

1.4. Contract Award: The contract will be awarded to the bidder whose proposal is deemed most advantageous to Mount Pleasant Municipal Utilities (MPMU) or authorized representatives, taking into consideration the evaluation criteria mentioned above.

1.5.1 Payment: Payment will be made to the Vendor in an amount of ninety-five percent (95%) of the Proposal value, upon delivery, assembly, and testing of the Transformers at the Owner’s site. The balance of the amount due the successful bidder will be made within 30 days following the successful energization of the Transformers by the Owner, subject to the conditions and in accordance with the provisions of Chapters 384 and 573 of the Code of Iowa, no later than 180 days following delivery to site. If Vendor requires staged progress payments, please include a detailed payment milestone schedule in the bid submittal for consideration.

1.5.2 Tax: All bids shall indicate the Iowa sales tax (7% of base bid amount) as a separate line item determined from the base bid amount.

1.5.3 Amount: Prices shall remain valid for a period of ninety (90) days after 5/19/2025.

1.5. Disqualification: The Owner reserves the right to reject any and all Bids, at their sole discretion, and to waive irregularities and informalities therein and to award the purchase in the best interests of the Utility.

1.6. Clarifications and Inquiries: Exceptions to the specifications are not recommended. Written questions regarding the specifications may be directed to Mr. Peter Bergamini, pbergamini@olsson.com by e-mail at the address provided in the contact information. Please do not contact Mr. Lucas or any Owner representatives with questions regarding the specifications.

1.7. Free on Board (F.O.B.): Delivery MUST include all freight and/or roadway taxes/tariffs and fees. Delivered to the transformer pad located at the address indicated above.

2. BIDDERS' PREQUALIFICATIONS

2.1. The bidder must show proof of having manufactured at least six (6 ea.) similar units in design, voltage class and MVA rating in the last ten years that were successfully installed and are currently in serviceable condition.

2.2. The bidder must have a minimum of fifteen (15) years of experience in manufacturing autotransformers.

2.3. The Buyer reserves the right to reject any or all bids and to waive irregularities therein, and all Bidders must agree that such rejection shall be without liability on the part of the Buyer for any damage or claim brought by any Bidder because of such rejections, nor shall the bidders seek any recourse of any kind against the Buyer or Engineer because of such rejections. The filing of any bid in response to this invitation shall constitute an agreement of the Bidder to these conditions.

3. GENERAL

3.1. SCOPE

This specification identifies the requirements for the design, fabrication, testing, furnishing, documentation, shipment F.O.B. site, assembly, and field testing of two (2) Autotransformers 345-69kV grounded-wye. The transformers shall be 30/40/50MVA rated, 65ºC temperature rise, 80ºC hot spot rise, 60Hz, Class II power autotransformers and shall have an On-Load Tap Changer (OLTC) on the Low Voltage (LV) winding. The autotransformers shall be suitable for operation with the neutral either solidly grounded or grounded through impedance. The autotransformers shall be installed at Skunk River Substation.

The manufacturer shall comply with all details of the transformers, auxiliary equipment and guarantees required in this specification. The transformer shall be designed for a minimum 40-year lifespan. No part of the transformers shall overhang the edge of the containment pit. Any exceptions to this specification must be clearly stated in the bid proposal.

3.2. SYSTEM DESCRIPTION

The transformers will be installed outdoors on new foundations (by others) in the Skunk River Substation. The transformers will be connected to the 345kV and 69kV sides via circuit breaker and isolation switch. Transformers MAY be operated in parallel to a single load. See Appendix A for preliminary one-line diagram.

3.3. STANDARDS

- The proposed transformer and all equipment/materials shall be designed, constructed, and tested in conformance with the requirements of the latest revisions and supplements of all applicable standards listed in section 3.4. (REFERENCES).

- Bidder specific standards shall be submitted to MPMU for approval during the bidding process.

3.4. REFERENCES

The following Documents/Drawings are part of the specification:

- Industry Codes and Standards

The transformer shall be manufactured and tested in accordance with the latest revision of applicable standards of the following organizations:

STANDARDS AND CODES	
American Society for Testing and Materials	(ASTM)
American Society for Non-Destructive Testing American Society of Mechanical Engineers	(ASNT)
Society of Mechanical Engineers	(ASME)
American Society of Civil Engineers	(ASCE)
American National Standards Institute	(ANSI)
American Iron and Steel Institute	(AISI)
American Welding Society	(AWS)
SSPC: Society for Protective Coatings	(SSPC)
Occupational Safety and Health Administration	(OSHA)
National Electrical Manufacturers Association	(NEMA)
National Electrical Safety Code	(NESC)
Institute of Electrical and Electronic Engineers	(IEEE)
Factory Mutual	(FM)
National Fire Protection Association	(NFPA)
National Electrical Code	(NFPA 70)
Underwriters Laboratory	(UL)
International Electro-Technical Commission	(IEC)
Transformer Oil Procurement Specification	(TOPS)

Table 1: List of Codes & Specifications

Where there is a conflict between the standards and this specification, the standards shall take precedence. Any deviation of design or testing from the above standards and MPMU specification by the Bidder shall be submitted to MPMU for prior approval before any work starts.

3.5. SUBMITTALS

3.5.1. PROPOSAL SUBMITTALS

- The Bidder shall provide submittals per this section of this document.

3.5.2. CONTRACT SUBMITTALS

- The Bidder shall provide the information listed below per the requirements of this specification.

  Equipment arrangement and outline showing weights, centers of gravity of transformer (empty and oil filled), (shipping splits and fully assembled), volume of oil, physical dimensions, plan and elevation views and un-tanking height.
  Nameplate and/or equipment ratings.
  Installation/mounting information including rail details.
  Items to be removed for shipment.
  Connection diagrams.
  Schematic diagrams showing interconnection of devices on Manufacturer's equipment and schematic diagram of cooling circuit.
  Performance data at 50%, 75%, 100%, and no-load excitation current and losses.
  Current transformer data and excitation curves.
  Bushing details.
  Shipping dimensions and weights.
  Torque and bolt tightening sequence.
  Valve drawings.
  Gasket and O-ring drawings showing dimensions and material used.
  Conduit layout with cable identification color coordinated for AC, DC, Control and CTs.
  All schematics and three-line drawings shall use IEEE/NEMA symbols.
  Guaranteed Impedance [%] at Base MVA rating
  Zero Sequence Impedance
  Drawing (physical, wiring, HV, LV and TV connections drawings). Drawing package shall include six (6) full size copies (24" x 36") of "as built", operation and maintenance manuals and shall be submitted in both paper and electronic (ACAD and PDF) formats.

- Three (3) ea. Installation, Maintenance, energization procedure of the transformer during cold weather and Storage Instruction Books for all devices provided by Bidder.

  <u>Instruction Books / Manuals / Lists shall include, as a minimum, the following:</u>
  Final reduced sized outline drawings and assembly drawings with a description of equipment arrangement and accessories.
  Itemized list of each component of the transformer, including the item numbers, quantities of component provided, description of each component, manufacturer, and catalog number for each component.
  Equipment identification and rating.
  Electrical reduced sized elementary wiring and connection diagrams as required.
  Performance curves as required.
  Description of equipment components, including instrumentation and accessories.
  Installation instruction and assembly procedures.
  List of codes and standards used and effective dates.
  ASME code data form(s) and Manufacturer's specification sheets (as applicable).
  Description of operation, performance curves, safety provisions, start-up, and shutdown procedures, etc. (as applicable).
  Maintenance recommendations and procedures.
  Torque values for flange bolts and thread plugs.
  Gasket specification including manufacturer address and serial number.
  Any information pertinent to the specific equipment provided (e.g., list of lubricants, parts list, bills of materials, etc.).
  Certified Transformer Factory Test Reports and Field Test Reports.
  Design magnetizing curves.
  Transformer inrush current curve

Inspection Photographs - The manufacturer shall provide photographs of the following:

1) The core and coils before they are assembled. The photographs shall clearly show all pertinent information such as general construction and any taps.
2) The assembled core and coils before installation in the transformer tank, taken from each side, each end, top, and bottom.
3) The assembled transformer after the dielectric tests have been successfully completed. A minimum of five photographs shall be taken from all four sides and from above to identify and locate all equipment on the transformer.
4) Prints of the photographs shall be supplied for each instruction book furnished. A digital copy of each photograph is to be furnished at time of shipment. Resolution on each digital photograph is to be a minimum of 5.0 megapixels.

Recommended spare parts list.

- Coating Product Data Sheets (PDS), Safety Data Sheets (SDS), and Application Procedures for MPMU authorized representative approval.
- Coating color samples for MPMU authorized representative approval.
- Safety data sheets (SDS) for all materials used in the construction of the equipment deemed hazardous by OSHA. SDS shall be submitted for transformer oil even though it is not hazardous.
- The Bidder shall supply all drawings and data electronically (in CAD and PDF formats) including but not limited to outlines, foundation plan, connection diagrams, nameplate etc. If available the Bidder shall provide a dimensionally accurate, 3D models of the complete transformer, capable of being opened within such software packages as Autodesk Inventor / Navisworks.
- Equipment fabrication shall not proceed unless the Bidder has received “Status-1 Accepted” or “Status-2 Accepted as Noted, Re-Submittal Not Required” drawings from MPMU.
- When MPMU returns Bidder’s documentation indicating non-conformance to the specifications indicated in the Purchase Order, Bidder shall revise such drawings to incorporate MPMU’s comments at Bidder’s expense. Revised drawings shall be provided two weeks after receipt of MPMU’s comments.
- Overall schedule of equipment and completion shall not be changed unless agreed to by MPMU, in writing.
- In any event, Bidder shall remain responsible for the engineering, design, manufacture, testing, and documentation of the equipment.
- All final calculations and drawings for seismic and civil/structural work shall be signed and sealed by an Iowa PE and submitted by Bidder for MPMU’s review and acceptance.
- Bidder drawings and documents shall indicate Serial No and MPMU asset number on documents (Asset No. provided by MPMU).

3.5.3. BIDDER DRAWINGS AND DOCUMENT SUBMITTALS

- Drawings shall be submitted FOR REVIEW and/or as FINAL CERTIFIED DRAWINGS. PRELIMINARY drawings will not be accepted. FOR INFORMATION drawings shall be treated as FINAL CERTIFIED DRAWINGS. The Bidder shall be responsible for increased costs associated with changes in FINAL CERTIFIED DRAWINGS.
- The Bidder Document Submittal Form attached to or integrated in the Equipment Specification identifies the document categories / types, submittal due dates, number of copies required, and the recipients that they are to be sent to.
- Drawing Return Comment Status Codes:

“Accepted” – Drawings were reviewed and accepted by MPMU. Bidder can proceed with fabrication. Drawings are considered “Final Certified”.

“Accepted as Noted, Re-submittal Not Required” -. Drawings were reviewed and accepted by MPMU. The Bidder may proceed with the work considering the corrections and comments noted on the drawing by the MPMU authorized representative. The drawings shall be resubmitted for record and reference after the necessary revisions are made.

"**Accepted as Noted, Re-submittal Required**" – Drawings were reviewed and accepted by MPMU. The Bidder shall **NOT** proceed with work but, within fifteen (15) calendar days, shall make the corrections and revisions or prepare a new drawing or calculation and resubmit the revised information for review at no change in schedule or cost to the MPMU authorized representative.

"Not Accepted" - Drawings were reviewed and rejected by MPMU. The Bidder shall not proceed with the work but, within fifteen (15) calendar days shall resubmit the required information to the MPMU authorized representative for review at no change in schedule or cost to the MPMU authorized representative.

- A master Bill of Material, with complete identifying information for instrument, control devices and appurtenances in the scope of supply, shall be provided as part of the following drawing submittals:

  FOR REVIEW: Drawings that will undergo review for conformance to general design and the information required are defined in the Equipment Specification. The Bidder Document Submittal Form attached to the Equipment Specification presents the scheduled submittal dates. Bidder shall allow at least fifteen (15) working days from the date MPMU receives submitted drawings for return of reviewed drawings.

  FINAL CERTIFIED DRAWINGS: The FINAL CERTIFIED DRAWINGS represent the equipment as it shall be provided and shall be used by MPMU personnel for inspection. These must be the latest drawings from which the equipment is manufactured. This includes revisions due to MPMU's review and any drawings required to install, maintain, and operate the equipment. MPMU retains the right to execute the "For Review" process for all documents received from the Bidder.

Following review of drawings and incorporation of all comments, Bidder shall submit final certified drawings in accordance with the Bidder Document Submittal Form attached to and/or integrated with the requisite Equipment Specification.

In addition to the above, MPMU requires electronic files of Bidder's as-built drawings submitted for MPMU's record. These shall be submitted, in addition to the files submitted in file formats specified.

The Bidder shall furnish the final certified drawings accurately showing the equipment information for the equipment "as shipped".
The Bidder shall supply the electronic (CAD and PDF) version of the equipment drawings.
These drawings shall be transmitted as "Certified Correct".
Bidder shall provide final drawings showing the information listed in Paragraph 3.8.3 above.
Bidder shall provide the certified FAT report approved by MPMU before shipping the transformer.
These drawings shall be transmitted within two (2) weeks after equipment shipment.

- Civil Submittals

  The equipment fabricator shall provide Iowa PE signed and sealed calculations and certification letter attesting to compliance with the 2015 International Code and requirements of section 5 (CIVIL REQUIREMENTS).
  The equipment fabricator shall provide shop drawings indicating dimension and center of gravity of the equipment.
  The equipment fabricator shall provide installation schematics and details including but not limited to outlines, base details, anchor bolt details, mounting details, including front and plan views, dimensions, weight, and load reactions for review.

4. EQUIPMENT AND SERVICES PROVIDED BY BIDDER (MANUFACTURER)

4.1. EQUIPMENT

- The Bidder shall provide transformers and services per requirements of this specification:

  MVA Rating: 30/40/50 (ONAN, ONAF1, ONAF2)
  Frequency: 60 Hz
  Nominal Voltage: 345-69kV
  Phase: 3
  Positive Sequence Impedance @50MVA: 345-69kV 6-7%*
  Zero Sequence Impedance @50MVA: 345-69kV 6.5-7.5%*

HV-LV – Star with auto-star neutral (H0X0) brought out to bushing.
Suitable for operation with neutral solidly grounded or through impedance.
Reinhausen Vacuum Interrupter Type LTC, 33 Tap Positions ±10% - 5/8% Per Tap.
Vector Group (Yd,A0)

4.2. SERVICES

4.2.1. GENERAL

- This shall be a contract where the Bidder will be responsible for the complete design, manufacturing, shipment, installation, and testing of the transformers. Design, fabricate, transport F.O.B. site, install, test and commission two (2) autotransformers. Transformers will be installed on new foundation pads provided by others. The physical dimensions, weight and control cabinet location for the transformers shall be clearly marked on preliminary documents to allow for design and fabrication of transformer foundation. The transformer MUST fit within the confines of the oil containment (APPENDIX F). The Bidder shall be responsible for any modifications required to achieve this if the provided design documentation differs from final product.
- English shall be used in all correspondence, drawings, reports, calculations, quality records and submittals for MPMU review and approval. All units of measurement used shall be Imperial. All device functions for electrical apparatus shall conform to ANSI C37.2.
- The HV and LV bushings of the new transformer shall meet IEEE/NESC clearance and insulation requirements.
- All items and services shall conform to MPMU's CIP policies.
- All submittals shall be per section 3.5 (SUBMITTALS) of the specification.
- Factory Acceptance Testing (FAT) and Tanking of Active Parts may be witnessed by MPMU's representatives and consider the inspection as a hold point.
- The control and monitoring wiring drawings shall use point-to-point wiring concept, with each wire uniquely identified by a distinguishing wire number or identifier.

4.2.2. SHIPPING AND STORAGE

- If the transformer is manufactured outside of North America, then an external inspection of the transformer shall be performed by a qualified Bidder representative at the port of entry into North America in presence of MPMU representative, unless waived in writing by MPMU.

  The representative shall:

  Analyze the impact recorder data.
  Perform core-ground testing.
  Verify positive pressure inside main tank.
  Visually inspect for damage or suspected damage.
  Submit a report on findings, recorded test results, and photos.

- If damage, or suspected damage (e.g., impact data exceeds g-force limits) is found during the inspection, then the representative shall contact the Bidder prior to departing the port to:

  Determine if an internal inspection is necessary.
  Determine if a SFRA or any appropriate additional testing is necessary (e.g., TTR, Meggar and Doble).

- All test results and Bidder evaluations shall be submitted to MPMU for acceptance, prior to unloading the transformer at the site. The Bidder or their representative shall be responsible for supplying any calibrated test equipment, tools, ladders etc. that may be required to perform the required inspection and testing.
- Unload transformers at the site and place on provided pads, completely assemble, fill with oil, test, and verify all critical measurements at this location per section 13 (BIDDING DOCUMENTS) of this specification.

  Provide optional pricing for a potential two stage effort of unloading the transformer on to temporary pads and then to the final pad positions.

- The shipping center of gravity shall be permanently and plainly marked ("Shipping Center of Gravity") on four sides of the tank to aid riggers and railroad inspectors in handling and shall be dimensioned on the outline drawing. The completely assembled and oil filled transformer center of gravity shall be permanently and plainly marked ("Assembled Center of Gravity") on four sides of the tank and shall be dimensioned on the outline drawing.

4.2.3. FIELD

- Completely assemble the transformer, including all bushings, radiators, control cabinet, AC power cabinet and metering current transformer on the transformer foundations
- If the control cabinet and AC power cabinets are not readily accessible from ground level, Bidder shall provide for platform with steps, handrails, guardrails as required for ready and safe access. Platform materials shall be hot dipped galvanized steel with non-slip grating steps and platform surfaces, full width of the cabinet +12" and approximately 4'-0" deep. The level gauges and temperature gauges shall be readable at ground level.
- Perform field tests on the transformer and all bushings in the presence of MPMU's representative. All test equipment shall be provided by the Bidder. Site inspection and testing plan (SITP) shall be provided for MPMU approval. The field tests shall be performed as described in section 10.4 of this specification.
- Perform transformer vacuum oil processing and fill per standard practices. The Bidder shall be responsible for providing all equipment for oil processing.
- Provide the transformer oil with negative gas tendency (Before shipping the oil to site the oil for the transformer must be approved by MPMU). The Bidder shall take production sample of insulating oil and send to Doble for Transformer Oil Purchase Specification (TOPS) analysis. Submit all test results and reports to MPMU Representative for acceptance. Bidder is responsible for all costs for sampling, testing, reporting, and retesting as necessary. Oil shall be non-PCB (Polychlorinated Biphenyl).
- Lifting procedures indicating center of gravities and lifting points, etc. are required for the transformer for partial or final assembly.
- The center lines of tank shall be permanently marked near the base on all four sides of the tank and shown on the outline drawing.
- Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing, and maintaining equipment and schedules. Two days of on-site training should be included in the bid.

4.3. TERMINAL POINTS

- The physical terminal points of the Manufacturer's equipment scope of supply are as follows:

  HV and LV bushings to existing bus conductors
  Neutral grounding bushings connected to ground bus.
  Four (4) NEMA Four-Hole Grounding Pads on the transformer tank
  Control and monitor (alarm) wiring terminal blocks
  CT wiring terminal blocks
  Auxiliary wiring terminal blocks

4.4. QUALITY ASSURANCE

- The manufacturer shall, upon request, provide MPMU with all the design data.
  MPMU may have a consulting engineer to review the design data provided by the manufacturer.

- Manufacturer shall make a design engineer available for questions on design.
  MPMU may ask the manufacturer to have the design engineer(s) available to discuss the design with MPMU and/or approved representatives.
  These meetings may be held via phone or in-person.

- Under no circumstances shall the manufacturer have any authority to change the design agreed upon without consulting with MPMU's Project Engineer.

4.5. SHIPPING, STORAGE, HANDLING

- The Bidder shall provide transportation means, route to site, off load and installation handling specifications to MPMU for review.
- The autotransformer shall be shipped F.O.B. to the substation autotransformer pad, in Mount Pleasant, Iowa. The manufacturer shall assume responsibility for safe arrival and handle all claims if damaged in shipment.
- The autotransformer shall be shipped from the manufacturer's facility filled with dry air having a -50ºF dew point or better.

A record of the exact dew point shall be included in the instruction book shipped with the unit.

All valves, shipping covers, etc. shall be sealed and effectively crated to prevent tampering or removal while in transit.

A valve/gauge arrangement to put in the one (1) inch filling valve located on the side of the tank shall be provided for allowing gas pressure measurement and dew point reading without the release of the gas.

- Core ground lead and connector shall be in place for shipment to allow an insulation resistance test (Megger) of the unit core ground, without opening the tank, to be performed at arrival at site. A rigid housing shall be installed to protect the core ground lead and connector during shipping.
- All conduits and auxiliary equipment mounting positions shall be sealed and/or covered to prevent water damage during shipment and storage.
- **The manufacturer shall attach two (2), two-way (vertical and horizontal), GPS enabled impact recorders to the autotransformer.**

  The requirement of two recorders is for redundancy in case one fails during transit.

  Upon arrival and before unloading the autotransformer, the impact recorder records will be inspected by MPMU and the manufacturer's representative.

  If, in the opinion of MPMU and/or the manufacturer's representative, the impact recorder records indicate rough handling during shipment, the manufacturer will be notified immediately.

  The records will be retained by MPMU for study.

  The manufacturer shall provide the necessary information for returning the impact recorders.

- All equipment furnished hereunder which requires packaging shall be clearly labeled with the MPMU purchase order number, substation name, item number (corresponding to the suppliers Bill of Materials) and a description of the contents enclosed.

  Any package, which contains more than one (1) item, shall have a separate packing list attached for the specific contents of that package.

  All equipment and packages shipped separate from the autotransformer shall be shipped either on pallets or bundled in an acceptable manner for off-loading.

  The method of packing shall be such as to adequately protect the contents from any damage that might reasonably be encountered in transportation and handling.

  Packing crates shall be such that long outdoor storage will not result in deterioration of crates or damage to contents.

  Any equipment, which requires protection from the weather, shall use packing material such that it will provide weatherproof protection for a period of one (1) year in outdoor storage areas.

  Any packages, which require indoor storage, shall be clearly marked.

  Prior to shipment, the Project Engineer shall receive a complete packing list of all items to be shipped in order to check for complete shipment upon arrival.

- All spare parts shall be **packaged separately** and clearly marked "**SPARE PARTS"**.
- The Bidder shall provide cost per week for storage at their facility.

5. CIVIL REQUIREMENTS

5.1. ICE LOAD

- Ice-sensitive structures shall be designed for atmospheric ice loads in accordance with the Ice provisions of Chapter 10 of ASCE/SEI 7-16.
- Ice load thickness shall be based on the geographical location and local governing building code requirements; however, ground snow load shall not be less than as shown in Table 2 for each site location based on the ASCE 7 Hazard Tool.

Ice thickness with concurrent 3-second gust speed per ASCE 7 Hazard Tool

ICE LOAD				
MPMU Site Name	**Location**	**Ice Thickness (in)**	**Wind Speed (mph)**	**Snow Load (lb/ft²)**
Skunk River Substation	40°59'03.5"N 91°37'45.0"W	**1.5**	**50**	**20**

Table 2: Ice Load

5.2. WIND LOAD

- Wind load design shall be in accordance with the wind provisions of and ASCE/SEI 7-16 and shall be at minimum as defined in the design requirement, whichever is more stringent.
- The following are minimum wind load design performance requirements:

Wind Importance Factor: Iw = 1.15
Exposure Category: C

- Basic Wind Speed: Minimum wind speed values for MPMU sites as per ASCE 7 as shown in Table 3.
- The supporting structures of electrical equipment shall be considered as “other structures” and wind load shall be calculated in accordance with chapter 29 of ASCE/SEI 7-16.
- Should local code or amendments to the MPMU provide more stringent analysis, design or detailing criteria than ASCE/SEI 7-16, the local codes or amendments shall govern.

Minimum Wind Speed as per ASCE 7 Hazard Tool (Risk Category IV)

WIND LOAD		
MPMU Site Location	**Location**	**Wind Speed (mph)**
Skunk River Substation	40°59'03.5"N 91°37'45.0"W	**120**

Table 3: Wind Load

5.3. SEISMIC LOAD

- All new construction and existing structures shall, at a minimum, be analyzed, designed, and detailed in accordance with the seismic provisions of ASCE/SEI 7-16 and shall be at minimum as defined in the design requirement, whichever is more stringent.
- The following are minimum seismic design performance requirements:

Seismic Importance Factor: IE = 1.5
Site Class: As determine per site specific geotechnical report.
Where the soil properties are not known in sufficient detail to determine the site class, use site class D.
Earthquake Ground Motion: Minimum earthquake ground motion for MPMU sites as per ASCE 7 (See Table below)

Minimum earthquake ground motion per ASCE 7 Hazard Tool (Risk Category IV)

SIESMIC LOAD			
MPMU Site Location	**Location**	**S_S ***	**S_1 ****
Skunk River Substation	40°59'03.5"N 91°37'45.0"W	0.89	0.067

Table 4: Seismic Load

*Note: * Maximum Considered Earthquake (MCE) of 0.2 second spectral response acceleration and 5 percent damping, site class B.*

*** Same as above except 1.0 second Spectral Response*

6. SHORT CIRCUIT LOAD

- The autotransformer shall be designed and manufactured to withstand the mechanical and thermal stresses caused by external short circuits, as defined by the latest revision of IEEE C57.12.00-2021, Section 7, when connected to an infinite bus on either the high or the low side, and thereby be completely self-protecting for all external faults.
- Evidence of design capability to meet these requirements shall be provided at time of bid evaluation.

7. OPERATIONAL LOADS

- Operational/Mechanical static and dynamic forces shall be obtained from equipment manufacturer. The manufacturer shall provide loading based on the actual testing of the equipment.
- The Operational/Mechanical/Other loads shall be applied and combined with all design load combinations.

8. SEQUENCING AND SCHEDULING

- Manufacturer shall sequence transformer design, procurement, fabrication, inspection, testing, preparation, shipment, site assembly, commissioning and ready for service to meet the schedule requirements of the Purchase Order.
- Bidder shall coordinate with MPMU and Authorized Representatives for all sequencing and scheduling.

9. TECHNICAL REQUIREMENTS

9.1. GENERAL

The phase used for these transformer' designation shall be "H1, H2, H3, X1, X2, X3 and H0X0" unless otherwise noted in this specification. All current carrying parts of this transformer shall be made of copper. All steel-based components provided with this transformer shall meet or exceed all ASTM. If the steel is procured outside of the USA (United States of America), the Bidder is responsible for furnishing and transporting samples of the proposed steel to a MPMU approved third party for testing (chemical composition and mechanical properties).

The transformer shall be designed in accordance with this specification to meet the dimensional limitations. The transformer shall meet the requirements and ratings indicated in the specification. The Bidder shall field verify all dimensions for the steel structure surrounding the existing transformer, LV and HV overhead bus conductors, controls connections, etc. The Bidder shall consider the dimensions of the existing foundation design.

The design shall conform to the Applicable Codes and Standards specified in Section 3.3.

All gaskets shall be non-asbestos; leak free, at Bidder's cost.

9.2. EQUIPMENT

9.2.1. BUSHINGS AND TERMINAL CONNECTIONS

- The bushings shall be paper-oil-capacitor type and conform to the latest revision of IEEE C57.19.01-2000 and to NEMA standard arrangement, spacing and nomenclature. In addition, they shall be "Sky Gray" in color (ANSI-70). The necessary bushings shall meet the following minimum requirements:

BASIC INSULATION LEVEL	
Rated Voltage	**Basic Impulse Level (BIL)**
HV – 345 KV	1300 kV
LV - 69 KV	350 KV
Neutral	350 kV

Table 5: Bushing Insulation Level

- The current rating of all bushings shall be at least 10% higher than the current at the maximum MVA rating.

The color of the bushing shall be ANSI 70, grey.

Bushings for the windings shall be suitable for connection to the overhead aluminum conductor or copper. The Neutral bushings shall be suitable for connection to the conductor or bus. Necessary terminal connectors shall be provided.

Bushings shall be tested for power factor at factory and test values shall be included in test reports. Space on the bushing nameplates shall be provided for stamping values of the initial field power factor tests.

Bushings shall be per ANSI standard.

All current carrying parts of transformer bushings shall be of copper or copper alloy material and contact surfaces shall be plated to inhibit deterioration.

A suitably sized copper bar shall be installed between the neutral bushing on the top of the tank and a ground pad at the base of the tank.

Internal lead to bushing connections shall be made utilizing stainless steel Belleville washers. Split lock washers for making internal lead-to-bushing connections are not acceptable.

9.2.2. WINDINGS

- The windings shall have insulation of high dielectric and mechanical strength and shall be arranged to permit free circulation of oil. Proper internal barriers shall be provided, and additional insulation shall be provided on end coils to protect against line disturbances. The coils shall be made up, shaped, and braced to provide for expansion and contraction due to temperature changes and to avoid abrasion of insulation. The coils shall be adequately braced to prevent distortion due to any abnormal operating conditions. Aluminum conductor material shall not be used for windings or leads. Transformer winding conductors shall be made of copper to minimize losses. Transformer winding leads shall be connected to bushings using flexible connections. The flexible connections shall be sufficiently insulated to prevent premature failure of the bushings, especially for draw lead type bushing connections.
- Transformer windings shall be suitably clamped by mechanical means at the top and bottom to prevent shifting under short circuit conditions. All windings shall be constructed and supported firmly to sustain external and internal mechanical stresses during operation and during internal and external short circuits. The coil clamps and inside of the tank shall be painted WHITE. All windings subjected to inward radial buckling shall be designed to withstand free or unsupported buckling in addition to “forced” or supported buckling. **At the design review, the calculated free buckling and the withstand values shall be presented**. The control of inward radial forces shall not depend on bracing to the core. Epoxy bonded conductors for both the inner and outer windings are encouraged and will be a design review item. Zero sequence Impedance shall be used for calculations. The windings shall be made of rectangular or round section covered with thermally upgraded insulation paper of adequate dielectric strength. It will be the manufacturer’s responsibility to design and include the winding type as prudent and appropriate for the specific winding.
- The lead support structure for the 345kV Windings shall be high density pressboard. Tying leads to the structure shall not be allowed. High density pressboard-type lead clamping shall be used to secure leads to the lead support structure.
- Fiberglass studs and nuts are preferred for connecting components of a pressboard support structure. If nylon hardware is used, it shall be at least 16mm nominal diameter.
- Cooling channels between the windings shall be included as required.
- The type of winding shall be consistent with rating and overall design. Disk, helix, interleaved, and similar winding types are generally acceptable. It shall be the Bidder’s responsibility to design and to include the winding type as prudent and appropriate for the specific winding.

- Transformers that meet the temperature and loading conditions of IEEE C57.12.00 shall be manufactured using thermally upgraded paper of adequate dielectric strength or an alternative insulation system that has been proven to possess minimum aging characteristics that either match or exceed those of thermally upgraded paper. This requirement applies to the insulation components that determine the minimum life expectancy, such as: winding insulation, layer to layer insulation, lead insulation, and other components.

9.2.3. SURGE ARRESTERS

- Six (6) polymer station class surge arresters, three (3) for the protection of the primary windings and three (3) for protection of the secondary windings, shall be provided mounted on the autotransformer tank or on suitable mounting brackets attached thereto. The primary winding surge arresters shall be mounted such that their line terminals are at the same height as the primary winding bushing line terminals. The secondary winding surge arresters shall be mounted such that their line terminals are at the same height as the secondary winding bushing line terminals.

- Insulated 500 MCM copper cable and all necessary connectors shall be provided to ground the surge arresters to the ground pads at the base of the tank. Three-way or “T” connections must be crimped or cad-welded. Means shall be provided along the tank wall to attach the cables to the tank in a removable fashion. Only one cable shall run down the tank for each set of arresters for grounding.

- The following are the surge arresters voltage characteristics:

SURGE ARRESTER RATINGS		
KV Class	**MCOV - KV**	**Duty Cycle - KV**
345	220	276
69	57	72

Table 6: Surge Arrester Ratings

- The manufacturer shall advise MPMU’s Project Engineer if suitable insulation coordination and protection cannot be achieved with the arresters given in the table above. In addition, the manufacturer shall supply graphical data, which shows the autotransformer’s design BIL ratings for each winding the arresters are protecting along with the arrester’s protection margin characteristics under lightning surge and switching surge conditions.

9.2.4. CTs

- The current transformer shall be designed, manufactured, and tested in accordance with the most recent revision of IEEE C57.13, "Instrument Transformer." The application data required from the manufacturer appears in Section 4. The number and location of current transformer required appears in this section.
- All current transformers shall be given ratio and excitation tests for each secondary ratio. All calculations and test curves for the current transformer shall be submitted to the MPMU for review. DC resistance readings shall be taken as well. Final copies of certified performance curves showing the results of each test shall be furnished.
- The secondary winding of the multi-ratio current transformer shall be evenly distributed around the entire core between each pair of adjacent taps. The secondary resistance of each relaying current transformer shall not exceed 0.0025 ohms per turn.
- The current transformer shall be installed for all high voltage tests and during all di-electric tests.
- All multi-ratio current transformer shall have standard ratios in accordance with ANSI/IEEE C57.13 and shall be capable of carrying at least two times the tap rating continuously (**RF = 2.0**). The rated secondary current shall be 5 amperes rms.
- The short-time mechanical current rating and short-time thermal current rating shall be sufficient to withstand the short circuit stresses within the transformer and the ANSI through fault criteria for which the power transformer is rated.
- The leads of all current transformer shall be run to the main terminal box in hot- dipped galvanized rigid steel conduit, and shall be terminated on approved screw type short-circuiting terminal blocks, see section 9.2.10 (CONTROL CABINET AND AC POWER CABINET). Current transformer secondary wiring shall be #10 AWG, tinned, stranded copper, 600 volts (2,500 volt withstand capability) crosslink polyethylene (XLPE) insulation, and terminated with crimped type, short shank, ring tongue, non-insulated connectors; American Pancor, Incorporated, Type Solistrand or

MPMU approved equal. The crimping tool shall be designed to prevent opening of the handles until full pressure has been applied and staking action is completed, equal to Thomas & Betts "Shure Stake" installing tool. All leads to be continuous. No splices permitted. Current Transformer ground wiring shall be #10 AWG, tinned, stranded copper, 600volts, with a GREEN color.

- The secondary leads of all current transformer shall be terminated on short- circuiting terminal blocks.
- Bushings with two (2) or more current transformer shall have each a set of secondary leads terminated on separate terminal blocks physically separated from each other within the main terminal box. The method and location for the physical separation is subject to approval of the MPMU.
- Lead wires from all current transformer taps to any intermediate terminal block shall not be smaller in size than the wire used for the current transformer winding itself.
- Each lead wire shall be uniquely identified at all terminations, including any and all intermediate terminations using a method of marking approved by MPMU.
- All of the leads of any particular current transformer shall be run in the same cable and/or conduit. Leads for primary current transformer circuits and secondary current transformer circuits shall not be run in the same cable and/or conduit (i.e., the H side and X side have 3 bushings per phase, 1 conduit per bushing set for a total of 6 conduits, 3 H side and 3 X side).
- CT Data Chart - CTs shall match the below CT quantities, locations, max ratios and class:

CURRENT TRANSFORMERS				
Location	**CT's**	**Max Ratio**	**Class**	**RF**
H1, H2, H3	1, 2, 3	2000:5 MR	C 800	2.0
H1, H2, H3	4, 5, 6	2000:5 MR	C 800	2.0
H1, H2, H3	7, 8, 9	2000:5 MR	0.3*	4.0
X1, X2, X3	10, 11, 12	1200:5 MR	C 800	2.0
X1, X2, X3	13, 14, 15	1200:5 MR	C 800	2.0
X1, X2, X3	16, 17, 18	1200:5 MR	0.3*	4.0
H0 X0	19	1200:5 MR	C 50	2.0

Table 7: CT Specifications

* - Indicates CT intended to be used for metering purposes and shall be of metering accuracy.

9.2.5. RELAYING AND MONITORING

H and X Terminals and Windings

- The current transformer relaying accuracy class shall be designated C800 on the maximum/higher tap, unless specified otherwise elsewhere in this specification (see Table 7). The maximum secondary terminal voltage shall be rated for 800 volts rms. The secondary windings of the multi-ratio current transformer shall be evenly distributed around the entire core between each pair of adjacent taps.
- The current transformer shall be designated for 5 amperes RMS secondary winding.
- See Appendix A for details.

9.2.6. INSTRUMENTATION

- All instruments, gauges, and indicators shall be marked in foot/pound/second (FPS) units unless noted in this specification. Temperature indicators shall be marked in degree Celsius (ºC). They shall be located so that they can be read without visual aids by a person standing on the ground.
- All gauges, meters, relays, recorders, thermal breakers, or other instruments sensitive to vibration and mounted on the transformer shall be either “shock proof mounted” to protect them from damage or wear which may be caused by normal transformer vibration, or they shall be sufficiently constructed to be functionally unaffected by the transformer shock and vibration.
- Service life of accessories shall be comparable with the transformer life.

- Contacts for AC control operation shall be rated 120 volts, 10 Amps continuous AC and suitable for operation in the range of 100V to 140V. Contacts for DC operation shall be rated 125 volts DC, 10 Amps operation and suitable for operation in the range of 105V - 140V DC.
- Pressure Relief Device: The transformer tank(s) shall be provided with one or more pressure relief devices determined by the Bidder (Qualitrol XPRD is the preferred or MPMU approved equal only) of adequate size to protect the tank against primary explosion. The relief devices shall be designed to minimize the discharge of oil and the entrance of air and water into the tank after it opens, and shall be of the mechanical, self-resetting type with both visual and electrical alarms. It shall be equipped with alarm contacts (Form C) suitable for operation on an ungrounded 125 volts DC system. Leads shall be run to main terminal box in hot-dipped galvanized rigid steel conduit and be appropriately terminated per NEC requirement. The pressure relief device shall have a metal discharge pipe and be piped to within 18" of the ground as practical. PVC discharge pipe is unacceptable.
- Liquid Level Gauge: The transformer shall be provided with a Qualitrol 032/042/045 (See Appendix B) or MPMU approved equal magnetic-type oil level indicating gauge equipped with Hi/Lo level alarm contacts (Form C) suitable for annunciation on an ungrounded 125 volts DC system. The gauge markings shall show the oil level at 25ºC as well as the minimum and maximum levels.
- Liquid Temperature Indicator: The transformer shall be provided with two (2) Weschler Instruments – Transformer Advantage, CT/LTC Advantage or MPMU approved equal. Each unit shall monitor Main Tank Top Oil Temperature, Ambient Temperature and Three Transformer Winding Temperatures/Currents and shall control multi-stage cooling equipment. The units shall be capable of tracking the insulation aging for each winding (loss of life).

  Each monitor shall be installed in a NEMA 3R Metal Enclosure with viewing glass window, suitable for mounting on the transformer or in a control cabinet. Operating temperature: -40 to 70 degrees C

  Each unit shall provide eight (form C) relays, (2) for controlling the multi-stage cooling equipment, (1) for alarm, (1) for trip, (1) for sensor failure and (3) spare. The contacts used for operating the cooling equipment shall be tested by the transformer manufacturer and operating temperatures furnished at which the cooling equipment is energized/de-energized. The cooling equipment relays shall have a sequencing function to equalize run time between cooling stages and a timer which can exercise fans at programmable intervals.
- Winding Temperature Indicator (Relays) for both HV and LV windings: Each transformer shall be provided with a winding temperature indication, with flexible stainless steel covering on capillary, winding temperature indicators associated with windings, suitably installed on the tank exterior. The indicator scale shall have a range of zero (0) degrees Celsius to plus (+) 180 degrees Celsius. The required temperature detectors shall be furnished and installed. Secondary leads from the internal switches shall be extended in hot-dipped galvanized rigid steel conduit to the main terminal cabinet and suitably terminated. These devices shall be factory calibrated to indicate the hottest spot copper temperature in degrees Celsius up to at least 180ºC. Correct calibration shall be demonstrated during the factory temperature test of the transformer. The contacts used for operating the cooling equipment shall be tested and operating temperatures furnished at which the cooling equipment is energized and de-energized. Each device shall be furnished with four (4) contacts or switches; two (2) for controlling the cooling equipment, one (1) for alarm and one (1) for trip. All contacts shall be suitable for operation on an ungrounded 125 volts DC system.
- Winding Temperature Current Transformer: The transformer shall be provided with two (2) current transformers (one in the high voltage winding and one in the low voltage winding) to operate simulated winding hotspot temperature devices. The secondary leads from each current transformer shall be connected to the heater and sealed drywell assemblies mounted in the tank wall. Calibration resistors and housing shall be easily accessible for recalibration tests. Instructions shall be provided which clearly outline the test method, and supply design information regarding the determination of the winding hotspots. Provisions shall be included for short-circuiting the current transformer and applying a test current to the heater and calibrating resistor while the transformer is energized.
- Rapid Pressure Rise Relay, Gas Detector Relay and Buchholz Oil Flow Relay: The transformer shall be provided with a rapid pressure rise relay (Qualitrol 930 RPRR {NERC-PRC-005-6 compliant} with Seal-in Relay or MPMU approved equal) and one (1) gas accumulator (Qualitrol or MPMU approved equal), and oil flow gas detector relay (Buchholz). Each shall operate for annunciation and alarm on occurrence of a fault in the transformer that will provide an abnormal rise of pressure. All gas pipe connected to gas detector relay shall have proper slope, so all gas will be accumulated in the gas detector relay. They shall not operate on pressure common to normal transformer operation or mechanical shock. They shall not operate on disturbances, such as short circuits, inrush currents and impulse voltages, unless the transformer is damaged internally. The sudden pressure relays shall work in conjunction with the seal-in relay, which when energized through the pressure relay, will seal itself in. In order to reset, a switch or pushbutton shall be provided and located near the relay. (The relay and switch or pushbutton shall be located in the main terminal cabinet). The Qualitrol Rapid Pressure Rise Relay (Qualitrol 930) shall be factory tested per the manufacturer's recommendations and delivered with one (1) field test kit (Qualitrol KIT 930). (See Appendix C)

- Nameplate / Device Identification: The transformer shall be provided with a stainless steel nameplate conforming to the requirements of IEEE C57.12.00. It shall have as a minimum the following: sound level in decibels, volume of insulating oil in gallons, positive sequence impedance, and rating of windings with MVA and kV ratings for ONAN/ONAF1/ONAF2 cooling stages. The OLTC shall be provided with a separate nameplate conforming to the requirements of IEEE C57.131.

  All major equipment, devices, panels, and cubicles shall be provided with nameplates. Self-adhesive nameplates shall not be used. All nameplates shall be secured with screws or rivets.
- Resistance Temperature Detectors: Each winding of the transformer shall be monitored with a standard platinum 100 ohm at 25ºC, three wire, resistance-type winding temperature detectors, for use with remote recorders to be furnished by others. Wiring shall be completed from these detectors to main terminal cabinet in rigid conduit and be suitably terminated. The RTDs shall be located to indicate the expected hottest location in the windings. The actual location shall be subject to the review of the Bidder engineer and/or the MPMU during the design of the transformer.
- Alarm and Trip Contacts: All Alarm and Trip contacts shall be wired to the terminal blocks located in the control cabinet. At a minimum, the following:

  Low oil level (conservator tank)
  Low Alarm and Low-Low oil level Critical Alarm (Main Tank)
  Buchholz
  Oil temperature Alarms
  Winding temperature Alarms
  Sudden pressure rise relay

9.2.7. LOAD TAP CHANGING (LTC) EQUIPMENT

- The preferred LTC is a Reinhausen RMV II.
- The load tap changer shall vary the low voltage terminal voltage with a constant voltage on the high voltage terminal.
- If the tap changing system requires a series or a booster winding, the design shall be of a power class, round core/coil design and construction, and all windings shall be copper and shall be circular.
- The load tap changer contacts shall be located in an oil-filled compartment separated from the main tank. The load tap changing compartment shall be designed with a continuous lip across the bottom front, at the opening, to prevent residual oil from spilling out upon opening of the compartment door. The compartment door shall provide easy access to the equipment for maintenance and inspection.
- A 3/8" sampling valve shall be provided on the LTC enclosure with pipe cap on the open end.
- The barrier separating the load tap changer from the autotransformer main tank shall be able to withstand full vacuum from either direction. If full vacuum withstand is not possible, piping and a valve to allow for equalization between the load tap changer and main tank shall be installed. A metal sign with white background and large red letters shall be installed on the side of the main tank near the valve stating that the valve shall be open prior to vacuum and closed for normal operation.
- The cover on the oil-filled compartment shall be hinged to support itself when open, regardless of the weight of the cover.
- The load tap changing equipment housing shall be provided with a Messko GmbH type DB100RM maintenance free dehydrating breather, or approved equal, to prevent the buildup of pressure and condensation within the housing, as appropriate for the particular tap changer being used.
- A mechanical position indicator visible from outside the equipment shall be provided.
  The position indicator shall be calibrated L - N - R – i.e., Lower – Neutral – Raise - from the left end to the right end of the scale.
  The position indicator shall be located so that it will be visible to an operator at the control switch for the drive motor and located at eye-level.
  The position indicator shall be mechanically driven directly from the drive mechanism without auxiliary devices.
- A hand crank for manual operation of the drive mechanism shall be provided.
  The hand crank shall be removable and stored in the cabinet housing of the mechanism.
  An electrical interlock switch shall be provided to prevent electrical operation of the LTC mechanism while the hand crank is operated.

- A dead-front operating panel shall be provided whereby the gears and mechanism are covered to provide safety for the operator.
- A stainless steel nameplate shall be permanently mounted on the outside of the control cabinet housing the manual raise and lower controls, which shall reads "**LOAD TAP CHANGER**". An additional nameplate shall be mounted inside the cabinet, next to the raise and lower controls which shall reads "**LOAD TAP CHANGER - FOR OPERATION WITH AUTOTRANSFORMER ENERGIZED AND CARRYING LOAD**". These nameplates are to be shown on the outline drawing. These nameplates shall also indicate the vacuum capability of the barrier and the manufacturer's model number of the LTC.
- The low voltage winding shall be provided with tap changing under load equipment, which shall connect to and regulate the low voltage winding.

  The tap changer shall have full rated MVA on taps above neutral and a current rating corresponding to the full load current of rated voltage on taps below neutral voltage.

  This equipment shall be capable of ± 10% voltage regulation in 33 - 5/8% (0.625%) steps at full capacity above neutral and reduced capacity below neutral voltage.

  The nomenclature for the various positions shall be 1 through 16 above, neutral and 1 through 16 below neutral voltage. Use of 1 through 33 with 17 as the neutral position is not acceptable.

  The current rating of the tap-changing equipment shall be based on the maximum force-cooled rating of the autotransformer.
- Completely automatic, self-contained control equipment shall be mounted in the control cabinet at an accessible height for a person standing on the autotransformer foundation. The control equipment shall include the following items:

  The bidder will install one (1) tap changer control relay, Beckwith Electric Co. M-2001C, to initiate operation of the tap changer in the raise or lower direction as required. The tap changer control relay will be installed in the LTC control cabinet. The control cabinet shall be designed to accommodate connection to this tap changer.

  Adjustable delay equipment for imposing a time delay between the closing of the voltage regulating relay contacts and the response of the tap changing mechanism. The time delay and adjustment shall have a minimum range of five seconds. The equipment shall be so connected that in the event that more than one tap change is required to restore the voltage to the required level, the time delay may be imposed on the first tap change only (Sequential operation).

  One control switch for selecting either automatic or manual operation, with the control so interlocked that manual and automatic control cannot be provided simultaneously, three position, "AUTOMATIC", "OFF", "MANUAL", General Electric Co. type SB-1 or equal.

  One control switch to manually operate the tap changer in either the raise or lower direction, General Electric Co. type SB-1 or equal.

  One control switch for selecting either local or remote control of the load tap changer, General Electric Co. type SB-1 or equal.

  A motor control relay with the two sides mechanically interlocked to prevent any possibility of energizing both windings of the motor simultaneously.

  An operation counter to record the number of tap changing operation.

  High and low limit contacts for remote alarm (dry "a" contacts).

  Off - position contacts for remote alarm.

  One LTC control back-up relay to prevent a failure of the voltage control from running the voltage to a high or low limit, complete with time delay, and alarm contacts. Beckwith Electric Company, Inc. Model # M-0329. The back-up relay shall be set for a 120 Vrms band center and 1 Vrms fixed dead band. (Note: The input potential to this relay will be provided independent of the regulating input potential to the Series 2000 regulating relay).
- The autotransformer shall have provisions for remote operation and indication of the load tap changer equipment. The following equipment or provisions shall be provided for remote operation and indication of the load tap changing equipment:

  The power transformer control cabinet shall be designed in order to accommodate a connection to MPMU installed synchro transmitter (Incon model #1292) and a programmable position monitor (Incon model #1250B). These devices will be provided/installed by MPMU in the relay control panel located in the control house.

  Wiring provisions shall be provided in the control cabinet for remote connections to a control switch, or switches, for selecting automatic or manual control of the tap changing mechanism and for manual operation of the tap changing mechanism.

  Wiring provisions shall be provided in the control cabinet for remote connections to indicating

lamps; red to indicate tap-changing mechanism in the “OFF” position and white to indicate a loss of control voltage.

9.2.8. DE-ENERGIZED TAP CHANGER

- An externally operated De-Energized Tap Changer (DETC) or No-Load Tap Changer (NLTC) shall be provided for the high voltage winding taps.
  - ± 5% Regulation.
  - 5 Steps
  - 2-1/2% Voltage Steps
  - Full capacity taps
- De-energized tap gauge indication shall read 1-5.

DETC Tap Position	Voltage (kV)
1	362.25
2	353.625
3	345
4	336.375
5	327.75

Table 8: DETC Positions

  - Tap 1 to indicate “HIGH” position.
  - Tap 3 to indicate “NEUTRAL” position.
  - Tap 5 to indicate "LOW” position.
- A positive type position indicator shall be furnished, complete with provisions for padlocking the DETC in any on-tap position.
  - Padlock having 3/8” shanks and 2”x2”x7/8” bodies.
  - Suitable weather shield shall be provided over the padlock and positioning pin and shall not require special tools for access.
  - Any exposed portion of the mechanism, such as a position indicator or Geneva gear, shall also be furnished with a weather shield.
- The DETC operating handle is to be readily accessible for operation without interference from adjacent parts.
- All DETCs on a transformer shall be operated by a suitable single external manual handle device, conveniently and safely operable from the ground.
  - Handle no more than 3-5 feet above the tank base.
  - Multiple DETC operating handles are **not** acceptable.
- Any shaft penetration designs directly through the tank wall at a location below the top of the core/coil assembly shall have double sealing on the rotating shaft and on the mounting flange.
- Under no conditions shall a sprocket and chain drive arrangement be acceptable for connecting the DETC assemblies on each phase to the common operating shaft.
- DETCs shall be prevented from being left between taps and shall be prevented from moving off tap due to vibrations or bumping.
- All tapered pins used in DETC assemblies shall be fully driven into the holes, slightly below the surface of the entrance side of the holes, and the entrance side of the holes deformed.
- The transformer’s actual impedances for each DETC tap shall not differ from the quoted impedances by more than IEEE tolerances.
- Shall be a Reinhausen DEETAP DU or MPMU approved equivalent.
- DETC’s shall comply with the requirements of Category 2 DETCs.
  - As specified in IEEE C57.131-2012
- Standard Requirements:
  - Each DETC containing insulation that depends on oil impregnation of any material shall be subjected, as a routine test, to a partial discharge test with voltage levels, time durations and PD limits as prescribed in C57.131

9.2.9. OIL VALVES

- All oil valves shall be especially designed for use with insulating oil. All valve materials shall be suitable for the fluid medium and shall be capable of handling the maximum design pressure and temperature of the oil system.

- The material, design, and manufacturing of valves, fittings, and seals shall be of the best quality to perfectly suit the purpose and shall not suffer from deterioration due to environmental impacts.
- All valves used in the oil system shall have a positive means of indication of open or closed position, visible from the ground.
- All valves 2 inches and smaller shall be lockable 1/4 turn ball valves.
- All open valve ends shall have plugs or caps installed.
- All valves shall be identified with brass tags attached with crimped stainless steel cable or welded in place. Identification shall be stamped into tag with lettering no smaller than 0.125 inches in height. Tags shall match valve schedule on Bidder's drawings.
- The transformer shall be provided with suitable valves for the following:

  Complete draining of the tank.
  Sampling the oil in the extreme bottom of the tank.
  Lower filter press connection (2 inch minimum) and complete drain on bottom of tank.
  Upper filter press (Vacuum Pump) connection (3 inches) at top of tank.
  Isolating each oil connection to and from each radiator/heat exchanger.
  Draining oil from each radiator/heat exchanger.
  Isolating the sudden pressure relay.
  Isolating, bleeding and testing fault pressure relay.
  Isolating the conservator tank.
  Isolating the gas detector relay.
  Isolating the fault gas monitor.
  Isolating the oil pumps (if applicable)

- A combination drain and lower filter valve shall be provided on the main tank in accordance with IEEE C57.12.10. This shall be a globe valve provided for drainage of the liquid to within 25 mm (1 in) of the bottom of the tank.
- The size of the drain valve shall be 2-in National Pipe Thread (NPT) and shall have tapered pipe threads (in accordance with ASME B1.20.1) with a pipe plug in the open end. The 2-in drain valve shall have a built-in 0.375 in sampling device, which shall be located in the side of the valve between the main valve seat and the pipe plug.
- The sampling device shall be supplied with a 5/16-in × 32-threads-per-in (5/16– 32 in) male thread for the user's connection and shall be equipped with a cap.
- The upper filter valve shall be provided shall be provided on the main tank in accordance with IEEE C57.12.10. The upper filter valve shall be 2-in National Pipe Thread (NPT) with tapered pipe threads (in accordance with ASME B1.20.1).
- Valve Identification and Location Nameplate. A separate nameplate showing the valve locations, titled "Valve Identification and Location", shall be furnished and mounted externally near the main transformer nameplate in a location to permit reading from the ground. The nameplate shall include a transformer outline drawing showing the location of all valves, and a chart identifying the type, size and purpose of each valve and specifying the initial position of each valve for the field oil-filling procedure and the position of each valve when the transformer is energized.

9.2.10. CONTROL CABINET AND AC POWER CABINET

- All accessories which require wiring shall be installed in "hot dipped rigid galvanized steel conduit" (**Underwriters Laboratories listed, no exceptions**), which shall be carried to a conveniently located and readily accessible terminal box (NEMA 3R) mounted on the transformer. Conduits shall be securely fastened to the transformer tank using fittings approved for the purpose. **PRIMARY AND SECONDARY CT WIRING** shall not be in same conduit. CT wiring shall not be in same conduit with control or power wiring.
- All switches, lamps, receptacles, control circuit breakers, conduit fittings, conduit bodies, elbows, couplings, outlet boxes and covers, enclosures, junction boxes, terminals, disconnects, wiring, etc. shall be Underwriters Laboratories (UL), approved. All devices or equipment provided shall be in accordance with the National Electrical Manufacturer's Association (NEMA) standards or criteria and installed in accordance with the NFPA-70 National Electric Code.
- All AC electrical accessories (heaters, outlet and lights) shall be protected by circuit breakers and wired separately such that they remain energized when all the fans are manually turned off.
- All circuit breakers and fuses shall have provisions to be lockable and conform to Lock Out, Tag Out (LOTO) standards.

- There shall be adequately marked terminal blocks indicating terminal number and each terminal identified with a unique number.
- Terminal blocks for all control wiring shall be States Company, Catalog # BM-251 or GE type EB-25 (black covers with marking strips).
- All alarm device contacts for MPMU's use shall be routed to screw type terminal blocks located in the control cabinet.
- All current transformer (CT) secondary leads shall be routed to shorting type screw terminal blocks located in the control cabinet. Shorting terminal blocks shall be States Company, Catalog # BM-251-G or GE type EB-27(black covers with marking strips).
- 240/120VAC power and 125VDC control and alarm leads shall be routed to different terminal boards. DC terminal blocks shall be marked DC (+/-). AC and DC loss of voltage relay shall be provided.
- A minimum space of 10 inches shall be allowed in the terminal box for the pulling, bending and proper grouping of all external power and control cables, and a suitable removable drilling plate shall be provided for external conduits.
- A flat bare copper ground bus bar, not less than 1-inch by ¼-inch, located at the bottom of the control cabinet and run the width of the control cabinet shall be provided with minimum of ten (10) # 10-32 tapped holes and binder head screws to be used for the connection of external control cable shields. The screws shall be evenly spaced within the cabinet. All ground connections inside the cabinet shall be made to the ground bus. A pressure type cable connector sized to accommodate a 4/0 AWG ground cable shall be furnished and attached to each end of the ground bus bar. The grounding bus bar / cable shall be supported by 5kV insulators.
- Ground wires shall be identified by means of a green conductor.
- The control cabinet and AC power cabinet shall be weatherproof (NEMA 3R), shall be integrally mounted to the transformer tank and shall contain all control circuits, auxiliary relays, terminal boards, etc. as required to provide a single interface for MPMU's field installed wiring to the transformer. If the location of the control cabinet is changed then the existing underground cables and conduits shall be re-routed.
- The door shall be hinged (door pins shall be stainless steel) front access and lockable.
- All controls and displays mounted in the terminal box shall not be higher than 6 feet above the transformer base.
- The AC power compartment shall be provided with a 120VAC, 2 gang weatherproof box, with 2 GFCI duplex receptacles, mounted externally, and equipped with metallic weatherproof in use cover, and wired into the AC power panel 120VAC convenience circuit.
- One 15A, 120V AC circuit breaker shall be provided that is wired to a terminal block in the main control cabinet that will be connected to the purchaser's oil pit sump pump.
- The control and AC power cabinets interior shall contain an adequately guarded LED light source in fixture, activated by a door switch. The light shall be mounted minimum of 12 inches from any energized device.
- The control and AC power cabinets interior shall contain two thermostatically controlled heaters of sufficient size to prevent condensation and moisture accumulation. Heater applied voltage: 120 VAC, 1-phase. The heater connection shall be made with heat-resistant insulated wires rated for a minimum of 250ºC insulation (Tefzel or MPMU approved equal). The heaters shall be protected with guards.
- All 600V power wiring shall be segregated from control wiring and low voltage devices for personal safety by means of an insulated barrier. Power wiring shall be single conductor 600V, #12 AWG minimum, copper. Multi-conductor power cable shall have copper conductors, with 90ºC heat, moisture and flame-retardant cross-linked polyethylene (XLPE) insulation and low smoke zero halogen thermosetting jacket. The XLPE insulation shall meet the physical and electrical requirements for Type 1 insulation. The power cable shall be multi-strand copper, Class D stranding, with ferrule crimps. The insulating material shall be thermally upgraded and shall be capable of continuous operation in accordance with ANSI. Any taping shall be done with thermally upgraded tape. The color shall be ANSI Grey. PVC insulation is not acceptable.
- CT circuit secondary wiring shall be #10 AWG minimum. Grounds for CT wiring shall be GREEN #10 AWG.
- Splicing of wiring is prohibited. No more than two conductors shall be connected to any one terminal point.
- All devices in the control and AC power cabinets shall be identified with the nameplates in accordance with section 12 (NAMEPLATES) of this specification.
- The interior of the cabinets shall be painted white.
- The top of the cabinets shall be sloped with a minimum of a six (6) inches overhanging above the doors. The slope shall be away from the front of the cabinet.

- Short lengths of “Sealtite” (flexible metal conduit with an outer PVC jacket) UL listed, flexible connection systems are acceptable, but lengths shall not exceed 36 inches at any one location. All Sealtite shall include a separate ground wire and both ends shall bond this ground wire to the metal conduit or enclosure. This will ensure a continuous ground through the Sealtite. All associated fitting shall also be insulated Sealtite fittings.
- All electrical control circuits shall consist of not less than # 12 AWG, multi-strand copper with ferrule crimps, and 90ºC conductor temperature, with 600 volt crosslink polyethylene insulation.
- All wiring internal to panels shall be capable of passing the vertical flame test requirements of IEEE 383.
- All terminations shall be made with crimped type ring tongue connectors with non- insulated short shanks. Connectors shall be Thomas& Betts Sta-Kon or MPMU approved equal. The crimping tools shall be designed to prevent opening of the handles until full pressure has been applied and staking action is completed, equal to Thomas & Betts "Shure Stake" installing tool.
- Power circuit wiring shall not be run through control conduits or to control terminal blocks. Separate power terminal blocks and conduits shall be provided for power circuits. The paralleling of several equivalent smaller wires in place of a single wire is not acceptable. Wiring for primary and secondary current transformer circuits shall be segregated from each other and from power circuits.
- All transformers shall be furnished and mounted with a terminal block for terminating load and line three (3) - phase, three (3) - wire, 60 hertz service and one (1) phase as needed.
- All internal wiring shall be connected to terminal blocks in a manner to allow the MPMU's external cables, including all conductors, to be terminated on consecutive points of the blocks. Terminal points shall be provided for the MPMU's use in the amount of 20% for power wiring termination. At least 20% terminations for control wiring shall be provided. Control wiring terminal block type must be approved by the MPMU.
- A permanent engraved marking strip, identified in accordance with approved wiring diagrams, shall be furnished on each terminal block and each piece of equipment. Handwritten identification mark ups are not acceptable. Adhesive strips are not acceptable. All terminals and nameplates for all devices shall be identified with LAMICOID engraved nameplates having black background with white letters. Each nameplate shall be fastened by means of screws or rivets.
- All conductors shall be neatly bundled into groups with Thomas & Betts' "Ty-Wraps", or MPMU approved equal, in a manner that will permit the removal of any conductor without undue interference with adjacent conductors. No metal ties or clamps shall be used.
- Conductors shall be uniquely identified at all terminations (both ends) with heat shrinkable wire marker using indelible printing, including any and all intermediate terminations using a method of marking approved by MPMU. Adhesive wire labels are not acceptable.
- Wiring clamps and supports at hinge-transition points shall be protected to prevent chafing of insulation when the door is open and closed.
- One or more removable steel plates shall be provided in the bottom of the cabinet housing to be drilled in the field for the necessary field conduit connections, plates shall be a minimum of 16” x 36”. Actual plate sizes to be determined by MPMU at a later date. All doors and openings on each operating mechanism housing, control cabinet and AC power cabinet shall be provided with gaskets made with neoprene or other suitable material as required to render the housing waterproof when the doors or openings are closed. Access to all terminals of all devices shall be provided without requiring the removal of the control panel. Sufficient space shall be provided to properly train the MPMU’s cable to the terminal blocks.
- To enable automation to SCADA/Protection for Skunk River Substation, each new transformer control cabinet shall be equipped with a remote digital I/O processor & controller, Schweitzer Engineering Lab. Inc. Cat# SEL-2414. Use digital inputs to monitor critical alarms such as oil levels, pressures, gas accumulation, and trouble points with sensors, as well as status points tertiary switch open/closed. This I/O processor & controller shall provide a fiber-optic connect port (MM) and DNP3 Serial or IP protocol for SCADA system and shall be operational with a 125VDC supply. The door of Control Cabinet is lockable and alarmed.
- All control and power wiring shall be routed in a neat and professional manner. Conductors shall be routed in Panduit-type wire way or secured with wire ties at 2 to 3 inch intervals. Conductors shall not cross-unprotected sheet metal edges which will subject the insulation to chafing, cutting, or other abrasions. Jumpers, where required at terminal blocks, shall be as short as possible. Use of in- line splices, wire nuts, split-bolt connectors, etc. is not permitted. All wiring crossing from the Panduit- type wire way to the control cabinet door must be properly protected from damage and/or weather exposure. Unacceptable installations shall be rejected by MPMU.

9.3. INSULATION

- Transformers that meet the temperature and loading conditions of IEEE C57.12.00 shall be manufactured using thermally upgraded paper or an alternative insulation system that has been proven to possess minimum aging characteristics that either match or exceed those of thermally upgraded paper. This requirement applies to the insulation components that determine the minimum life expectancy, such as: winding insulation, layer to layer insulation, lead insulation, and other components.

9.4. INSULATING LIQUID

- The transformer shall be shipped without oil and filled with dry air for protection. Dry air bottle shall be provided with regulator. Spare dry air bottle shall also be provided. The Bidder shall ship the oil in tankers properly sealed against contamination. The oil shall be shipped at such times as the MPMU may direct, and on a schedule that shall permit a continuous filling operation for the particular phase of installation involved.
- Prior to mobilization to the installation site, the Bidder shall submit for, and obtain MPMU review and approval for, a Spill Prevention Control and Countermeasure Plan (SPCC) addressing all oil filled equipment and environmental hazards based on the work scope. The Bidder's SPCC shall include the means and methods to prevent and contain and respond to a spill or release during any aspect of the Bidders work onsite (oil storage, oil transfer, filling the unit, oil filtration, oil removal, cleaning fluids, thinners, additives, chemicals, etc.). Bidder shall provide all supplies and subcontracts necessary, as identified in the approved SPCC. MPMUs SPCC Plan for this site can be made available for reporting and emergency contacts.
- The Bidder shall make provisions for the oil tankers at the transformer while the oil is being unloaded into the transformer. Samples from each tanker shall be tested and the results analyzed before oil filling.

  The oil shall be delivered in tank trucks upon notification by MPMU's Project Engineer.
  The hose connection valve shall be sealed to ensure that all oil shipped is received at the site.
  The oil delivery trucks shall be of the common manifold type to allow oil-filling procedures without changing hose connections.

- Oil for impregnating the windings for factory testing, including any residual oil shipped with transformer, must meet new oil requirements, and the oil must be of the same refining process as oil used for final filling of the transformer. All oil shall be certified "PCB Free" and with negative gas tendency.
- Oil used for factory testing must be sent to Doble for full dielectric test including DGA, particle count, Power Factor vs. Oxidation, and Doble Comprehensive Screening expanded to meet the requirements of Table 8 below, at the cost of the Bidder. Residual oil from the transformer must be sent to Doble for full dielectric test (at the cost of the Bidder) and no oil shall be added to the transformer at delivery site until satisfactory results are obtained. In the event of contamination, Bidder shall flush main transformer and repeat testing until satisfactory results are obtained. The results of this Doble test shall be sent to MPMU for their approval before the transformer will be allowed to be shipped. (Please See Doble Transformer oil purchase specification-(TOPS) test limit)

INSULATION LIQUID		
Type of Test	**ASTM Method**	**Test Limits**
Aniline Point, ºC	D611	80 Maximum
Color ASTM	D1500	0.5 Maximum
Corrosive Sulfur	D1275B	Passes
Dielectric Breakdown, kV	D1816 (1/2mm)	20/40 Minimum
Flash Point, ºC	D92	145 Minimum
Interfacial Tension, Dynes/CM	D971 (Unfiltered)	40 Minimum
Neutralization #, MG KOH/G	D974 (Modified)	0.015 Maximum
Pour Point, ºC	D97	-40 Maximum
Power Factor at 100ºC	D924	0.3% Maximum
Power Factor at 25ºC	D924	0.05% Maximum
Specific Gravity, 60/60	D1298	0.865 - 0.910
Viscosity at 40ºC Kinematic, CS or Saybolt, SUS	D445, D2161 D88,	11 Maximum 40 Maximum
Sludge Free Life, at 8 Hour periods	Doble Procedure	68 Hour minimum (+/- 8 Hours)
PFVO Rating	Doble Procedure	As Per Limit Curve

Table 9: Insulation Liquid Test Limits

Note: Neutralization Number is measured by using 1/100 normal potassium hydroxide standard alcoholic solution.

- Conformity to these tests does not constitute unqualified approval. Such approval is based upon full conformance to all required performance characteristics as determined by the MPMU.

- MPMU has established an oil particle count limit for transformer, as listed in Table 9 below. These limits must be met in the Factory and the field (after assembly). Contaminated oil must be cleaned and/or replaced at the Bidder's cost.

OIL CONTAMNATION		
Voltage Class	**Particle Count**	**Condition Of Oil**
115kV to 345kV	0 – 1500	Normal
	1500 - 4000	Fair
	Above 4000	Contaminated
345kV to 765kV	Above 1000	Contaminated

Table 10: Oil Particle Count Limit

Sampled at ≥4 microns/mL on a 250mL sample

- New oil which is stored for use in tankers must be tested prior to start of processing. The oil processing equipment shall be flushed with oil that will fill transformer and shall also be tested at a point just before where the piping is attached to the transformer (after all oil processing equipment).

  The following criteria must be met:

  Gas-in-oil analysis must indicate little or no residual gasses.
  Physical test criteria must be as follows:

GAS IN OIL		
Test	**Standard**	**Criteria**
Water	ASTM D-1533	30 ppm maximum
Power Factor 25ºC	ASTM D-924	0.05 % maximum
Particle count		Same as new oil

Table 11: Gas in Oil Physical Test Criteria

Any deviation from the above results must be reconciled prior to start of oil fill. Values above those listed shall not be considered acceptable until after discussion with the responsible parties at the location involved, and MPMU acceptance.

9.5. OIL PRESERVATION EQUIPMENT

- The oil preservation system shall be conservator type with a sealed bladder (Atmoseal system or equivalent), as per the latest revision of **IEEE C57.12**.
- All gaskets are to be below minimum oil level.
- Bladders are to be fully pressure tested before installation in the conservator tank.
- A gate or globe valve suitable for full vacuum shall be placed at both the autotransformer tank and at the conservator tank.

  A braided stainless steel flexible connection shall be provided to eliminate potential alignment problems.

- The conservator tank shall be provided with a Messko GmbH MTraB DB200RM-T series maintenance free dehydrating breather and bleeder valve.

  The silica gel breather shall be mounted 5’ above autotransformer for easy access.
  The power supply of the breather shall be protected by a 15A circuit breaker.

- The conservator tank is to be located such that all parts on the cover of the main tank, including bushing casing, gas detector relay and mechanical pressure relief devices, can be completely filled with oil at the minimum oil level in the conservator tank.
- The conservator tank shall be capable to operate at an ambient temperature range of -10 degrees to 40 degrees Centigrade.
- The conservator tank shall be sized to permit continuous 120 degrees C top oil temperature operation without oil discharge.

9.6. TANK CONSTRUCTION, LIFTING EYES AND JACKING PADS

- The autotransformer tank shall be of steel plate construction, electrically welded and braced, oil tight and suitable for skidding into position and filling under **full vacuum** with a minimal visual detectable tank deformation.
- The conservator tank shall be provided with at least two (2) inspection openings, one in each end of the tank, to allow easy inspection and/or replacement of the air cell. Conservator tank shall be designed to withstand full vacuum.
- The steel used for the tank and conservator shall be ASTM A36, Standard for Carbon Steel, all milled in the US. Carbon steel piping shall meet ASTM A53.
- The bidder is permitted to include an alternate proposal or an equivalent or better steels not from USA steel mills for A36, AISI4150 and A53. The bidder shall provide documentation to demonstrate that the proposed steel is equivalent or better including the material specification and sample Certified Material Test Reports (CMTR). The alternate materials not from USA steel mills, for the fabrication of tank, conservator and wheels, if approved by the MPMU, shall be subject to testing for chemistry and mechanical properties for each heat lot, at a USA testing facility designated or approved by MPMU. Such testing shall be at the sole discretion of MPMU and the cost for such testing shall be borne by the successful Bidder for this transformer contract.
- The top of the transformer, including all high points (e.g., CT and bushing Pockets) shall be manufactured so that any free gas will migrate to the gas detection system (Buchholz) and shall be piped to the conservator tank (through the gas accumulator relay) in such a way to ensure that these areas fill completely with oil and no voids exist. Verify by testing following the Bucholz manufacturer test procedure.
- Suitable guides shall be provided for lowering the active part into the tank, or for guiding the tank cover, the core(s), and winding(s) as they are being raised or lowered.
- The tank shall be provided with manholes of a size to afford easy access to the lower ends of the high voltage, low voltage and neutral bushings, and the upper portion of the coils. Manholes shall be provided at the top cover to permit inspection of core and coils and other components requiring inspection or maintenance work. All manholes, hand-holes, bushing holes and other openings at the tank cover shall have flanges of minimum 10 mm elevation around the edges to prevent entry of water when the manhole cover is removed. Where access requires bodily entry including those at the top cover, manholes should be large enough to allow passage of a 450 mm diameter sphere. The design shall incorporate the requirements of confined space entry for inspection of the core, windings, and other internal components.
- The main tank shall be designed to withstand without leakage, damage or deformation, a full vacuum and a pressure of 125 percent of the maximum pressure resulting from the oil preservation system or 10 psig, whichever is greater. Tank, radiators, and conservator shall be able to withstand full vacuum without leaking, damage or (minimal) deformation. A vacuum and pressure test shall be conducted for the tank and conservator prior to any painting.
- Welding/brazing shall be performed by qualified welding/brazing operators using qualified welding/brazing procedures all in accordance with industry standard. All training, qualifications, re-qualifications, and record keeping shall be the responsibility of the Bidder and shall be submitted to MPMU for review and approval upon request.
- Transformer tank wall-to-wall and wall-to-baseplate (floor) joints shall be full penetration welds with back gouge to sound metal and with reinforced fillet. Fillet welds alone shall not be utilized for the wall-to-wall and wall-to-baseplate joints. Conservator seams shall be full penetration welds. For the tank and conservator, all welds that may be leak path for oil shall be inspected by liquid penetrant (PT) inspection. Ultrasonic (UT) inspection shall be performed on 10% of the total tank's wall-to-wall and wall-to-baseplate full penetration welds.
- Safety – Fall Arrest Provisions – Provide two (2) fall arrest system base plates with tie off anchor, Pelsue Catalog # FB-SW3 (See Appendix D) or MPMU approved equal, welded to the top of each transformer, with two (2) fall protection arrest towers Pelsue Catalog # FT-C70 or MPMU approved equal. The plates shall be uniformly spaced and shall not be less than 4 feet from the edge. All fall protection systems must meet OSHA requirements. Locations of the welded base plates shall be recommended by the Bidder and must be approved by MPMU. The plates shall be located as near as practical to the center of the transformer tank cover, with no obstruction vertically perpendicular to the base plate to a height of seven feet. A permanent ladder shall be installed on the transformer to facilitate access to the top of the unit. Fall arrest shall be installed on ladder with case per OSHA requirements.
- The top of the tank shall be finished with a non-skid material.
- Jacking, lifting, pulling and skidding provisions must be provided to allow for installers choice of installation methods when transformer is fully assembled and full of oil. ALL lifting and jacking points shall be tested with dye penetrant NDE by a Certified Testing Specialist. A certified copy of the test results shall be included in the Certified Test Report. Jacking bosses shall be a minimum of fourteen (14) inches above the transformer base.
- The transformer tank shall have provisions for attachment of slings for lifting the complete transformer when filled with oil. **The transformer lifting eyes shall have the same spacing and locations on both transformers**.

Bidder shall provide an Add-Alternate cost with Bid for providing a new lifting beam with slings as described in this paragraph. **The Bidder shall provide new lifting beam and Kevlar slings that are compatible with both transformers**. The lifting beam and slings shall become the property of MPMU and shall be provided at the same time as delivery of the transformer. The designs for the lifting beam and slings shall be performed by and signed and sealed by an IOWA PE. The lifting beam shall meet ASME BTH-1. All structural welding shall be in accordance with ANSI/AWS D14.1. The lifting beam shall comply with all OSHA regulations. A load test is required at 125% of rating. Load test shall be performed prior to painting. After load test, non-destructive test shall be performed on all structural welds using PT or MT. Bidder shall perform and MPMU shall witness load testing of the lifting beam being provided. Load beam shall be painted to match transformer painting requirements.

- Four (4) NEMA four-hole ground pads, one at each corner of the tank shall be provided for tank grounding. One grounding pad shall be dedicated for neutral grounding. Ground pads shall be furnished on the transformer in accordance with the requirement of IEEE C57.12.10. Ground pads shall be provided for the surge arresters per IEEE C57.12.10.
- A copper ground bus bar of same ampacity as the neutral bushing shall be provided between the neutral bushing and grounding pad. Locate near bottom of tank (approximately 400mm above pad level). Support ground strap with insulators with 5kV bushings.
- Pick points on the transformer shall be arranged so that they are always level when picked, without additional equipment than provided.
- The constant pressure conservator shall be of a design which precludes direct contact of oil with air and shall include the reservoir tank with air-cell and supports, oil connection to the main tank with shut-off valve, oil level gauge, Messko MTraB or Qualitrol STB000 or MPMU approved equal breather facilities, and all other equipment required for satisfactory operation. Oil level gauge shall be of suitable size so that it can be read from the ground. The liquid level gauge shall be provided with Hi/Lo level alarm contacts (Form C) suitable for operation on an ungrounded 125 volts DC system, and the leads shall be run to the main terminal box in hot-dipped galvanized rigid steel conduit and be appropriately terminated. An alarm shall be provided for the air cell to indicate failure or any abnormal condition with the air cell for each conservator.
- The conservator system shall be designed to withstand full volume and provision shall be made for filling of the main tank and conservator while under vacuum. The conservator shall be sized such that no oil shall be released until after the top oil temperature exceeds 120ºC.
- The Bidder shall design the bottom of transformer tank and skids to support the entire weight of the transformer fully dressed out with oil. The transformer tank bottom shall be designed with a safety margin of 1.2 % above the final dressed out weight of the transformer.
- Neutral grounding bus shall be supported by 5kV insulator.

9.7. COOLING SYSTEM

- The transformer shall be furnished with natural convection oil and air cooling (ONAN), and oil natural and forced fan air cooling (ONAF1/ONAF2) and conforming to the transformer rating specified herein. The cooling equipment shall be complete with all piping, valves, control equipment, etc.

- Radiators shall be designed and arranged with relation to the main transformer tank such as to be readily accessible for inspection, cleaning, and to completely drain oil into the tank when the tank is being drained. Radiator shall be hot-dipped galvanized type and each radiator shall have lifting lugs or eyes at top and bottom for ease in handling, and shall be valved, vented and arranged such that any radiator can be removed and replaced without de-energizing the transformer. All radiators shall be of the same nominal dimensions and shall be interchangeable. Approved oil-tight valves shall be furnished in all connections of radiators to the main tank and shall be a permanent part of the main tank. Radiators shall be of welded construction, shall have flanged connections, and shall have provisions for draining and venting all oil passages by means of valves with plugs. Tank and radiators shall be able to withstand full vacuum without leaking or deforming. It is the Bidder’s responsibility to assure that the radiators and all parts of the transformer are within the confines of its containment walls. Radiators shall be positioned not to obstruct access to manholes, hand holes or other inspection/maintenance locations. The design and construction of the header, fins and the assembly shall be such as to inhibit collection or retention of water or debris.

- Fan motors (high efficiency type) manufactured by Krenz or California Turbo or approved equal shall be of weatherproof construction and designed for fan duty. Each cooling fan shall be complete with all required rigid conduit, wired with quick disconnect cords and cable, automatic control equipment and thermal overload protection. Fan guards shall be heavy duty hot-dipped galvanized, OSHA compliant. Short circuit protection shall be furnished for all fan motors and may be arranged in groups, subject to the MPMU's approval. Tank and radiators shall be able to withstand full vacuum without leaking. It is the Bidder's responsibility to assure that the radiators and all parts of the transformer are within the confines of its containment walls. Fan motors shall be configured to run on single phase 240V AC.

9.8. CORE

- The core shall be carefully assembled to ensure minimum vibration under all operating conditions. Clamping structures shall be designed and constructed to minimize eddy currents and noise. The core shall be suitably mounted on the tank to prevent movement during faults, shipping, and installation.
- The core shall be constructed of high-grade cold rolled grain-oriented, silicon steel laminations, with high magnetic permeability. CIRCULAR DESIGN ONLY. Magnetic flux density is to be kept well below the saturation point. The core construction shall include step-lap mitered joints to keep core losses, excitation current and noise level within specifications in section 9.9 (NOISE LEVELS). Core should be circular type.
- The core shall be grounded, and the ground connection shall be accessible for testing without the necessity of removing the oil cover. Any frame or clamping grounds shall also be accessible. Provision shall be provided to test core to frame or clamping to tank without entering inside transformer. A junction/termination box on the transformer is required. For each core and clamp, a ground lead shall be brought out through an appropriate bushing such as a "spark plug bushing" or MPMU approval equal design into the junction/terminal box and then grounded to the transformer tank. An engraved metallic nameplate shall be provided to permanently identify the core ground and clamping termination box.
- If Core and Coil are grounded through a resistor (external only), then the resistor technical data shall be provided with submission documents and two (2) spare identical grounding resistors shall also be provided.
- Core clamping arrangement to be equipped with core and coil connections to disconnect during testing.
- The type and material of core shall be indicated in the technical data Sheet Section 13.3 (ADDITIONAL INFORMATION) #16.
- Core material technical data sheet shall be provided with RFQ (Bid).
- The windings and core assembly shall be designed and constructed to withstand 5/3/2G or higher impacts for transport forces (longitudinal/transverse/vertical).
- Each lead for connection to tap changers, bushings or other windings shall be permanently stamped and identified H1, H2 and H3 for high voltage and X1, X2 and X3 for low voltages. Grease pencil is not acceptable.
- Brazed joints or pressure crimp connectors are acceptable. Splices are not allowed in leads. No soldered connections shall be used.
- Blocking should be provided for every core step in horizontal and vertical direction.

9.9. NOISE LEVELS

- The transformer shall be designed such that the guaranteed average audible sound level shall not exceed the values given in NEMA TR1.
- Audible sound shall not exceed NEMA TR1 during service life of the equipment.
- The transformer shall be designed and built such that it will not cause interference with radio reception or telephone communication circuits in accordance with the best modern practices.
- **The specified guaranteed sound level shall be without sound enclosures** or any other additional arrangement outside (external) of the Transformer to reduce the noise levels.

9.10. TEMPERATURE RISE

- The transformer shall be rated in accordance with IEEE C57.12.00. The observable temperature rise over an average ambient temperature of 30 degrees C for twenty-four (24) hours (maximum ambient temperature of 40 degrees C) shall not exceed 65 degrees C by resistance on all ratings (self-cooled and force cooled (ONAN/ONAF1/ONAF2)) on

the tap connection that gives the highest losses. The ampacity of all current carrying components shall be suitable at the 65 degrees C rating.

- Hot Spot temperature rise shall NOT be more than 80 degrees C.
- The transformer shall be capable of being energized from a condition of thermal equilibrium at -30 degrees C. If this is not possible, cold start instructions shall be provided with the tender documents and this shall also be identified in the technical data sheet.

9.11. NAMEPLATES

9.11.1. EQUIPMENT

- A nameplate shall be provided and mounted on or near the control cabinet.
- The nameplate shall be fabricated from stainless steel and attached with stainless steel hardware.
- Each current transformer shall be provided with a diagrammatic type nameplate located near the CT terminal blocks.
- Self-Adhesive labels shall not be used.

9.11.2. TRANSFORMER

- The nameplate shall be located and permanently affixed on the transformer.
- The nameplate shall be of non-oxidizing metal and permanent markings of ratings and connections.
- The nameplate shall be as per the latest revision of IEEE C57.12.00-latest revision.
- The required nameplate information:

Serial Number
Class (ONAN/ONAF1/ONAF2)
Frequency
Number of phases
MVA Rating
Voltage ratings
Tap Voltage
Rated current for all voltages.
Rated current on different LTC Taps.
Temperature Rise
Phasor Diagrams
Polarity
% Impedance
Sound Level
Transformer core type & number of limbs
Date of Test
Date of manufacture
Purchaser
Purchaser Order Number
Asset ID (If applicable)
Name of Manufacturer
BIL, Weight and insulating material, tank pressure, liquid data.

9.12. PAINTING AND CORROSION PROTECTION OF EQUIPMENT

- Painting and corrosion protection of equipment shall be in accordance with Society for Protective Coatings (SSPC) standards the Manufacturers standard practice and must be submitted for MPMU approval.

All coatings and processes shall be suitable to withstand the equipment service conditions.
Surfaces exposed to oil shall be coated with a product compatible with the fluid it is exposed to.
Use of lead-free paint is required.

- After fabrication, equipment shall be thoroughly cleaned of all grease, weld spatter, dirt and any other foreign matter per SSPC-SP1. The completed tank shall be blasted to SSPC-SP10/NACE 2, near white commercial blast cleaning, and achieve the surface profile required by the coating manufacturer.
- Verify cleanliness of abrasive media as per SSPC-AB 1/2/3 and compressed air per ASTM D4285.

9.12.1. PAINTING

- All coated surfaces shall be coated with approved materials, per an approved process, and in accordance with manufacturer recommendations.
- Testing per section 10.5 (PAINT TEST).

  Test reports shall be submitted to MPMU for review and acceptance.

- The Bidder shall submit for MPMU's approval: two (2) 8 inch x 6 inch color samples of the paint to be provided for the equipment. Samples shall be properly labeled to include contract number and description of the finished system.

  Including color, manufacturer and type of paint.
  LEAD PAINT IS NOT ALLOWED.

- Finish paint color for exterior surfaces shall be ANSI 70 (Grey). Finish paint color for the interior surfaces shall be white. Hot dip galvanized surfaces shall not be painted.
- The entire top of equipment shall be painted with a "Non-Skid" type of paint or surface application.
- The Bidder shall furnish touch up paint in the amount of two quarts for the equipment. All finished metal work shall be suitably protected from damage during shipment and installation.
- Porosity inspection shall be performed on the entire interior and exterior surfaces of the tank.

9.12.2. HOT-DIP GALVANIZING

- Radiators, conduits, platforms materials and fan guard shall be hot-dipped galvanized. Hot-Dipped galvanizing practices shall be in accordance with the application portions of ASTM A 123/123M.
- Water quenching or chromate conversion coating should be avoided as these processes interfere with paint adhesion and surface preparation.
- Surfaces shall be inspected for conformance to the required zinc thickness in accordance with ASTM A 123/A 123M utilizing a magnetic-field type thickness instrument.

  Instrument in accordance with ASTM E376-11
  Any surfaces falling below the equipped zinc thickness, before or after removal of any high spots, shall be repaired in accordance with ASTM A 780.

10. TESTING REQUIREMENTS

10.1. GENERAL

- The manufacturer's test floor shall have a documented calibration program. All equipment shall receive regular calibrations. Calibration standards shall be traceable to National Bureau of Standards. Records of all equipment calibration shall be made available to the Buyer upon request.
- Detailed test plans outlining all production tests with test procedures and acceptance criteria shall be submitted at least four (4) weeks prior to factory testing for MPMU's approval. **Also, the oil the Bidder will be using for this testing must be provided in the same time frame.**
- Test reports shall be provided in accordance with ANSI C57.21.
- All components of the transformer shall be completely assembled for factory testing.
- MPMU will require heat runs for the first unit and ONAN/ONAF2 condition on all remaining units.
- If the transformers fail any of the tests, MPMU shall be notified immediately.

  MPMU shall be consulted about the test conditions and the extent of the failed test. (% of failure, test limits etc…)
  MPMU may require a complete retest of all tests.
  If the unit fails during retesting, MPMU shall have the right to reject the unit completely for not meeting guaranteed values.

10.2. FACTORY ACCEPTANCE TEST (FAT)

- Minimum tests to be performed for FAT.

  Insulation resistance test
  Dielectric absorption test (Per IEEE C57.12.90 Latest Version and applicable NEMA standards)
  Winding resistance measurement
  Turns ratio test.
  Core-to-ground insulation resistance test.
  Applied voltage tests.
  Induced voltage tests.
  Partial Discharge (PD) tests
  Sound(noise) level test per NEMA standard.
  All accessories including HV and LV bushings, control cabinet, AC power cabinet etc. shall be tested with the transformer during the FAT.
  The oil to be used for factory testing must be free of corrosive sulfur per ASTM D1275B and new oil requirement per Table 1 and must be approved by MPMU prior to factory acceptance test. A sample of oil used for testing shall be sent to “Doble” for full dielectric and screening testing included power factor verses oxidation and covered conductor deposition prior to filling the transformer with oil.
  Sweep Frequency Response Analysis (SFRA) with “Doble 5500 SFRA” instrument and leads for both with and without oil.
  Ratio measurements shall be made on every LTC tap position of all windings to the rated tap of all other windings.
  Each phase of the transformer shall be tested to verify the subtractive polarity of each phase.
  Heat run test, during this test the Bidder shall simulate the tight quarters and physical arrangement of walls where the transformer will be installed (if applicable). The Kelman unit shall be functional for the heat run test. (See General 10.1 for heat run requirements per unit)
  Non-destructive weld inspection method shall be used for the tank leak test.

- Additional tests required by manufacturer(s) of supplied parts.

10.3. FIELD TEST

- Minimum field tests to be performed prior to energization:

  Megger
  TTR
  Sweep Frequency Test
  Visual Inspection
  ADDITIONAL MPMU TESTS REQUIRED?

- Additional tests required by manufacturer(s) of supplied parts.
- Site sound study – (performed prior to energization, and after energization of both transformers).

10.4. PAINT TEST

- The Bidder shall perform the following tests on painted surfaces:

  Anchor Profile Measurement Test.
  Dry Film Measurement Test.
  Final Curing Test.

10.5. OTHER REQUIRED TESTS

- Transformer shall be tested according to ANSI/IEEE C57.12.90. Bushings shall be tested per IEEE C57.19.00. Additional tests shall include but not be limited to the following design and special tests:

  1) Power factor tests with Doble test set on transformer, bushings, oil, and insulation
  2) Insulation resistance tests
  3) Resistance – Cold (-25 degrees C) and Hot (105 degrees C)
  4) Polarity and phase relation
  5) Zero sequence impedance tests
  6) Corona and radio influence voltage (RIV) tests

7) Core ground and clamp megger test
8) Lightning impulse test on all Phases
9) Switching impulse test on all terminals
10) Ratio and polarity test on all windings for all tap connections
11) Noise test per NEMA standard
12) Control equipment tests, wiring dielectric test.
13) Ancillary Test include, but not limited to the following:

    Annunciator Alarms
    Control Cabinet and AC Power Cabinet Devices (heaters, lights, etc.)
    Fault Pressure Relay - using the Qualitrol field test kit KIT 930 to NERC standard.
    Fans Operation
    Gas Accumulator - Buchholz relay shall be tested by the method of gas injection test.
    Top Oil Temperature Thermometer/Monitor
    Winding Temperature Thermometer/Monitor
    Liquid Level Indicator
    Metering CTs - (ratio, polarity, insulation, applied voltage, and saturation curve)
    Relays CTs - (ratio, polarity, insulation, applied voltage, and saturation curve)
    Other CT(s) – Connected to winding temp. gauge - (ratio, polarity, insulation, applied voltage, and saturation curve)

14) All control circuits shall be tested point to point to validate control continuity and performance.
15) Determination of transformer regulation and efficiency at rated load and rated voltage.
16) Losses: load, auxiliary. Impedance and load loss shall be measured at minimum, middle, and maximum LTC tap positions.
17) No-load loss and excitation current shall be measured both at nominal rated voltage and at 90, 100 & 110 percent of nominal rated voltage, both before and after impulse tests. No-load loss results taken after the dielectric test are used for calculating transformer loss evaluation.
18) Loss Compliance:

    Values of no-load loss and excitation current measured at nominal rated voltage after impulse tests shall be the values used in determining compliance with the seller's quoted loss and excitation performance. These values shall not exceed the values measured before impulse tests by more than 7.5 percent.
    IEEE tolerances from the seller's performance quotation for no-load loss at nominal rated voltage shall also apply to the excitation current at nominal rated voltage.
    No supplier shall ship to MPMU a transformer that exceeds the quoted loss value by 10% or more for no-load losses (NL) or load losses (LL) or by 6% or more for total losses (NL + LL)

19) Temperature rise test- The temperature rise test shall be performed per ANSI/IEEE requirements. The manufacture shall simulate the tight quarters and physical arrangement of walls where the transformer will be installed (if applicable).

    The duration of ultimate temperature rise test when the unit reaches stabilization (temperature rise does not vary more than 2.5% or 1℃, whichever is greater) shall be held for a minimum of consecutive twelve (12) hours. The temperature rise test shall be performed on all units. The Kelman unit shall be commissioned and functional during the factory acceptance testing. Oil samples shall be drawn at four (4) hour intervals during the duration of temperature rise test and the results shall be compared with the data received from the Kelman unit.
    The tank wall surfaces shall be checked for hot spots during the heat run test. The tank-wall hot-spot temperature rise shall not exceed 70℃ for any transformer while operating at 100 percent of its rating.
    During the temperature rise test at maximum continuous rating, the transformer tank (4 walls, cover, and pockets, if any) and bushings shall be scanned for hot-spot. It is preferred that the equipment used for scanning be capable of continuously monitoring and broad scanning the transformer. The measured hot-spot temperature on each wall, bushings, covers and pockets, if any, shall be recorded and included in the certified test report. The hot-spot temperature rise of these parts shall not exceed the limits of temperature rise for continuous operation.
    Winding hot spot and oil temperature rise shall be monitored using fiber optic probes as well as the 'standard' hot spot system. Fiber optic characteristics shall be included in the Certified Test Report.

Temperature rise test shall be performed prior to the dielectric testing of the transformer. The winding temperature indicator circuit will be preset with the design values of the winding gradient so that the winding temperature indicator and circuit operation can be observed during the temperature rise test. The winding temperature indicator shall be reset (as necessary) to the actual tested winding gradient value from the temperature rise test, and any forms or checklist explaining or stating that this process has been completed shall be provided to the MPMU.

20) The winding hot spot rise shall be calculated using the following two methods and the larger value shall be used:
    a. Manufacturer's standard method.
    b. Hot spot rise = (top oil rise) + (1.2) (winding gradient over average oil rise)
21) Gas chromatographic analysis – Dissolved gas-in-oil (DGA) samples will be taken prior to the start of the factory acceptance tests (FAT), after the dielectric tests, before and after heat run test, after the completion of the factory acceptance tests (FAT).
    a. The maximum allowable limits for dissolved gas-in-oil generated during the temperature rise tests are as follows:

DGA	
Gas	**PPM**
Hydrogen (H_2)	20
Carbon dioxide (CO_2)	250
Carbon monoxide (CO)	40
Methane (CH_4)	3
Ethane (C_2H_6)	2
Ethylene (C_2H_4)	1
Acetylene (C_2H_2)	Nondetectable

Table 12: DGA Allowable Limits

22) After FAT, perform a degree of polymerization test for the cellulosic insulation through IEEE standard calculation method and provide the reports. DP shall be more than 1000.

- These tests may be performed by the Bidder and reports provided to MPMU or performed as part of the FAT.

11. ADDITIONAL REQUIREMENTS

- The transformer and all auxiliaries shall be capable of outdoor operation under all weather conditions which are expected to be encountered in Mt. Pleasant, Iowa. This includes a temperature range of minus (-) 30 degrees Celsius to plus (+) 100 degrees Celsius, and exposure to solar radiation.
- If the MPMU desires to review drawing preparation or inspect the equipment at the factory, at any time, MPMU representatives shall be allowed free access during business hours. Failure of the MPMU representative or inspector to call attention to any defect in material or workmanship shall not be construed as acceptance of the same.

12. ELECTRICAL CLEARANCES

- All electrical clearances for this equipment shall meet or exceed those stated in table 14 of IEEE C37.30.1 (See Appendix F). Column 3 of this table describes phase to phase electrical clearances and column 4 shows phase to ground electrical clearances.

13. BIDDING DOCUMENTS

13.1. GENERAL DATA

For evaluation purposes, bidders shall fill in the following data and provide it with the bid package.

TRANSFORMER WEIGHTS:

1. Weight of core and coil _____ lb.
2. Weight of tank and fittings _____ lb.
3. Weight of copper in windings _____ lb.
4. Weight of oil _____ lb.
5. Gallons of oil in transformer _____ gal.
6. Gallons of oil in LTC _____ gal.
7. Weight of total assembled unit's _____ lb.
8. Weight of heaviest part as shipping _____ lb.

TRANSFORMER DIMENSIONS:

1. Height (overall) _____ in.
2. Depth (front to back) _____ in.
3. Width (side to side) _____ in.
4. Minimum un-tanking height (FND to crane hook) _____ in.

COOLING

1. Number of fans _____
2. Number of radiator banks _____

Comments:

_____
_____
_____

SHIPPING DATA

List parts removed for shipment:

_____
_____
_____
_____

PAINTING

Describe method of painting and type of paint used:

_____
_____
_____
_____

IMPEDANCE:

The contractor shall supply the following design calculated impedances at 14MVA, 65°C:

	Positive Sequence	Zero Sequence
High to Low Voltage	_____	_____

SOUND LEVELS:

Calculated sound values at the rated voltage for 30/40/50 MVA load ratings at the stages of 65°C rise cooling: ___/___/___ db.

13.2. GUARANTEED PERFORMANCE DATA

For evaluation purposes, bidders shall fill in the following data and provide with bid package.

REGULATION:

Guaranteed regulation in percent for rated voltage, MVA (30) and frequency at 85°C average winding temperature, high to low voltage

1. Unity power factor _____ percent
2. 90 percent power factor _____ percent
3. 80 percent power factor _____ percent

Regulation table/curve – attach data sheet _____

Guaranteed regulation in percent for rated voltage, MVA (50) and frequency at 85°C average winding temperature, high to low voltage.

1. Unity power factor _____ percent
2. 90 percent power factor _____percent
3. 80 percent power factor _____percent
4. Regulation table/curve – attach data sheet _____

EXCITATION CURRENT:

Guaranteed excitation current in percent, at HV terminals.

1. 95 percent rated voltage _____ percent
2. 100 percent rated voltage _____ percent
3. 105 percent rated voltage _____ percent
4. 110 percent rated voltage _____ percent
5. Core excitation – attach data sheet _____

IMPEDANCE:

Guaranteed impedance in percent at 85°C average winding temperature on the ONAN rated of 50MVA

1. High to low voltage _____ percent
2. Guaranteed tolerance to bid impedance to actual impedance of:
    i. High to low voltage _____ percent
3. Impedance table for all LTC positions for:
    i. Nominal 69kV Tap – attached data sheet _____

FORCED COOLING:

Maximum continuous rating in MVA not exceeding 65° rise, 50MVA, copper temperature.

1. Loss of one-third of fans _____ MVA
2. Loss of two-thirds of fans _____ MVA
3. Auxiliary power requirement at maximum (65°C, continuous) _____ kW
4. Rated voltage of fan motors _____ V
5. Fan motor phasing (single, three) _____

EFFICIENCY:

Guaranteed efficiency in percent based on full load self-cooled rating.

1. One-quarter load _____ percent
2. One-half load _____ percent
3. Three-quarter load _____ percent
4. Full load _____ percent

LOSSES (USED FOR EVALUTION PURPOSES ONLY):

Guaranteed losses in kW at rated voltage and frequency at the specified temperature. If losses are determined at another temperature, Bidder shall compute and furnish them on the specified base for evaluation purposes.

1. No load losses at rated voltage and frequency at 20°C _____ kW
   (1 used to calculate Excess No Load Loss Penalties – Evaluated at $6,820/kW)

2. No load losses at 110% of rated voltage and at rated frequency at 20°C _____ kW

3. Load losses (ONAN rating, copper losses only at 85°C average winding temperature)
   i. At 25 percent rated load _____ kW
   ii. At 50 percent rated load _____ kW
   iii. At 75 percent rated load _____ kW
   iv. At 100 percent rated load _____ kW
   (3.iv used to calculated Excess Load Loss Penalties – Evaluated at $1,680/kW)

4. Total losses (ONAN rating, copper losses only at 85°C average winding temperature)
   i. At 25 percent rated load _____ kW
   ii. At 50 percent rated load _____ kW
   iii. At 75 percent rated load _____ kW
   iv. At 100 percent rated load _____ kW

5. Auxiliary losses
   i. With no cooling fans _____ kW
   ii. With Stage 1 cooling _____ kW
   iii. With Stage 1 and 2 cooling _____ kW
   (5.iii used to calculate Excess Auxiliary Loss Penalties – Evaluated at $1,680/kW)

LOSS MEASUREMENT ACCURACY:

1. No load losses – error less than _____ percent
2. Load losses – error less than _____ percent

TEMPERATURE:

Guaranteed temperature rise at 50MVA

1. High voltage
   i. Winding _____ °C
   ii. Hot spot _____ °C
2. Low voltage
   i. Winding _____ °C
   ii. Hot spot _____ °C

PARTIAL DISCHARGE LEVEL:

Guaranteed RIV level _____ µV

Guaranteed partial discharge level _____ pC

13.3. ADDITIONAL INFORMATION

For evaluation purposes, Bidders shall fill in the following data and provide it with bid the package.

1. What is the recommended maintenance/inspection intervals required during the first 500,000 LTC operations? Give the intervals and describe the required action at each.

   _____
   _____
   _____
   _____
   _____

2. Will the LTC equipment, if in operation at the time of through fault on the LV side, successfully complete the tap change? __Yes/No__

3. If control power is lost during a tap change, will the LTC equipment complete the change using stored mechanical energy? __Yes/No__

   If "No", what are the ramifications?

   _____
   _____

4. LTC Equipment:
   i. Type of interrupter: _____
   ii. Regulating location and type: _____
   iii. BIL and ampacity ratings: _____

5. Would the oil level of the main tank have to be lowered to the point where the core and coil are exposed for maintenance of the LTC tap board barriers or gaskets?

   __Yes/No__

6. Would the oil level of the main tank have to be lowered to the point where the core and coil is exposed for removal or installation of any high or low voltage or neutral bushing?

   __Yes/No__

   If "Yes", which one(s)? _____

7. Describe briefly the method used to dry the transformer to ensure dryness as required by this specification.

   _____
   _____
   _____
   _____
   _____
   _____

8. Gasket Material:
   i. What type of material is used? _____
   ii. Are bushing gaskets recessed? __Yes/No__
   iii. Are hand hole gaskets recessed? __Yes/No__
   iv. Are LTC covers recessed? __Yes/No__

9. Gas Accumulator Relays:
   i. Type: _____
   ii. Manufacturer: _____
   iii. Catalog Number: _____
   iv. Location: _____

10. Are fan motors designed so that an overload protection device is not required for locked rotor condition? __Yes/No__

    If "No", What type of overload protection device will be provided? _____

11. What is the limiting factor for overload capability of the transformer?

	Rating (Amps)	% over 50MVA rating
Bushings	_____	_____
LTC	_____	_____
Other	_____	_____

Comments:

_____
_____
_____

12. In addition to your obligations under this specification, in case of equipment failure, what is your policy relative to replacing failed equipment? (May attach support document)

_____
_____
_____

13. Has a transformer similar in design to that proposed under this specification been tested for the ability to withstand a short circuit per this specification? (May attach support document)

_____
_____
_____

14. Tank structural capability:

    i. Number of tank ruptures in the last 10 years? _____
    ii. Number of gallons of oil lost for each incident? (Approximate, may attach support documents)

_____
_____
_____

15. State the type of oil preservation system

_____
_____

16. Equipment being bid:
Please populate the below table per the transformers being proposed.

Vendor Bid			
Equipment	**Manufacturer**	**Model**	**Part Number**
345kV Bushings (H1,2,3)			
69kV Bushings (X1,2,3,0)			
Core Ground Bushings			
Insulation Paper on Windings			
Support Methods for Leads in Core and Coil			
Liquid Level Indicators			
Temperature Monitor			
LTC Control			
Ball Valves			
Butterfly Valves			
Expansion Tank Rubber Bladder			
Fault Gas and Moisture in Oil Monitor			
Pressure Relief Devices			

345kV Surge Arrestors			
69kV Surge Arrestors			
Shorting Blocks for CT leads			
Sudden Pressure Relay – LTC			
Sudden Pressure Relay – Main Tank			
Cooling Fans			
Paint			
Insulating Oil			
Load Tap Changer			
De-Engergized Tap Changer			
Magnetic Liquid Level Gauge			
LTC Motor Drive			
Remote Tap Position Indicator			
Control Wiring			
Core Material			
Core Type			

Table 13: Vendor Bid

17. Experience and Performance of Bidder – Experience and performance of the Bidder may be used in the evaluation process:
    i. Provide a list of transformers manufactured in the past 10 years with a high side nominal voltage rating greater than or equal to 69kV. (Include year of manufacture, cooling type, MVA and voltage ratings) (May attach supporting documents)

    ii. Provide a list of in-service failures during the past 10 years in accordance with the IEEE C57.117 failure reporting guide. List the failure percent by a summary for each failure.

    iii. Provide a list of factory test failures for the past five years. A failure is defined as an instance where the active part was removed from the tank to make repairs. List by year the percent of such failures and a description for each failure.

18. Availability of Parts and Service:
    i. Replacement parts for the transformer shall be available from manufacturer's factory located at
    _____

    ii. Contractor's service headquarters for the State of Iowa area is located at
    _____

    iii. The transformer will be built at the Bidder's factory located at
    _____

    iv. Warranty work would be performed at the Bidder's factory located at
    _____

19. Schedule:
    i. State the quoted lead time from date of PO Issuance: _____ weeks

    ii. State the number of weeks after PO issuance that preliminary drawings will be submitted for MPMU approval:
    _____ weeks

iii. State the number of weeks after PO issuance that final drawings will be submitted to MPMU: _____ weeks

iv. State the number of weeks required for manufacturing and assembly of the transformer after final drawing approval: _____ weeks

v. State the number of weeks before transformer shipment that certified test reports will be submitted to MPMU: _____ weeks

vi. State the number of weeks it will take to complete the field assembly and testing of the transformer after it arrives on site: _____ weeks

13.4. EXCEPTIONS

For evaluation purposes, Bidders shall clearly state any and all exceptions taken to the specification.

Exceptions List			
Section	**Requirement**	**Change**	**Comments**

Table 14: Exceptions List

13.5. SCHEDULE OF ITEMS BID

For evaluation purposes, Bidders shall fill in the following data and provide with bid package.

13.5.1. BASE PRICE

The Contract provides for the furnishing of all labor and materials necessary to manufacture and deliver* two (2) 50MVA 345/69kV Autotransformers for Mount Pleasant Municipal Utilities' (MPMU) Skunk River Substation Overall project scope includes installation of two (2) new transformers. This transformer procurement contract includes the manufacturing, factory and field testing, delivery, assembly, and vacuum filling (if applicable). The transformers shall be delivered and unloaded by the **Seller** on concrete foundations (prepared by Owner) at the project location.

*Delivery MUST include all freight and/or roadway taxes/tariffs and fees. F.O.B. destination transformer pads are located at Skunk River Substation.

The price shall include a base five (5)year warranty. The warranty begins when all field services have been completed. Field services shall be completed within 12 days of delivery. Extension given for unintended weather or MPMU related delays.

Exceptions to the specification are allowed, but not preferred. All exceptions need to be approved by MPMU or an authorized representative. No exceptions will be allowed after the order has been awarded to the qualified vendor.

Base Bid Price: $_____

13.5.2. SPARE PARTS FOR THE TRANSFORMER

Spare Parts			
Description	**Probably Purchase Quantity for Evaluation Purposes**	**Unit Price (including all multipliers)**	**Extended Price**
345kV bushings to tank gasket	3		
69kV bushings to tank gasket	4		
LTC door gasket	2		
LTC contacts (moving, stationery and arcing)	1 Set		
Radiator gasket	6		
Manhole gasket Set	1		
Radiator	1		
345kV arrestors	3		
69kV arrestors	3		
Vacuum interrupter	1 Set		
Total Extended Price			**$**

If additional spare parts are recommended, include in the bid the items and individual prices. (May attach supporting documents). Customer reserves the right to add, modify or remove spare parts as required during the bidding process.

13.5.3. ADDITIONAL PRICING INFORMATION

The following may be used for evaluation purposes:

1. Adder to include all associated in-out transportation costs for factory repair for the initial five (5) year warranty.

   $_____

2. Cost to extend warranty for second five (5) year period including associated in-out transportation costs for factory repair.

   $_____

3. Cost to extend warranty for second five (5) year period excluding associated in-out transportation costs for factory repair.

   $_____

4. Cost of potential two stage move onto temporary pad before final pad position.

   $_____

5. Cost of training for MPMU maintenance personnel (two days).

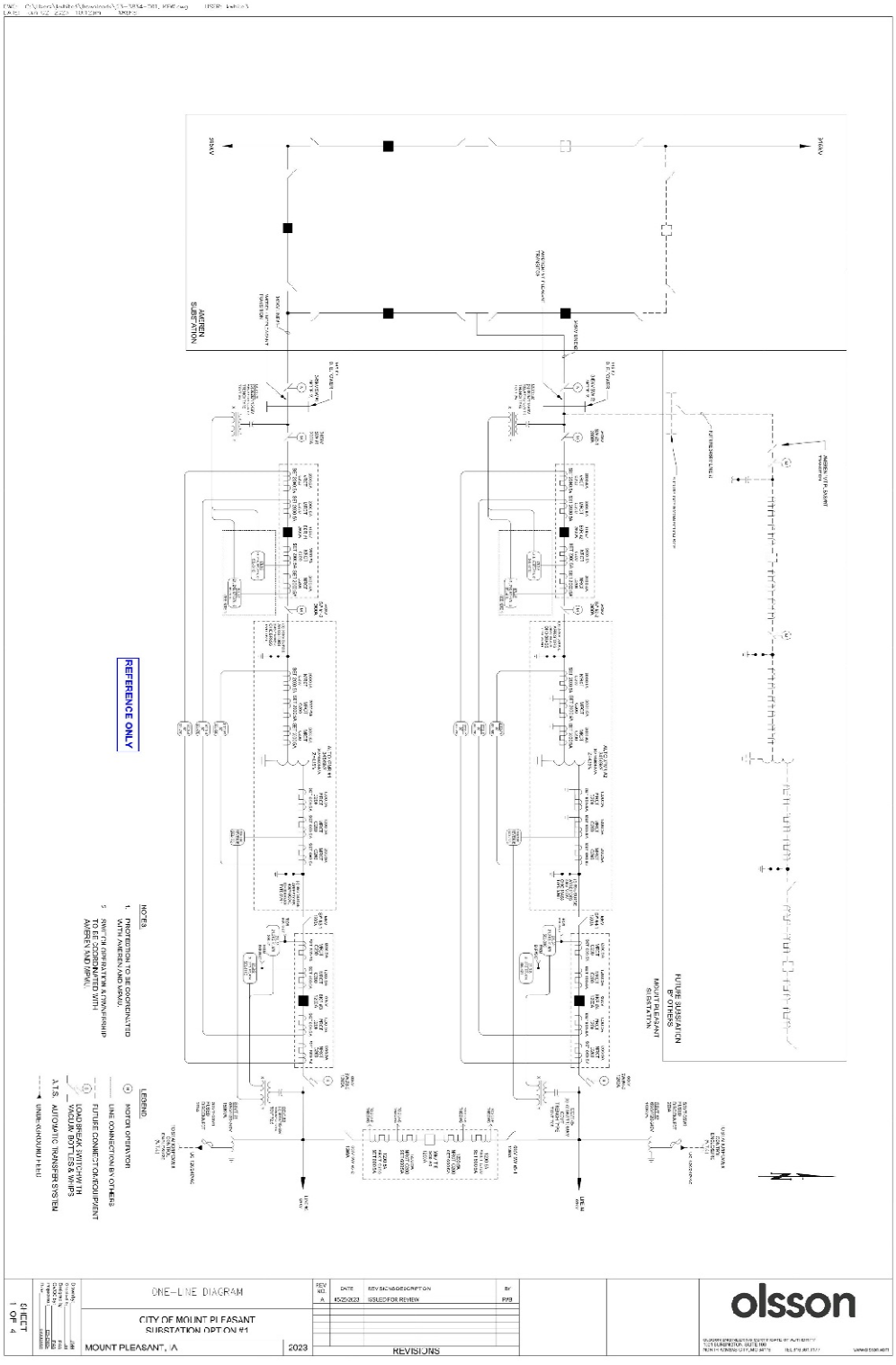
   $_____

6. Cost per week of storage at manufacturer facility.

   $_____

14. APPENDICES

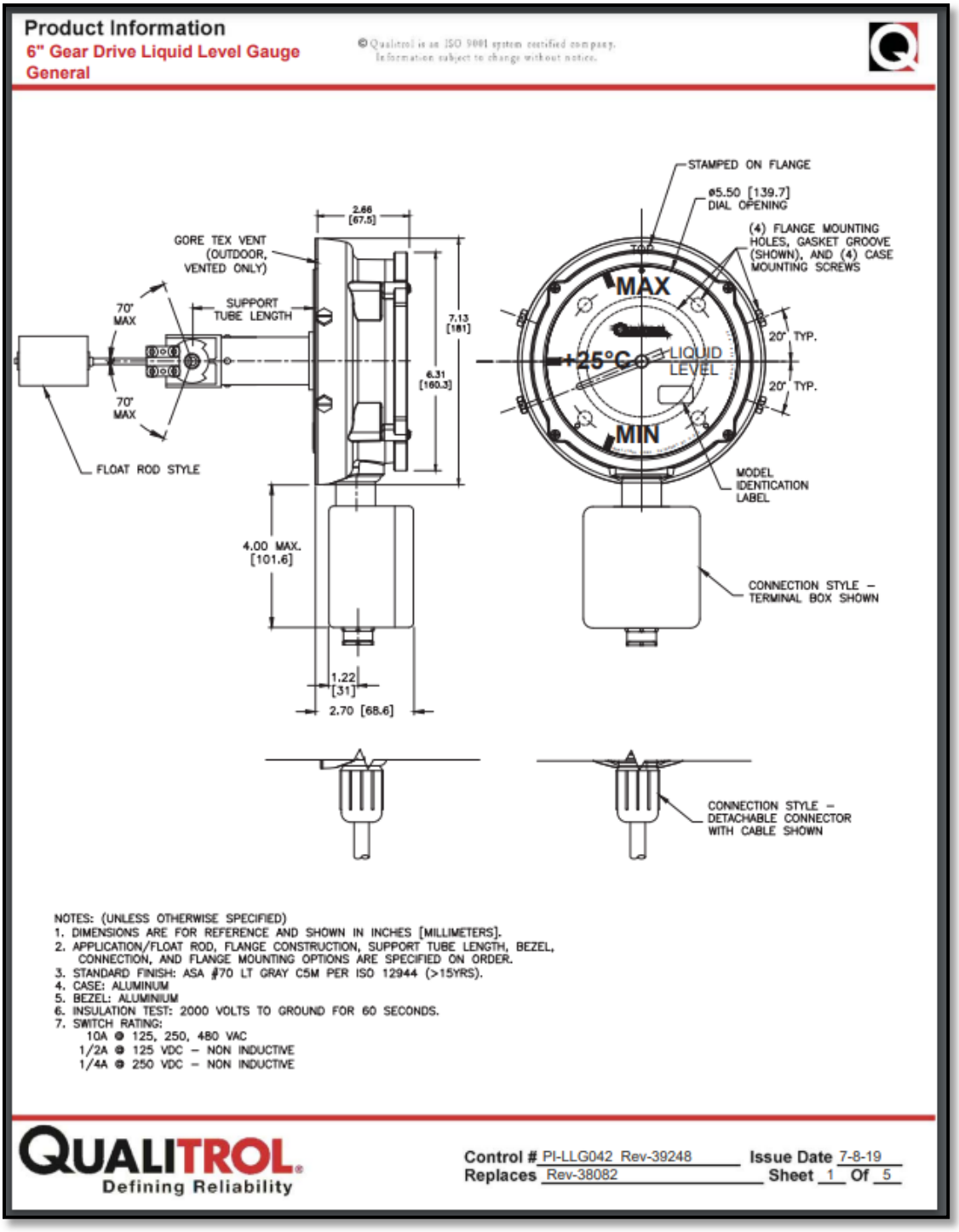
14.1. APPENDIX A: SKUNK RIVER SUBSTATION PRELIMINARY ONE LINE DIAGRAM



Larger version attached see “Skunk River One-Line” PDF

14.2. APPENDIX B: LEVEL GAGE

Qualitrol Oil Level Indicator Model No. 042

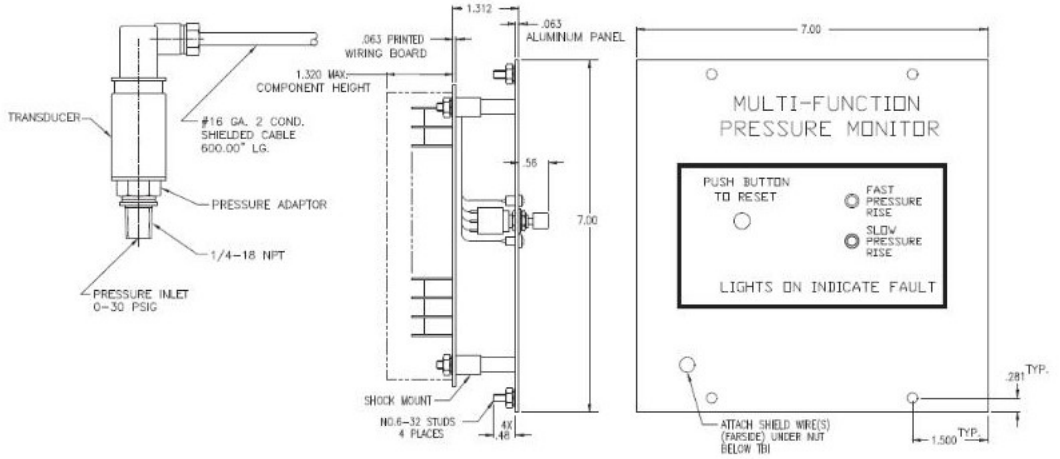


14.3. APPENDIX C: RAPID PRESSURE RISE RELAY

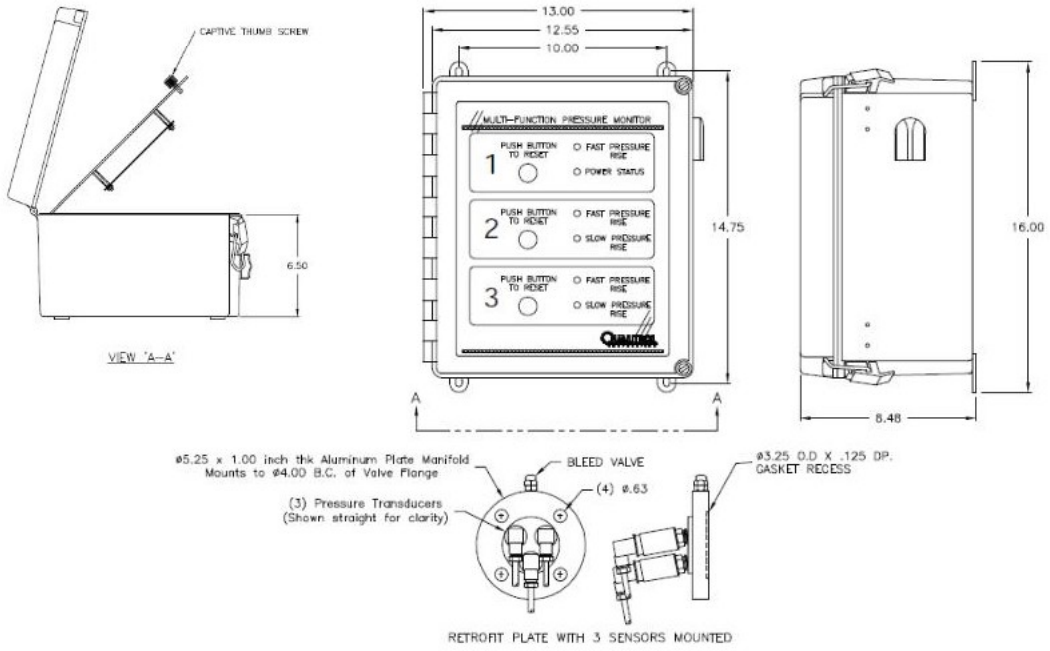
Qualitrol 930 Electronic Pressure Monitor

QUALITROL® 930 electronic pressure monitor

Single sensor pressure monitor



Multi-sensor pressure monitor

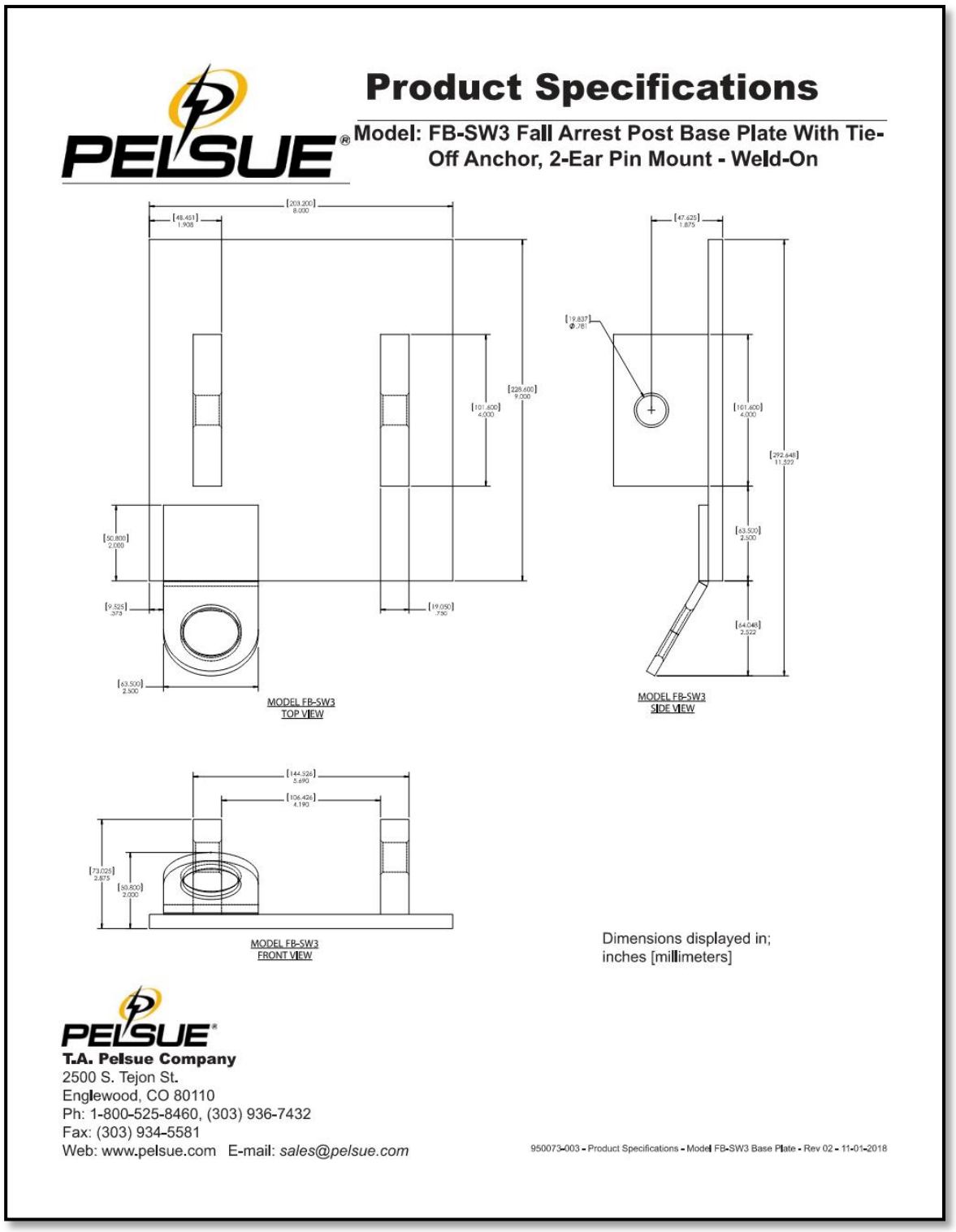


QUALITROL®
Defining Reliability

Email info@qualitrolcorp.com
www.qualitrolcorp.com

14.4. APPENDIX D: FALL ARREST BASE PLATE

Pelsue FB-SW3



14.5. APPENDIX E: ELECTRICAL CLEARANCES

IEEE C37.30.1 Table 14

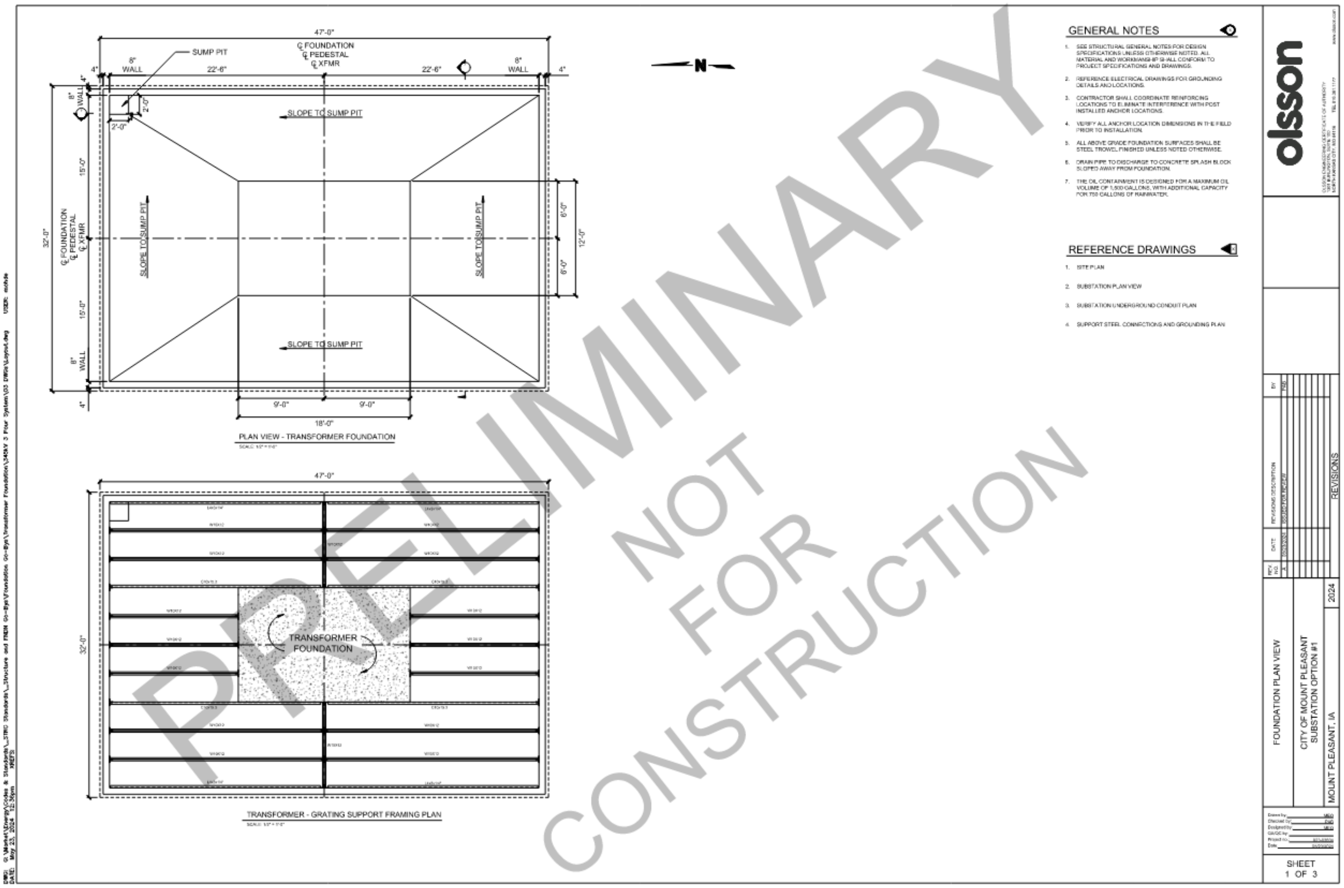
Table 14—Phase spacing and ground clearance for station class outdoor air switches

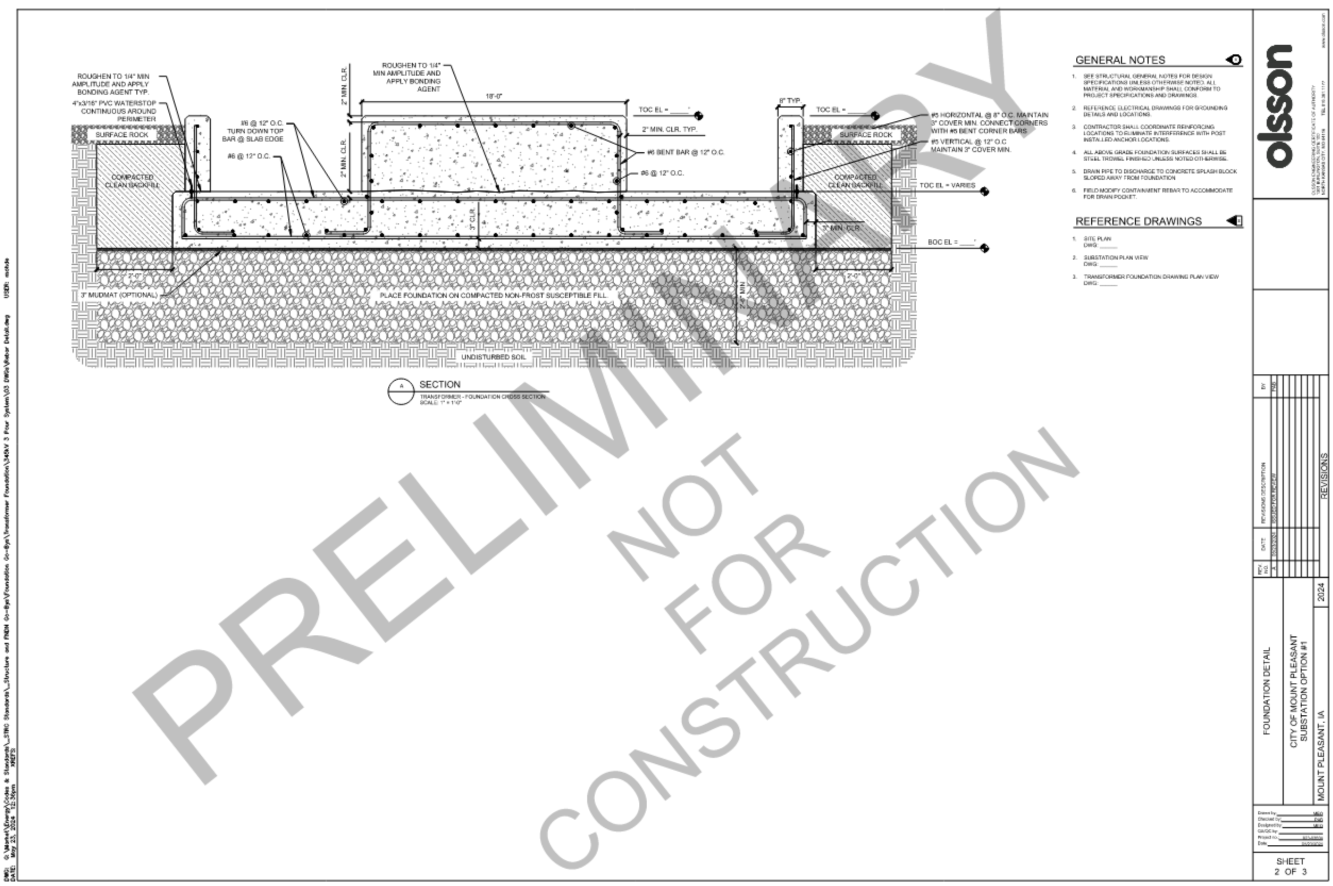
Line number	Rated maximum voltage (rms kV)	Rated lightning impulse withstand voltage (kV peak)	Minimum phase-to-phase metal-to-metal distance disconnecting switches[a]		Ground clearance[b] Recommended		Ground clearance[b] Minimum		Centerline-to-centerline phase spacing[c]: Vertical break disconnecting switches and bus supports		Centerline-to-centerline phase spacing[c]: Side break (horizontal break) disconnecting switches		Centerline-to-centerline phase spacing[c]: All horn-gap switches (vertical and side break)	
			(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)
	(1)	(2)	(3)		(4)		(5)		(6)		(7)		(8)	
1	8.3	95	178	7	191	7.5	152	6	457	18	762	30	914	36
2	15.5	110	305	12	254	10	178	7	610	24	762	30	914	36
3	27	150	381	15	305	12	254	10	762	30	914	36	1220	48
4	38	200	457	18	381	15	330	13	914	36	1220	48	1520	60
5	48.3	250	533	21	457	18	432	17	1220	48	1520	60	1830	72
6	72.5	250	533	21	457	18	432	17	1220	48	1520	60	1830	72
7		350*	787	31	737	29	635	25	1520	60	1830	72	2130	84
8	123	350	787	31	737	29	635	25	1520	60	1830	72	2130	84
9		450	1120	44	991	39	846	34	1830	72	2310	91	2620	103
10		550*	1350	53	1190	47	1070	42	2130	84	2740	108	3050	120
11	145	350	787	31	737	29	635	25	1520	60	1830	72	2130	84
12		450	1120	44	991	39	846	34	1830	72	2310	91	2620	103
13		550	1350	53	1190	47	1070	42	2130	84	2740	108	3050	120
14		650*	1600	63	1330	52.5	1270	50	2440	96	3350	132	3660	144
15	170	450	1120	44	991	39	846	34	1830	72	2310	91	2620	103
16		550	1350	53	1190	47	1070	42	2130	84	2740	108	3050	120
17		650	1600	63	1330	52.5	1270	50	2440	96	3350	132	3660	144
18		750*	1830	72	1560	61.5	1470	58	2740	108	3960	156	4270	168
19	245	550	1350	53	1190	47	1070	42	2130	84	2740	108	3050	120
20		650	1600	63	1330	52.5	1270	50	2440	96	3350	132	3660	144
21		750	1830	72	1560	61.5	1470	58	2740	108	3960	156	4270	168
22		900*	2260	89	1930	76	1800	71	3350	132	4870	192	4870	192
23		1050	2670	105	2300	90.5	2110	83	3960	156	5500	216	5500	216
24	362	1050	2670	105	2300	90.5	2130	84	3960	156	5500	216	5500	216
25		1300*	3020	119	2690	106	2640	104	4430	174	See Note	See Note	6100	240
26	550	1550	[d]	[d]	[d]	[d]	3150	124	[d]	[d]	[d]	[d]	7620	300
27		1800*	[d]	[d]	[d]	[d]	3660	144	7620	300	[d]	[d]	8230	324
28	800	2050	[d]	[d]	[d]	[d]	4220	166	[d]	[d]	[d]	[d]	15240	600

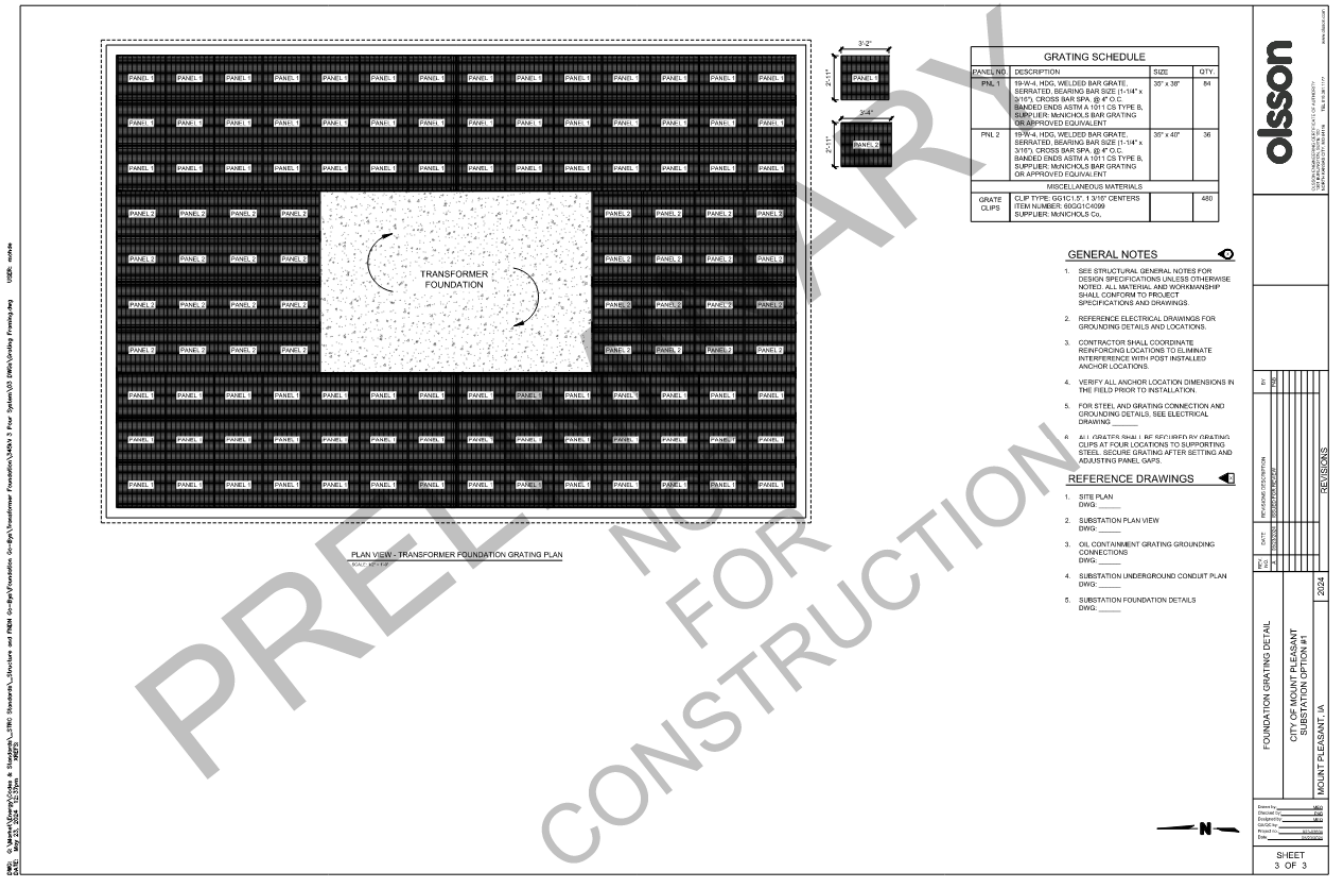
NOTE—Close lightning arrester coordination may allow lower lightning impulse values. Traditional values are indicated with an asterisk (*).

[a] Minimum metal-to-metal distance may be modified, providing proof of performance is substantiated by dielectric tests.
[b] Ground clearance for switches with voltages 362 kV and above are based on switching surge voltage levels. Refer to "Minimum Electrical Clearances" [B1].
[c] The phase spacings in column 6, column 7, and column 8 are recommended values. Overall width of switch and bus support energized parts, angle of opening of side break switches, etc., may allow a reduction in phase spacing depending upon voltage concentration on sharp projections. Resultant metal-to-metal distances between phase-energized parts should not be less than that shown in column 3.
[d] Values not yet established.

14.6. APPENDIX F: PRELIMINARY OIL CONTAINMENT


PLAN VIEW - TRANSFORMER FOUNDATION
SUMP PIT
SLOPE TO SUMP PIT
TRANSFORMER - GRATING SUPPORT FRAMING PLAN
TRANSFORMER FOUNDATION
GENERAL NOTES
REFERENCE DRAWINGS
1. SITE PLAN
2. SUBSTATION PLAN VIEW
3. SUBSTATION UNDERGROUND CONDUIT PLAN
4. SUPPORT STEEL CONNECTIONS AND GROUNDING PLAN
PRELIMINARY
NOT
FOR
CONSTRUCTION
olsson
REVISIONS
FOUNDATION PLAN VIEW
CITY OF MOUNT PLEASANT
SUBSTATION OPTION #1
MOUNT PLEASANT, IA
2024
SHEET
1 OF 3


SECTION
TRANSFORMER - FOUNDATION CROSS SECTION
SURFACE ROCK
COMPACTED CLEAN BACKFILL
3" MUDMAT (OPTIONAL)
PLACE FOUNDATION ON COMPACTED NON-FROST SUSCEPTIBLE FILL
UNDISTURBED SOIL
TOC EL = VARIES
GENERAL NOTES
REFERENCE DRAWINGS
PRELIMINARY
NOT
FOR
CONSTRUCTION
olsson
REVISIONS
FOUNDATION DETAIL
CITY OF MOUNT PLEASANT
SUBSTATION OPTION #1
MOUNT PLEASANT, IA
2024
SHEET
2 OF 3



[Larger version attached see “Skunk River Oil Containment” PDF]