Material Procurement Contract & Specification
Public Utility District #1
Of
Okanogan County

Step-Down Transformers
115 kV - 13.8 kV
12/16/20 MVA

Prepared by:
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1 Overview & Executive Summary

FOR
12/16/20 MVA TRANSFORMERS
OKANOGAN PUD

It is the intent of the Okanogan Public Utility District (District) to procure and install six - new 12/16/20-MVA transformers:

This specification outlines the requirements for manufacture and delivery of each new 12/16/20-MVA **Sandflat Substation**. The transformers shall have a design life of 35 years. The new 12/16/20 MVA Transformer will have the following ratings:

12/16/20 MVA Transformer Ratings					
Rating	ONAN/ONAF1/ONAF2	**HV tap A**	120,750 Volts	**Impedance**	8.5%
Frequency	60 Cycles	**HV tap B**	117,875 Volts	**Total Weight**	
Temp. Rise	65^0 C rise self cooled	**HV tap C**	115,000 Volts	**Oil Weight**	
Phase	3	**HV tap D**	112,125 Volts	**Phase Angle relationship**	Low side lags high side by 30^0
HV winding Connection	Delta	**HV tap E**	109,250 Volts	**HV Phase Bushing**	800 Amps Standard type
LV winding Connection	Wye	**Low voltage winding**	13,800 L-L 7967 L-N Volts	**LV Bushing**	1200 Amps Standard type
HV Winding BIL	450 kV	**HV bushing BIL**	450 kV phase	**Bushing Current Transformers High Side**	Each bushing 2 x C400 CTs 600/5 multi ratio
LV Winding BIL	110 kV	**LV bushing BIL**	110 kV 110 kV neutral	**Bushing Current Transformers**	Each bushing 2 x C400 CTs 1200/5 multi ratio

The table used for general reference only, and is not to be used specifically for bid preparation or quotation of any kind. Please refer to the technical section for details.

2. Identification of Parties

2.1. **Owner:**

Contractual Issues
Public Utility District #1 of Okanogan County
1331 Second Ave. N.
P. O. Box 912
Okanogan, WA 98840
Attention: Roy Schwilke Contracts Administrator
Telephone: 509-422-3310
Email: RoyS@okpud.org

Technical Issues
Public Utility District #1 of Okanogan County
1331 Second Ave. N.
P. O. Box 912
Okanogan, WA 98840
Attention: Kyle Richter, System Engineer
Phone: 509-422-8423
Email: KyleR@okpug.org

2.2. **Engineer:**

Ripplinger Engineering Laboratories
4117 N Garry Rd
Otis Orchards, WA 99027
Telephone: 509-892-1375
Email: R.E.L@comcast.net

2.3. **Manufacture:**

The manufacturing firm that the Owner shall select to supply the equipment specified in these documents.

3. Bid Terms & Conditions

3.1. All bids shall be firm and remain valid for 30 days from the bid due date. All bids shall be complete with regard to these specifications.
3.2. Alternate bids as well as optional equipment and/or services recommended by manufacture shall be delineated and priced separately.
3.3. Field installation services shall be priced or bid separately. If priced, price schedule shall include all costs including test equipment costs, shipping and complete travel expenses.
3.4. Standard Manufacture's Terms & Conditions do not apply unless agreed to by letter or other written form by Owner.

4. **Bid Technical Data Requirement:** These requirements are found in the Bid Proposal data sheets to be filled out by Manufacturer.

5. **Equipment Guarantee:** Without limiting any other provisions of this specification regarding guarantees, the Manufacturer shall guarantee that the complete transformer, together with all parts included in the original purchase is free of defect in workmanship and materials, and is capable of continuous and satisfactory performance when operated in accordance with the instructions provided by the Manufacture at the specified rating and capacity.

1. **General**

1.1. This specification covers six three-phase liquid-filled generator step-down transformers for outdoor application.

1.2. Transformer shall be designed and manufactured to the latest ANSI/IEEE standards. If this specification indicates stricter performance requirements than ANSI/IEEE, this specification shall prevail.

1.3. It is the intention of these Technical Specifications to ensure transformer and auxiliary equipment quality. If any of these specifications differ with the Manufacturers standard components, the manufacturer is encouraged to contact the Engineer to discuss proposed alternate materials and/or procedures. It is up to the Engineer in all circumstances to approve such materials *before incorporation into the transformer. Engineer reserves the right to reject proposed materials and/or procedures. All approved proposed changes must be in writing and signed by the Engineer and Owner.*

2. **Service Conditions**

2.1. Continuous Duty.

2.2. Ambient temperature - Cooling air shall not exceed 40^0 C and the average temperature of the cooling air for any 24 hour period shall not exceed 30^0 C.

2.3. Altitude - The altitude of the transformer installation is less than 3300 feet above sea level.

2.4. Transformer oil system shall be capable of operation from **-30^0C to 105^0**C.

2.5. Transformer shall be braced for operation in Seismic Zone 2B (0.2 g)

3. **Rating & Electrical Characteristics**

3.1. Supply voltage and current - sinusoidal with a harmonic factor of less than 0.05 per unit.

3.2. 60 Hertz.

3.3. Three Phase.

3.4. Step Down use.

3.5. Operation above rated voltage or below rated frequency - transformer shall be capable of operation at 110% volts/hertz.

3.6. Transformer Capacity:

3.6.1. 12 MVA at 65^0 C rise, ONAN
3.6.2. 16 MVA at 65^0 C rise, ONAF1
3.6.3. 20 MVA at 65^0 C rise, ONAF2

3.7. Transformer shall have the following high-voltage winding taps, and be constructed for grounded WYE operation:
3.7.1. Tap A - 120,750 Volts
3.7.2. Tap B - 117,875 Volts
3.7.3. Tap C - 115,000 Volts
3.7.4. Tap D - 112,125 Volts
3.7.5. Tap E - 109,250 Volts

3.8. High voltage winding tap changer mechanism shall be of the "de-energized operation" type. Tap changer shall have provision to pad lock in place.

3.9. High voltage winding and phase bushings shall have a BIL rating of 450 kV.

3.10. High voltage winding shall be DELTA connected

3.11. Transformer shall have the low voltage winding rating of 13,800 Volts.

3.12. Low voltage winding shall be WYE connected.

3.13. Low voltage winding shall lag high voltage winding by 30 electrical degrees (standard design).

3.14. Low voltage winding and bushings shall have a BIL rating of 110 kV.

3.15. Transformer shall have standard 8.5% impedance; subject to ANSI/IEEE C57.12.00 and C57.12.10 tolerance. Impedance shall be measured at rated average temperature rise plus 20^0 C.

3.16. Transformer shall have a through fault capacity as specified in C57.12.00. 7.1. The following system impedances shall be used to calculate 12/16/20 MVA through fault capacity:

115 kV System Minimum Impedance Ohms on 100 MVA Base	
Z(+)	0.014 + j0.092
Z(-)	0.014 + j0.092
Z(0)	0.043 + j0.275
X/R	6.4

3.17. **Bushings** shall conform to the latest ANSI/IEEE Std. 24. All bushings shall be so designed that there will be no undue stressing of any parts due to temperature changes, and adequate means shall be provided to accommodate conductor expansion. High voltage bushings (115 kV) shall be **ABB Style 115W0800AA or exact bolt in replacement**.. All contact surfaces of external terminals shall be silver plated using pure silver free of copper, and the thickness of which shall be not less than 0.001 inch (0.025 mm). All porcelain used shall be free of lamination, cavities, or other flaws. Porcelain glazing shall be defect free.

3.18. Threaded stud-type terminals shall be furnished on the high voltage side, neutral and low voltage bushings. NEMA 4-hole space connector shall be provided to connect bushing terminal to substation conductors.

3.19. Bushing ratings:

	Voltage Rating	**Minimum Current Rating**	**BIL Rating**
High Voltage Side[1]	121 kV	800 A	450 kV
Low Voltage Neutral	15 kV	1200 A	110 kV
Low Voltage Side	15 kV	1200 A	110 kV

[1] High voltage bushing must be ABB Style 115W0800AA or exact bolt in replacement.

3.20. Neutral bushing: Provision shall be made to externally bond the neutral to the tank cover by means of a flexible copper braid and a standard NEMA 4-hole terminal connector. Connection to the tank shall be via a standard 4-hole NEMA stainless steel pad welded to the tank. An additional NEMA 4-hole terminal at the neutral bushing shall be provided for connection to substation ground grid.

3.21. Bushing spacing: High voltage bushings shall have spacing appropriate for 450 kV BIL level. Low voltage bushings shall have spacing appropriate for 110 kV BIL.

3.22. All porcelain bushings shall be ANSI-#70 light gray glaze.

3.23. Bushings shall be mounted on cover as per ANSI/IEEE C57.12.10 section 9.

3.24. **Surge & Lightning Protection:** Transformer shall be equipped with electrical surge protection on both the primary and secondary as follows:

3.24.1. H1, H2 &H3 connections to each have one polymer station class 96.0 kV maximum continuous operating voltage (MCOV) arrester.

3.24.2. X1, X2 &X3 connections to each have one polymer station class 10.0 kV maximum continuous operating voltage (MCOV) arrester.

3.24.3. Arrestor shall be mounted on steel structure adjacent to transformer bushings. 4/0 Copper ground cable shall be run by customer up one side of the transformer, through the arrester connections and down the opposite side of the transformer, thereby forming a loop. Transformer manufacture shall make provision for properly attaching cable to sides of the transformer. One loop shall be run for H side arresters and another loop for X side arresters.

3.25. **Grounding Pads:** Transformer shall have four stainless steel 2-holed NEMA pads welded to the transformer tank adjacent to each tank corner.

4. **Auxiliary Electrical Systems**

4.1. **Current Transformers (CT):** Transformer shall be equipped with bushing type current transformers as follows:

Transformer Leads	Number per Bushing	Ratio	Overload Rating	Accuracy
H1,H2,H3	2	600:5 Multi-ratio	1.0	C400
X0	2	1200:5 Multi-ratio	1.0	C400
X1,X2,X3	2	1200:5 Multi-ratio	2.0	C400

4.1.1. All current transformer leads shall be brought to the auxiliary control cabinet on transformer side wall.

4.1.2. All current transformer leads shall be terminated on shorting type terminal blocks. Only heavy duty 75 Ampere, 600 Vac terminal blocks with double #10-32 screws per node shall be used (such as Marathon Special Products / Kulka 1506SC or equal). Terminal blocks shall not be of DIN rail mounting type. Current transformer secondary wiring shall use ring tongue compression connections only.

4.1.3. Current transformer secondary wiring shall be AWG #10, 600 Vac or larger.

4.1.4. Current transformer secondary wiring shall be run in dedicated metal conduit. Wiring other than CT wiring shall not be run in dedicated CT conduit.

4.2. **Auxiliary Supply Circuits:** Terminal blocks shall be provided for both single phase 240 Vac fan/heater supply and single phase 14 Watt LED rough service 120 Vac light and 120 Vac GFI duplex courtesy receptacle.

4.2.1. 240 Vac single phase power supply input terminal block shall be heavy duty 75 Ampere, 600 Vac with #10-32 screws suitable for ring tongue compression connectors, 6 terminals. Terminal blocks shall be Marathon Special Products / Kulka 1506STD or approved equivalent.

4.2.2. 120 Vac single phase power supply input terminal block shall be heavy duty 75 Ampere, 600 Vac with #10-32 screws suitable for ring tongue compression

connectors, 4 terminals. Terminal Blocks shall be Marathon Special Products / Kulka 1504STD or equal.

4.2.3. Both 120/240 Vac power supply 120 Vac "legs" shall each have a 120 Vac signal relay with at least one set of form "C"[2] contacts to provide customer loss of power remote status indication system with indication of loss of control power. Simple control relay such as Magnecraft 750XBXM4L-120A or approved equivalent is suitable for signal relay.

4.3. **Cooling Fan Circuits:** Transformer shall be supplied with one stage of cooling fans with automatic and manual control system to provide proper cooling for FA rating of the transformer. Control system shall be complete for the installation of a second stage of future fans.

4.3.1. Cooling Fans shall be single phase, 230 Vac, 60 Hz. *Fan motors shall not have internal mechanical shaft driven starting switch.*

4.3.2. Separate single phase 240 Vac circuit breaker shall be provided for fan circuit.

4.3.3. Cooling fan control circuit shall be 120 Vac. Automatic fan control shall be controlled by winding temperature (49) thermometer assembly.

4.3.4. Cooling fan control circuit shall be provided with a manual control switch with the following settings:

4.3.4.1. Off
4.3.4.2. Automatic
4.3.4.3. On-Stage One
4.3.4.4. On-Stage Two
4.3.4.5. On- Stage 1 & 2

4.3.5. Fan control contactors (stage 1 and stage 2) shall have at least one set of form "C" contacts for remote status indication. Signal relay such as Magnecraft 750XBXM4L-120A or approved equivalent placed in parallel with each contactor operate coil is acceptable.

[2] A "C" contact is a three wire Normally Open and Normally Closed contact combination. One wire is common to both NO and NC contact.

4.4. **Cabinet Heater System:** Strip heaters shall be provided to eliminate moisture condensation in auxiliary cabinet.

4.4.1. Heaters shall be operated on 240 Vac.

4.4.2. Heaters shall have no moving parts.

4.4.3. Heaters shall be equipped with a metal shield or screen to reduce the possibility of contact with heater element.

4.4.4. Heater circuit shall have independent circuit breaker or dead front fuses.

4.4.5. Heaters shall be of the low wattage, continuous type (no thermostats). Heater wattage shall be low enough such that cabinet internal temperature rise shall not exceed 20^0 C from ambient outside temperature.

4.4.6. Heaters shall have a dead front manual on/off switch.

4.4.7. Heaters shall be placed on cabinet wall as close to the floor as recommended by manufacturer.

4.5. **Terminal Blocks** (other than CT or power supply): Terminal blocks shall be of heavy duty construction with a 20 Ampere, 600 Vac rating. Terminal blocks shall have #10-32 screws suitable for ring tongue compression wire terminals. DIN rail mounting is acceptable for other than CT or supply power circuits. All status and indication contacts shall be brought out from device and terminated on terminal blocks. Customer shall wire from terminal blocks to customer apparatus.

4.6. **Cabinet** shall be of such size that terminal blocks on customer wiring side shall have at least 8 inches (20 cm) from terminal block edge to any other device including CT and power supply terminal blocks. No devices or equipment shall be mounted to the cabinet floor. All enclosures shall be mounted in a position readily accessible from the ground when the transformer is mounted at the manufacture's recommended pad height.

4.7. **Sudden Pressure Relay:** Transformer shall have appropriate sudden pressure relay and seal in circuit suitable for 125 Vdc control power. Seal in circuit shall provide at least two form "C" contacts suitable for customer lockout relay operation.

4.8. **Winding Temperature Relay (on Indicator):**

4.8.1. Adjustable Alarm contacts; shall have one form "C" contact.
4.8.2. Adjustable Trip contacts; shall have one form "C" contact.
4.8.3. Adjustable Fan control contacts.

4.9. **Oil Temperature Relay (on Indicator)**

4.9.1. Adjustable Alarm contacts; shall have one form "C" contact.
4.9.2. Adjustable Trip contacts; shall have one form "C" contact.

4.10. **Oil Level Relay (on Indicator)**

4.10.1. Adjustable Alarm contacts; shall have one form "C" contact.
4.10.2. Adjustable Trip contacts; shall have one form "C" contact.

4.11. **Remote Monitoring Electronic Equipment** - Transformer shall have a digital remote monitor that monitors various transformer quantities. Unit shall be complete with software. Unit shall be communicated with and programmed locally via an RS 232 or USB connection. Unit shall monitor the following:

4.11.1. Winding temperature.
4.11.2. Oil temperature.
4.11.3. Oil level. A differential pressure transducer is acceptable, one port connected to the very bottom of the oil space, the other port connected to the ullage space. Such transducer shall be capable of exposure to vacuum and pressure levels in transformer oil space during oil vacuum processing and highest tank pressure.
4.11.4. Nitrogen Cylinder Pressure gauge pressure; 0 to 3000 PSIG (1.6 MPa) or closest standard range[3].
4.11.5. Ullage (gas space) gage pressure; -15 to +15 PSIG (+/- 100KPa) or closest standard range[3].

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[3] A standard transducer shall be selected that has the range specified included if exact conformance to the specified range is not available from transducer manufacture. Transducer range is not to be more than 200% of that specified to limit loss of transducer resolution.

5. **Thermal Performance:**

5.1. Maximum temperature rise permitted: Not exceeding a 65^0 C average winding temperature rise by winding resistance, or an 80^0 C hottest spot temperature rise as covered in the latest version of IEEE C57.12.00 & C57.12.10.

5.2. Transformer shall be suitable for operation over a range of top-oil temperature from -30^0 C to 105^0 C provided the liquid level has been properly adjusted to the indicated 25^0 C level.

6. **Loss Performance:**

Losses shall be measured using methods delineated by ANSI/IEEE C57.12.90. Losses shall be multiplied by the following loss multipliers. The results for each loss shall be added by the Owner to the bid value of the transformer for evaluation of total transformer cost.

6.1. **No load losses at 100% voltage shall be $3,300/kilo-Watt**. The core losses shall be measured and corrected to 85^0 Celsius. (IEEE C57 12.90.8)

6.2. **Load losses at 100% ONAN loading and 100% voltage shall be $2,250/kilo-Watt at 12 MVA load.** Full winding losses shall be measured and corrected to 85^0 Celsius (IEEE C57 12.90 sections 9 & 14.1)

6.3. Auxiliary power requirements shall be with measured with full cooling fans and heaters operating. **Total auxiliary power will be calculated at $1,500/kilo-Watt**.

6.4. Liquidated Damages shall be assessed to the Manufacture if actual losses exceed losses indicated in this bid submittal. The damages shall be based on the same evaluation listed in 6.1 through 6.3 above. Amount of liquidated damages, if any, shall be retained from final payment. No credit is due manufacturer if actual losses are below the losses indicated in the bid submittal.

7. Mechanical & Physical Characteristics

7.1. Windings:

7.1.1. Windings shall be of copper only.

7.1.2. Windings shall be of circular construction only.

7.2. Tank Assembly:

7.2.1. Tank is to be of welded steel plate construction with a welded cover.

7.2.2. Tank is to be oil tight with oil-fittings in place.

7.2.3. Tank shall be designed to withstand internal pressure with no leaks when using warm oil as per ANSI C57.12.10-7.5.1.

7.2.4. Tank shall be suitable for vacuum filling and vacuum drying in the field.

7.3. Joints and Gaskets:

7.3.1. All gasket joints are to be provided with machined surfaces.

7.3.2. All joints shall be provided with the necessary stops to assure even and effective pressure on the gasket at all points.

7.3.3. The gasket shall be provided with suitable means to prevent overstressing the gasket and to maintain oil tightness of the joint under all service conditions.

7.3.4. The joints shall be provided with gasket retainers and metal-to-metal stops.

7.4. Transformer and Apparatus Height:

7.4.1. Manufacturer shall conform to latest National Electric Safety Code for height of energized parts above 600 volts.

7.4.2. Transformer Manufacturer shall provide an outline drawing with each transformer bid.

7.5. **Core and Core assembly:**

7.5.1. Core shall be manufactured from high quality transformer steel suitable for operation at rated frequency. 1 kg of steel scrap from the construction process shall be supplied with the transformer for customer archive.

7.5.2. Laminations shall be of a "non-aging" alloy. Manufacturer will provide aging information with transformer bid.

7.5.3. Joints in the winding or bushing locations shall be joined by high temperature process (electric arc or flame brazed) or compression spliced. Relatively low temperature processes such as soldering are not allowed. Manufacturer shall provide a complete description of splicing process used.

7.5.4. All insulating material in contact with transformer oil shall be chemically compatible with oil for long term use (greater than 50 years) and shall not be affected by oil.

7.5.5. The transformer assembly shall be braced and bolted adequately to prevent displacement and distortion of the core and core assembly under all normal conditions of handling and operation as well as under fault conditions.

7.5.6. Locking provisions shall be used on all inside bolted connections.

7.5.7. Transformer serial number shall be stamped on the core in a conspicuous place.

7.5.8. Core ground shall be accessible from the manhole for testing of the core ground.

7.5.9. Core-coil assembly shall be of the circular type design only.

7.6. **Radiators:**

7.6.1. The transformer shall be provided with removable radiators. Radiators shall be attached to headers with bolted connections. Each connection shall have a valve to permit the isolation and removal of the radiators without draining the main tank oil. Radiator assembly shall have its own drain plug.

7.6.2. Picking eyes or similar devices, and a rigging and maintenance procedure shall be provided for the removal and repair of individual radiators.

7.7. **Transformer Oil:**

7.7.1. Transformer oil shall be provided complete with new oil. Oil shall comply fully with ASTM D3487 latest version, Specification for Mineral Insulating Oil Used in Electrical Apparatus.

7.7.2. Oil shall have less than 1 parts per million polychlorinated-biphenyls (PCBs). Oil shall be certified by petroleum supplier as "NON PCB".

7.7.3. Manufacture is invited and encouraged to supply an option to bid for the use of Cooper FR3™ Envirotemp® fire resistant natural ester fluid. Please refer to "Bid Proposal Data Form".

7.7.4. Transformer shall be provided with oil inhibited (Type 2) with di-tertiary-butyl-par-cresol (DBPC) or equal. The amount of DBPC shall be 0.3% by weight. Inhibited oil shall be indicated on transformer nameplate. If oil is a non-petroleum base fluid, manufacture shall adhere to oil manufacture's specifications and guidelines regarding preservative.

7.7.5. Transformer shall be shipped with the oil installed, and labeled PCB free. If some oil must be shipped separately, it shall be in new 55 gallon (208 liter) sealed steel drums, new IBC "Cargo-Tote", or cleaned and certified tanker truck. For quantities less than 6 cubic meters (1600 gallons) IBC containers are preferred.

7.7.6. A certified test report shall be supplied stating that the transformer has been filled with PCB free oil.

7.7.7. A two x one liter samples of the transformer oil shall be taken of the Manufacturer's new oil before it is added to the transformer to serve as a future basis.

7.8. **Oil Preservation System:**

7.8.1. The oil preservation system shall be of the gas-oil seal type as defined in ANSI C57.12.10, paragraph 22.3 (3) except that the temperature range shall be as specified below.

7.8.2. Oil preservation system shall be designed to permit satisfactory operation of the system over a liquid temperature range of -30^0 to 105^0 C.

7.8.3. Manufacturer is invited to supply price adjustments for an alternate oil preservation system of inert gas pressure system. Such system shall conform to ANSI C57.12.10 paragraph 22.3 (1).

7.8.4. High pressure nitrogen cylinder shall have a Form A dry contact indicating the nitrogen cylinder is at or below 250 psi.

7.8.5. Nitrogen Cylinder connection shall be standard CGA No. 580 with right hand thread.

7.9. **Plumbing[4]:**

7.9.1. Transformer exterior nitrogen and monitoring system plumbing shall be of stainless steel 304 or 316 tubing. Tubing connectors shall be of the "Swagelok" compression/wedge two ferrules or approved equal. Gap inspection tools shall be used for proper connector tightening.

7.9.2. Nitrogen pressure regulator and associated pressure controls shall be of standard brass or stainless steel construction. National Pipe Thread/Size (NPT) connections are allowable.

7.9.3. Gas valves shall be provided for purging the gas spaces of the transformer interior and permit testing of the seal on the transformer by admitting dry nitrogen under pressure.

7.9.4. All gas valves shall be of stainless steel construction. Valves shall have welded bellows stem construction and compression/wedge two ferrule tubing connection, such as Swagelok or approved equal.

7.9.5. Small NPT gas connections to the transformer interior space may be of mild steel construction and NPT stainless steel to tubing connection shall be used to continue to other devices.

[4] Unfortunately, oil and nitrogen plumbing on transformers cause a majority of transformer maintenance activity.

7.9.6. One, two inch NPT drain globe valve with sampling device shall be provided for the lower connection of a filter press. A minimum of two inches of pipe shall be installed outside of the tank. Valve shall be of the standard 4 bolt flange type. A flange to 2 inch NPT threaded fitting shall be fitted on the outlet, with a pipe plug installed. The drain line shall be located on a side wall at the very bottom of the transformer tank to allow complete draining of the transformer oil.

7.9.7. One, two inch NPT ullage globe valve with sampling device shall be provided for the upper connection of a filter press. A minimum of two inches of pipe shall be installed outside of the tank. Valve shall be of the standard 4 bolt flange type. A flange to 2 inch NPT threaded fitting shall be fitted on the outlet, with a pipe plug installed. It is recommended to be of the same type and model as 7.9.6.

7.9.8. Great care shall be exercised in terminating any NPT connection. High grade pipe thread sealant such as Loctite PST 561 or approved equivalent shall be used. *Teflon tape shall not be used on any threads.* Threads shall not be chipped or damaged during the threading process and proper National Pipe Thread chart shall be used to ensure minimum thread length.

7.10. **Paint -** All exterior surfaces are to be thoroughly cleaned of mill scale and rust by shot or grit blasting. Surfaces are to be prepared in accordance with Steel Painting Council SSPC-10 near white blast cleaning. Oil and grease are to be removed by suitable solvent. One epoxy based primer and two epoxy based finish coats of paint shall be applied in a quality manner. Minimum thickness of each coat shall be (DFT) 0.003 inches (76 micro-meters). Color shall be ANSI #70 light gray. Powder coating of the exterior surfaces are considered superior to painting. Manufacturer shall include additional price for powder coating if such capability is available. Powder coat must be capable of long term outdoor weather exposure. Please refer to “Bid Proposal Data Form”.

7.11. **Lifting, Moving and Jacking Facilities** - Facilities shall be in conformance with ANSI C57.12.10 - Ph. 19.2.6 and the following:

7.11.1. Jacking facilities shall be welded to the tank near the base at each corner and suitable for lifting the fully assembled transformer with oil.

7.11.2. Lifting lugs welded to the tank near the top suitable for lifting the fully assembled transformer with oil.

7.11.3. Base plate with beveled edges for easy skidding designed for rolling or skidding parallel to either centerline.

7.11.4. Pulling eyes mounted at the base, two per side, to allow the transformer to be pulled in a direction parallel to either center line.

7.11.5. Eyes for lifting man cover.

7.11.6. Facilities for lifting core and coil assembly.

7.11.7. A complete set of rigging, lifting, moving and installation instructions shall be provided.

7.12. **Noise Level -** Noise level shall not exceed standard decibel levels shown in NEMA Standard TRI-1974, or latest version, for BIL and rating of transformer.

7.13. **Pressure Relief Device -** Mechanical pressure relief device with alarm contacts ("C" type contact as described in Electrical 4.7) to indicate when the relief has operated shall be provided.

7.14. **Wiring & Conduit Methods:**

7.14.1. Wiring, conduit, and pneumatic piping shall be fabricated and installed in a neat, workmanlike manner considered acceptable in the industry.

7.14.2. All wiring runs shall be in rigid steel or aluminum conduit, except for short flexible conduit runs to fans, instruments, or other equipment.

7.14.3. Short runs of flexible cable shall be outdoor rated cable, NEC rated "SOOW", such as Anixter 4AX series or approved equal. Cable shall be expressly rated for exposure to moisture and weather in an outdoor application. Minimum size on flexible cable shall be #12 AWG.

7.14.4. Flexible cable runs shall be long enough so that connected equipment such as fans, gauges, and other devices may be mechanically un-mounted from the transformer without interference from flexible cord.

7.14.5. All devices shall be wired to terminal blocks (as per the Electrical section) located in rain-tight enclosure near the base of the transformer. These enclosures shall have provision for two (2), four-inch conduit connections on the bottom. All enclosures shall be mounted in a position readily accessible from the ground when the transformer is mounted at the recommended pad height.

7.14.6. All wiring shall be marked at both ends using permanent wire markers. Wire marker wire designator shall correspond to wiring diagrams submitted. Adhesive wire markers are not considered by Owner to be permanent and not allowed.

8. **Spare Equipment:** Manufacturer shall provide the following spares included in transformer bid. Manufacturer shall also provide a list of additional spares recommended by Manufacturer at extra cost to Owner.

Note: The total number of spares is for the complete order of six (6) 12/16/20 MVA transformers.

8.1. 121 kV apparatus bushing, two in total.
8.2. 15 kV apparatus bushing, two in total.
8.3. High voltage side lightning arrester, six in total.
8.4. Low voltage side lightning arrester, six in total.
8.5. Complete set of gaskets, one set.
8.6. Cooling fan, six in total.
8.7. Cabinet heater, six in total.
8.8. CT type terminal blocks, six in total.
8.9. Terminal blocks general (other than CT or Power blocks), two in total - if of the DIN rail type, 12 spare terminals.

9. **Morgan-Schaffer Calisto 9 Transformer Monitor:** Manufacturer shall procure and install a Morgan-Schaffer Calisto 9 Transformer Monitor on each transformer. Units shall be installed as per Calisto 9 instruction manual. Units shall be procured with the following:

9.1. DNP3 Ethernet communications for interface with Owner SCADA system. The physical communications can be a copper RJ-45 interface or a Fiberoptic interface using ST connectors operating at a wavelength of 1300 nm. Communications to a third party device, such as an SEL 2411 is acceptable, provided that analog quantities can be polled via DNP protocol.
9.2. 125 Vdc power supply. Transformer Manufacturer shall connect power supply wiring from Calisto 9 to dedicated terminal block terminals for Owner connection.
9.3. Stainless steel 304 or 316 tubing with Swagelok or equivalent plumbing shall be used.
9.4. Plumbing connection of the Calisto 9 to the transformer tank shall include bellows type stainless steel valves. Valves shall be placed at the connection to the transformer tank and enable isolation of the transformer tank for replacement of the stainless steel tubing and/or the Calisto 9 unit without venting transformer tank.
9.5. Transformer shipment shall be complete with Calisto 9 software included.

10. **Inspection and Tests - General**

10.1. Engineer shall be present during any tests made on the transformers. Manufacturer shall notify Owner in writing 21 days prior to any and all tests or inspections required as part of this specification.

10.2. Standard tests shall be made on the transformer, except as specifically stated below. All tests shall be made in accordance with the current version of ANSI C57.12.90. The Manufacturer is to record which test method was used when more than one test method is allowed by test code.

10.3. Two copies of each test and inspection reports shall be delivered to the Owner within 10 days of completion of the test. Additionally, a complete set of test and inspection reports and results shall be submitted upon project completion. Electronic PDF files are acceptable.

11. **Tests**

All tests shall be performed and completed in strict adherence with ANSI/IEEE specification C57.12.90, latest version.

11.1. **Resistance:** The cold resistance of each winding shall be measured and corrected to 65^0C + 20^0C = 85^0C as recommended in IEEE C57.12.90, 5.2.

11.2. **Ratio:** The ratios for the windings and for all taps shall be determined.

11.3. **Polarity and phase relation**: The angular phase displacement shall be tested and the lead marking checked on each transformer winding.

11.4. **No-load loss** at rated 100% and 110% voltage.

11.5. **Excitation current:** The exciting current and waveform (photo of oscilloscope display) at 90, 100 and 110 percent rated voltage.

11.6. **Impedance** positive and zero sequence impedance shall be measured between all windings.

11.7. **Losses** at full load shall be measured.

11.8. **Temperature Tests:**

11.8.1. Temperature test shall be performed in accordance to ANSI C57.12.90 ph. 11.5.2. If Owner orders two or more identical transformers, manufacture may use the "Loading Back Method" ph. 11.5.2.2.

11.8.2. Transformer shall be tested at OA and first FA rating.

11.9. **Impulse tests:** Transformer shall be tested according to ANSI C57.98, impulse testing. Transformer shall be tested for the three basic impulse wave shapes and electrical responses recorded on appropriate oscillograms:

11.9.1. Full wave
11.9.2. Chopped wave
11.9.3. Front-of-wave

11.10. **Dielectric test:** Transformer, complete with its own bushings, shall be given applied potential and induced-potential test in accordance with C57.12.90.

11.11. **Insulation Power Factor test:** Each winding of the transformer shall be given a power factor test, and this data recorded.

11.12. **Regulation:** No regulation test is required.

11.13. **Efficiency:** Transformer efficiency shall be computed at each of 50, 75, and 100 percent load, at 100 percent tap voltage, 75^0C and 1.0 per unit power factor.

11.14. **Transformer Case** - Case shall be tested for oil and gas leaks when filled with oil at approximately 20^0 C to the normal level. Tests shall be made at 10 PSI (70 KPa) or greater for at least 30 minutes followed by 8 PSI (55 KPa) or greater for 24 hours.

11.15. **Bushing Tests:**

11.15.1. Power factor and capacitance voltage of each high voltage bushing shall be measured and recorded with the serial number of the bushing.

11.15.2. Each bushing current transformer secondary shall be given a low-frequency dielectric test of 2500 volts to ground for one minute and shall be checked for proper nameplate and polarity markings. To insure correct installation after mounting in the transformer, bushing shall be given a polarity check and ratio check.

11.16. **Control and Auxiliary Circuit Dielectric Test:** These devices shall be tested by application of 500 Volt DC Megger to ground. Electronic equipment manufacturers shall be consulted as to the ability of such equipment to withstand such test without damage.

11.17. **Insulating Oil:** Documentation stating the manufacture and specification of the oil furnished and test results on the oil after all transformer testing is complete shall be as follows:

11.17.1. Gas in Oil.
11.17.2. Oil Dielectric, Interfacial Tension and acid levels.
11.17.3. Karl Fischer moisture analysis.

11.18. **Test Documentation**

11.18.1. Each test and inspection shall be documented as per applicable IEEE standard for each test.

11.18.2. Results of every test or inspection shall be submitted by Manufacturer to Owner within 10 days of the completion of the test.

11.18.3. Submittals may be electronic in standard format (Word, Excel, PDF, or other Owner approved application), or in duplicate hard copy. Electronic copy is preferred.

12. **Photographs:**

12.1. A complete set of photo documentation of the manufacturing process and critical fabrication and assembly steps is required.

12.2. A set of digital photographs from each side of the core and coil prior to tanking shall be provided.

12.3. Photos shall be comprehensive for all major physical attributes.

13. **Delivery and Shipment:**

13.1. All bids shall include Freight On Board (F.O.B.), Pre-Paid, delivery of the **six power transformers to the Sandflat Substation** Okanogan County. For the purpose of this contract, Point of Delivery shall be the Sandflat Substation 378 Omak River RD Omak Washington 98841, Okanogan County, USA.

13.2. Transformers may be shipped via rail if proper impact and acceleration limiting rail cars and/or procedures are taken. If shipped by rail, Manufacturer shall consult Railroads for assistance with shipping schedule; rail routes and local unloading/truck transfer site selection.

13.3. Transformers may also be shipped via truck.

13.4. **Transformers shall be shipped to the respective substation sites by Manufacturer and set on substation transformer pad.** A complete set of picking and rigging instructions shall be submitted by Manufacturer for the safe off loading of the equipment at the Owner's site.

13.5. All shipping methods shall include a three axis recording accelerometer to record any undue accelerations and/or impacts imparted to each transformer. Accelerometer shall remain on transformer until transformer is set on the pad. Accelerometer recording shall be labeled for each portion of the journey so as to clearly identify each shipping and lifting phase of the transformer movement and the entity responsible for each movement.

13.6. All accelerometer recordings shall be copied by Owner and originals sent back to Manufacturer for Manufacturer's engineer to analyze and record.

13.7. Transformer shall be shipped oil filled or filled with an anhydrous (no moisture) nitrogen blanket of positive pressure.

13.8. A 30 day advance notice of transformer's delivery shall be provided to Owner. In addition, the transportation agent shall notify Owner by telephone or fax no less than 48 hours in advance of the transformer's arrival at the site.

13.9. Transformer shall be delivered between:

Two Transformers – June 1, 2021 and July 31, 2021
Two Transformers - September 1, 2021 and October 31, 2021
Two Transformers – March 1, 2022 and May 31, 2022

If Manufacturer shall fail to deliver transformers as outlined in the above schedule, then Manufacturer shall agree to pay to Owner, not as penalty, but as liquidated damages, $1,000 for every calendar day outside of the allowable delivery dates.

13.10. Delivery shall be between 08:00 and 12:00 noon Monday through Friday to allow transformer unloading during normal working hours.

13.11. The Manufacturer shall be responsible for the transformer and all related equipment during shipment and shall take whatever inspections are necessary after arrival to locate all shipping damage. Inspections shall be performed in the presence of Owner's representative. The Manufacturer shall settle any damage claims with the shipper.

13.12. Manufacturer shall provide a field service representative to supervise the unloading and perform bushing installation and to test the transformer prior to energization. Owner shall have the right to perform electrical and mechanical tests to the transformer at the Owner's expense prior to energization. If transformer is not placed in service immediately, Owner shall be responsible for the cost of redeploying field service representative. However, the cost of such deployment shall be stated in the Bid Proposal Data Form and shall be a firm price for 12 months.

14. **Instruction Manuals and Drawings:**

14.1. Owner shall be provided with three complete sets of installation, operation and maintenance instructions prior to transformer shipment and two complete sets of the above upon receipt of the transformer. These requirements are per transformer if the Owner orders more than one transformer. Replacement parts bulletins complete with identification symbols/drawings shall also be included with each instruction set.

14.2. Manufacturer shall also include in each set of documentation, a nameplate drawing with information as stamped on the transformer nameplate, complete with individual transformer tested impedance and serial number.

14.3. Manufacturer shall provide a complete set of drawings with each set of documentation. Such drawings will show both internal and external physical features of transformer.

15. **Approval Drawings:** The Manufacturer shall submit two copies of the following approval drawings after the Manufacturer's bid has been accepted:

    15.1. Base detail drawing.
    15.2. Nameplate.
    15.3. Bushing detail.
    15.4. Schematic and connection diagram for all control, CT and alarm circuits.
    15.5. Outline drawings.
    15.6. Arrester mounting bracket outline.

16. **Supply Chain Compliance:** The manufacture will provide an attestation that all equipment is complaint with all sections of Executive Order 13920 and that the manufacture adheres to the recommendations provided by the North American Reliability Corporation (NERC) regarding supply chain risk.

5 Construction Inspection Specifications

FOR

12/16/20 MVA TRANSFORMERS

OKANOGAN PUD

1. PURPOSE & SCOPE

    a. Inspection shall be performed by Owner and/or Engineer at various points in the Construction of each of the 12/16/20 MVA transformers.

    b. Construction inspection points (CIPs) shall be established at levels of completion to allow engineering inspection, witness of testing and documentation.

    c. Construction Inspection requirements of this specification shall not replace, or result in the omission of, any internal quality control procedure of the Manufacturer.

    d. Successful completion of such hold points, does not in any way, alleviate Manufacturer from any conformance to 12/16/20 MVA Technical Specifications or other obligation.

    e. Owner and/or Engineer will be prompt and work with Manufacturer's shop schedule to minimize any impact to 12/16/20 MVA production schedule or other production work of Manufacture.

    f. As it is understood that production schedules can and will change due to unforeseen circumstances, Manufacturer will give Owner and Engineer at least two weeks advanced notice of next CIP so Owner and/or Engineer may make proper travel plans.

    g. Owner and/or Engineer may, at the permission of Owner in written form, elect to skip a particular CIP. With receipt of written notice by Owner to skip a CIP, Manufacturer may continue with production work without inspection.

2. Construction Inspection Points

    a. Engineer shall inspect design process documents upon completion of all design calculations, design drawings, and materials lists.

    b. Transformer windings shall be inspected by Engineer after windings are complete. **Manufacturer shall provide a ½ meter sample of high voltage and low voltage conductor and a sample of high voltage and low voltage insulating material for Owner's future reference.** One sample for the delivered set of two transformers is adequate.

c. Transformer iron core shall be inspected by Engineer after iron stacking and clamping. **Manufacturer shall provide a 1 kg iron core lamination sample from shearing process for future reference. Scraps from the shearing process are acceptable.** One sample for the delivered set of two transformers is adequate.

d. Manufacture shall supply **two x one liter bottles of new transformer oil taken from the supply truck/tank at the factory before the transformer is filled to provide a record of the oil supplied by the oil manufacturer.** Engineer shall witness the taking of the sample. Sample bottles shall be of the chemical reagent type - Wheaton 1000 ml low alkali borosilicate glass #219820 only; with PTFE (Teflon) cap - only. One set of samples for the delivered set of two transformers is adequate.

e. Engineer shall inspect completed no-load tap changer assembly and core and coil assembly before assembly is inserted into the transformer oil tank.

f. Engineer shall witness transformer tank and plumbing pressure testing.

g. Engineer shall witness final electrical testing.

h. Engineer shall witness unloading and field testing.

The Bid Proposal Data Form is to be filled out by the Manufacture and submitted with the Manufacture's Bid Package:

Bid Pricing Data Form		
Item		**Cost Total**
P-A	**Base bid price per 12/16/20 MVA Transformer;** as per specifications above, six transformers, delivered in 2021, FOB Sandflat Substation	
P-B	Owner progress payments computed as a percentage of base bid (per transformer): 15% upon order 20% at 4 months ARO 20% at 8 months ARO 20% upon successful completion of testing 25% upon final acceptance by Owner **Total percent deduction offered by Manufacture for progress payments:**	
P-C	**Cancellation Fee (each transformer)** 4 months ARO: 8 months ARO:	
P-D	**Loss Evaluation as per Technical Specification "Loss Performance" (each transformer)** $3,300 / kW no load loss $2,250 / kW full load loss 85^0 C $1,500 / kW Auxiliary loss	
P-E	**Warranty Period** Standard Warranty period from date of energization: 3 year extended if available: 5 year extended if available: 10 year extended if available:	
P-F	**Field Service Representative:** Representative shall be responsible for supervisions of installation of transformer bushings and field tests. If additional work or re-deployment is required for placing equipment in service, Representative is offered at the following rate including all expenses (each transformer):	
P-G	**Formal Factory Interview:** Should Manufacturer be selected for an Owner's representative site visit and capability discussion at Manufacturer's facility, cost:	

P-H	**Design Conference at Owner's Facility:** Cost for Manufacturer to provide design conference at Owner's facility prior to any award by Owner to any Manufacture:	
P-J	**Cooper FR3™ Envirotemp®** fire resistant natural ester fluid, additional cost above transformer mineral oil.	
P-K	**Powder Coating of Transformer Exterior surfaces in lieu of painting, if available.**	
P-L	**Identification of Point of Manufacture,** City and Country	

Bid Technical Data Form		
	Item	**Value**
T-A	High Voltage winding conductor maximum electric current density (amps per square centimeter) at rated power level (ONAN).	
T-B	Low Voltage winding conductor maximum electric current density (amps per square centimeter) at rated power level (ONAN).	
T-C	Winding conductor minimum electrical conductivity or resistivity at 20^0C. (Ohm*meters or per cent of International Anneal Copper Standard - IACS).	
T-D	Iron core maximum magnetic flux density (Tesla) at 100% rated AC HV tap voltage and rated frequency.	
T-E	Iron lamination minimum thickness.	
T-F	Magnetic induction curve for the proposed iron at 20^0C and aging information.	To be supplied on separate sheet
T-G	High voltage winding geometric design, i.e. circular, rectangular etc.	Circular Only
T-H	High voltage winding insulation type, i.e. paper, oil, air, etc.	Oil
T-I	Low voltage winding geometric design, i.e. circular, rectangular etc.	Circular Only
T-J	Low voltage winding insulation type, i.e. paper, oil, air, etc.	Oil
T-K	Shipping mass of larges piece (Maximum)	kg
T-L	Mass of core and coil assembly (Maximum)	kg
T-M	Mass of oil (Maximum)	kg
T-N	Mass of fully assembled transformer (Maximum)	kg
T-O	Type of oil preservation system	

T-P	Mass (or volume) of oil to be shipped separately Please indicate units (kilograms, cubic meters etc.) (Maximum)	kg or m^3
T-Q	Physical height to cover of transformer (maximum)	
T-R	Physical height to top of highest bushing (Maximum)	
T-S	Maximum base plate dimensions	L
		W
T-T	Maximum outside overall physical dimensions	H
		W
		D
T-U	Current rating of high voltage bushings	
T-V	Current rating of low voltage bushings	

Additional Information Required with Proposal: The transformer bid shall be complete and submitted along with the other information itemized below. Any exceptions taken by the Manufacturer to this specification shall be itemized in a separate letter of transmittal and made part of the proposal.

1 Manufacturer's supplemental descriptive data for all proposed equipment and accessories.

2 Proposed Nameplate.

3 Proposed Warranty.

4 Outline drawing.

5 Identify items that will be shipped unattached to the transformer.

6 Maximum guaranteed no-load loss measured at 85^0 C at 100% and 110% voltage.

7 Maximum full load OA and first FA rating load losses corrected to 85^0 C.

8 Auxiliary power requirements, kVA for cooling stages and heaters.

6 Bid Proposal Data Form

FOR

12/16/20 MVA TRANSFORMERS

OKANOGAN PUD

Information on Bid Proposal Data form is guaranteed by manufacture:

Manufacturer: _____

Manufacturer's Officer: _____

Officer's Title: _____

Date: _____

Bid shall be valid for 30 days from Owner's submission deadline