SEL Engineering Services, Inc.

Appendix A to RFP for SEAPA Ketchikan Substation Transformer Procurement

Ketchikan Substation Design Project
Power Transformer Specifications

Southeast Alaska Power Agency

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ACRONYMS AND ABBREVIATIONS

A	amperes
ac	alternating current
ASME	The American Society of Mechanical Engineers
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials International
BCT	bushing current transformer
BPVC	Boiler and Pressure Vessel Code (ASME)
C	celcius
CGA	Compressed Gas Association, Inc.
CT	current transformer
CTC	continuously transposed cable
dc	direct current
DETC	de-energized tap changer
EPA	Environmental Protection Agency
F	farenheit
FEA	finite element analysis
F.O.B.	free on board
GCFI	ground fault current interrupter
GRC	galvanized rigid conduit
HV	high voltage
Hz	hertz
IEEE	Institute for Electrical and Electronics Engineering
kV	kilovolt
kVA	kilovolt-ampere
LMFT	liquid tight flexible metal conduit
LTC	load tap changer
LV	low voltage
MVA	megavolt ampere
MVAR	megavolt-ampere reactive
MW	megawatt
NEMA	National Electrical Manufacturers Association
PCB	polychlorinated biphenyl
psi	pounds per square inch
PTC	positive temperature coefficient
RGS	rigid galvanized steel
RMC	rigid metallic conduit
SEL	Schweitzer Engineering Laboratories, Inc.

SEL ES	SEL Engineering Services, Inc.
UL	Underwriters Laboratory
UV	ultraviolet
V	volts
Vac	volt alternating current
Vdc	volt direct current

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SECTION 1: OVERVIEW

This specification details technical requirements for the purchase of one power transformer for the new Ketchikan Substation.

A summary of transformer ratings are as follows:

- Voltage
  - 115,000/66,395–34,500 V (grounded wye-delta)
- Capacity
  - 20/25 kVA ONAN/ONAF at 65°C rise
- Frequency – 60 Hz.
- BIL – 550 kV high voltage (HV), 550 kV HVN, 200 kV low voltage (LV).
- High-side de-energized tap changer (DETC) with 2.5 percent steps, with 2 steps above and 2 below the rated voltage.
- Impedance – 8.5 percent at 20 MVA.
- Oil insulated with a nitrogen gas preservation system.
- Round-core/circular-wound copper windings – high and low sides
- Galvanized radiators

Note: Any exceptions to these technical specifications must be clearly identified in the bid response.

SECTION 2: STANDARDS

The transformer shall be designed, constructed, and tested in accordance with the latest revision of the applicable IEEE, ANSI, ASTM, and NEMA standards, except where specific requirements of these specifications exceed these standards. In such cases, these specifications shall take precedence.

It is assumed that the equipment provided by the manufacturer will be in strict compliance with these specifications, unless specific exception is taken and an explanation is provided.

The current applicable revisions of IEEE, ANSI, ASTM, and NEMA standards are:

- IEEE Std C57.12.00, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
- IEEE Std C57.12.10, IEEE Standard Requirements for Liquid-Immersed Power Transformers.
- IEEE Std C57.12.70, Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers.
- IEEE Std C57.12.90, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
- IEEE Std C57.19.01-1991, IEEE Standard for Performance Characteristics and Dimensions for Outdoor Apparatus Bushings,
- IEEE Std C57.91, IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators.
- IEEE Std C57.98, IEEE Guide for Transformer Impulse Tests.
- IEEE Std C57.109, IEEE Guide for Liquid-Immersed Transformers Through-Fault-Current Duration.
- IEEE Std C 57.119-2001, Recommended Practice for Performing Temperature Rise Tests on Oil-Immersed Power Transformers at Loads Beyond Nameplate Ratings.
- IEEE Std C57.13-2006, IEEE Standard Requirements for Instrument Transformers.
- IEEE Std C57.104-2008, IEEE Guide for the Interpretation of Gasses Generated in Oil-Immersed Transformers.
- IEEE Std C57.119-2001, Recommended Practice for Performing Temperature Rise Tests on Oil-Immersed Power Transformers at Loads Beyond Nameplate Ratings.
- IEEE Std C57.120-1991, IEEE Loss Evaluation Guide for Power Transformers and Reactors.
- IEEE Std C57.131-2012, IEEE Standard Requirements for Tap Changers.
- IEEE Std C57.136-2000, IEEE Guide for Sound Level Abatement and Determination for Liquid-Immersed Power Transformers and Shunt Reactors Rated Over 500 kVA.
- IEEE Std C57.142, IEEE Guide to Describe the Occurrence and Mitigation of Switching Transients Induced by Transformers, Switching Device, and System Interaction.
- IEEE Std C57.144, IEEE Guide for Metric Conversion of Transformer Standards.
- IEEE Std C57.147-2008, IEEE Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers.
- IEEE Std C57.148, IEEE Standard for Control Cabinets for Power Transformers.

- IEEE Std C62.22, IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems.
- NEMA Standards Publication TR 1-2013, Transformers, Regulators and Reactors.
- ANSI/CGA V-1-1994, Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.
- ANSI/ISO 5712:2022, Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) – Method for Measuring The Power Generation Characteristics OF Piezoelectric Resonant Devices for Stand-Alone Power Sources.
- 2023 ASME Boiler and Pressure Vessel Code (BPVC).
- American National Standard for Unified Inch Screw Threads (UN and UNR Thread Form)
- ASTM D1275-96a, Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils.
- ASTM D92-05a, Standard Test Methods for Flash and Fire Points by Cleveland Open Cup Tester.
- ASTM D117-10, Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Oils of Petroleum Origin.
- ASTM D1933-03(2017), Standard Specification for Nitrogen Gas as an Electrical Insulating Material.
- ASTM D3487-00. Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.

SECTION 3: OPERATING CONDITIONS

The new transformer will be installed in Ketchikan, Alaska, on N. Tongass Highway, in Ward Cove. The transformer will be approximately 300 ft from the saltwater. Other conditions are as follows:

Ambient Temperature

- 19℃ maximum daily average
- Design for 40℃ maximum and –30℃ minimum

Elevation: The transformer specified herein shall be located at 3,300 ft above sea level, or less, and shall be rated for continuous operation at 3,300 ft altitude without de-rating.

Audible Sound Level: The sound level of the transformer shall not exceed levels of NEMA TR.1 when measured at the tap position of DETC "C."

SECTION 4: SPECIFICATIONS

Note: Any exceptions to these technical specifications must be clearly identified in the bid response.

4.1 ELECTRICAL CHARACTERISTICS

The transformer shall be two winding, oil immersed, outdoor type and designed to operate with the high-voltage neutral solidly grounded. Other characteristics include:

Number of Phases: 3

HV Capacity at 65°C Rise: 20/25 kVA

LV Capacity at 65°C Rise: 20/25 kVA

Cooling Class: ONAN/ONAF

Coolant: Mineral Oil, according to ASTM D3487

Frequency: 60 Hz

High Voltage: 115/66.39 kV, grounded wye

- HV BIL: 550 kV
- HVN BIL: 110 kV

Low Voltage: 34.5 kV, delta connected

- LV BIL: 200 kV

Impedance: 8.5 percent at 20 MVA (HV-LV)

Customer Supply Power: All ancillary, cooling, and control equipment shall be designed for operation from a 240/120 Vac, three-wire, 60 Hz, single-phase power supply.

The alarm circuit devices shall be rated for 125 VDC.

4.2 DE-ENERGIZED TAP CHANGER

The manufacturer shall state the guaranteed impedance at nominal voltage ratings and 65°C, ONAN rating with HV DETC at position "C" (115,000 V) tap in the quotation. Other characteristics include:

- Impedance Tolerance: ± 7.5 percent, according to IEEE C57.12.00-2021, paragraph 9.2.
- Taps at 2.5 percent and 5 percent above and taps at 2.5 percent and 5 percent below the rated voltage are to be provided. All taps are to be full-capacity rated.
- The tap changer for de-energized operation with operating handle shall be brought outside the tank.
- The operating handle for the DETC shall be located at a convenient height for operation by a person standing on the transformer pad.
- The operating handle shall include a position indicator with the highest voltage tap designated as "A."

- The operating handle shall have provisions for locking on position with a padlock.
- DETC: No load ratio adjusters shall be provided in the HV winding to permit changing of taps when the transformer is de-energized. The ratio adjusters shall be suitable for the maximum forced-cooled rating of the transformer. The tap changer control shall be brought out through the tank and provided with means for bolting or padlocking in any tap position. A hand hole for access to the tap changer shaft shall be provided.

4.3 LOAD TAP CHANGER

A load tap changer (LTC) is not required.

4.4 ELECTRICAL DESIGN

The transformer, including all core and coil assemblies, shall be power class, round-core/circular-coil design and construction.

The HV and LV windings for the main core/coil assembly shall be of either disk or helical construction; layer/barrel windings are not acceptable.

All windings shall be copper conductor and either rectangular magnet wire or continuously transposed cable (CTC).

All core bolts shall be insulated from the clamping structure at both ends. Core bolt insulation shall be high-temperature resistant.

The core and coils shall be assembled and braced to prevent displacement and distortion under all normal operating conditions, during handling and shipping, and under short-circuit conditions.

Insulating material, varnishes, compounds, and core material in contact with oil shall neither affect the oil, nor be affected by it, throughout the entire operating temperature range of the transformer.

All connections shall be brazed or clamped, not soldered.

Insulation on all conductors used in the coil winding process, except CTC, shall be cellulose insulating paper suitable for a minimum of 65°C rise continuous operation. It shall be wound onto the conductor employing a spinning process. The paper insulation shall be applied in single or multiple strands, such that a minimum of 30 percent of the paper surfaces are overlapped to provide for a continuous insulating surface. Sufficient tension shall be maintained on the paper strands so as to prevent loose wraps. If clamping rings are used in the transformer design, full-circumference rings shall be used.

The purchaser reserves the right to inspect the completed core and coil assembly prior to tanking. The manufacturer shall notify the purchaser not less than five days prior to the date of tanking to allow the Customer to witness tanking, if so desired.

Short-Circuit Withstand: The transformer design shall be adequate to withstand short circuits with the fault current limited only by the impedance of the transformer itself. The short-circuit withstand shall be calculated using finite element analysis (FEA) and shall consider all combinations of DETC and LTC tap positions for single-line-to-ground faults, double-line-to-ground faults, line-to-line faults, and other fault conditions to determine the tap position combination resulting in the highest stresses for transformer windings.

The transformer shall be designed and constructed to withstand the mechanical and thermal stresses produced by short-circuit conditions, as specified by the current ANSI/IEEE C57.12.00 and IEEE C57.12.90 transformer standards and guides.

Test data to substantiate claims of withstand capability in accordance with the current ANSI/IEEE C57.12.90 test standards shall be made available upon request.

Overload Capability: The transformer shall be capable of being loaded in accordance with the latest approved industry guides (IEEE C57.91, current revision). Loading capability will be limited by the temperature of the insulating media and not by ancillary components (bushings, tap changer, oil expansion, leads, bushing current transformers [BCTs], gaskets, etc.).

Core and coils shall be dried using a "vapor phase" system prior to filling.

4.5 COOLING EQUIPMENT AND CONTROLS

The cooling equipment shall be furnished as required to provide the rated capacity of the transformer without exceeding the guaranteed temperature rise. The cooling equipment control shall be provided via SEL-2414 Transformer Monitor. The forced cooling capacity shall be provided using fans for forced-air cooling. The temperature control shall be provided by winding temperature equipment, including a temperature indicator and relay contacts to automatically actuate forced cooling equipment in proportion to the transformer load. Cooling equipment motors shall be rated for service on a 120/240 Vac, single-phase power supply.

The control circuit devices shall be rated 120 Vac single phase and the cooling fan motors shall be rated 240 Vac. The fan motors must be "across the line" start induction motors without centrifugal switches and shall have NEMA specified frame sizes. The fan motors must have permanently lubricated bearings and hot-dipped galvanized housings. The mounting dimensions and shaft extensions must not be altered. The motors shall conform to the latest revision of NEMA MG-1. If vertically mounted, motors shall be designed for the added thrust loading that results. Motors shall be suitable for both continuous and intermittent operation. The fan blades and housings shall be of corrosion-resistant materials (stainless steel or aluminum). The alarm circuit devices shall be rated for 125 Vdc.

Manual control switches shall be provided in the control cabinet to allow testing and maintenance of the cooling fans and to enable selection of which group of fans is used for the first forced cooled stage. The transformer cooling equipment shall be designed for continuous self-cooled and maximum force-cooled operation.

4.6 MECHANICAL CONSTRUCTION

The tank and radiators shall be fabricated from steel with sufficient strength to withstand normal service stresses without distortion or damage. The tank shall be designed to withstand an internal operating pressure of 8 psi, with safety margin for a minimum of 25 percent over pressure and full vacuum. All tank seams shall be double welded (inside and outside) and shall be a minimum of 6 in from any corner. Corner welds are not acceptable. The cover shall be domed to shed water and welded to the tank. During welding of the transformer cover, an inorganic gasket will be permanently located between the cover and the tank flange to prevent the entrance of weld spatter into the tank. All gasketed openings shall be designed with means provided for controlled compression of the gasket, using machined metal-to-metal stops and reusable gaskets of oil-resistant material. All gasketed joints on the top of the transformer shall use flanges, which are raised at least 3/4 in above the cover surface. All external tank supports or stiffeners shall be box beam construction and continuously welded. The transformer shall be equipped with a base capable of being slid in a direction parallel to either centerline.

Paint

The transformer tank and all auxiliary equipment shall be painted with a rust-inhibiting primer and topcoat to provide a minimum 3 mil dry-film thickness. External paint color shall be sky gray, conforming to ANSI 70. The inside of the main tank shall be painted white.

An accelerated aging test must be performed on the paint to be used inside the tank. A plate steel sample coated with the white paint shall be submerged in transformer insulating oil and heated to 130°C. After 1,000 hrs, there may not be any change in the painted surface or in the power factor of the oil used for the test.

The top of the main tank shall be provided with a non-skid coating.

Insulating Fluids

Enough inhibited mineral oil shall be furnished for the transformer to fill it to the normal operating level. The insulating liquid shall meet all requirements as defined by ANSI standards, shall be chemically stable, free from acidity or other corrosive ingredients, and shall be certified "non-PCB" in accordance with current EPA regulations. The percent moisture by dry weight shall be < 0.5 percent.

Oil Preservation Systems

The transformer shall be equipped with a nitrogen inert-gas, oil preservation system. The nitrogen for use with inert-gas-protected transformers shall be in accordance with ASTM D1933-2017 The nitrogen shall be supplied in a 200 ft^3 cylinder, equipped with Connection No. 580 of ANSI/CGA V-1-1994. The filling pressure shall be 2200 lbs/in^2 at 70°F. The nitrogen cylinder shall be placed in an enclosure that is mounted on the transformer main tank.

A nitrogen gas pressure regulator and gauge with two sets of alarm contacts to indicate low cylinder pressure, two sets of alarm contacts to indicate low main tank pressure, and two (2) sets of alarm contacts to indicate main tank high pressure are required.

Vent valves located on the transformer cover shall be located as to avoid a tripping hazard and guarded to prevent damage. One purge shall be located inside the nitrogen pressure regulator enclosure.

4.7 AUXILIARY POWER AND CONTROL CIRCUITS

All auxiliary power and control circuits, which are supplied for connection to external circuits, shall be brought to suitable terminal blocks that are located in a common, weather-resistant, NEMA 3R control cabinet. The interior control cabinet panels shall be painted white. The control cabinet exterior shall be painted the same as the main tank of the transformer.

All contacts on auxiliary devices shall be wired to terminal blocks in the same cabinet for use by the purchaser. Terminal block shall be equipped with Phillips, washer-head binding screws and white circuit identification marking strips. Shorting-type terminal blocks shall be used on CT leads.

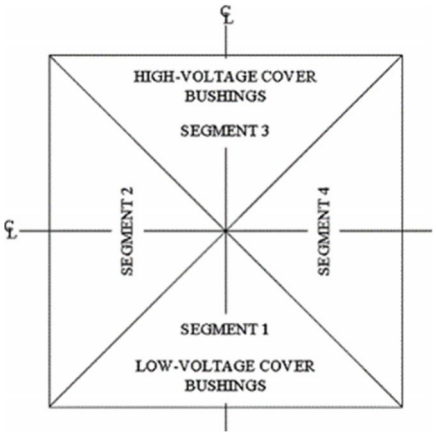
The cabinet shall be equipped with a stainless steel, 3-point latching mechanism and a continuous stainless steel hinge. Control wiring is to be conductor type SIS, with gray insulation, #12AWG minimum. The wire for the control and power circuits shall be rated for use in conduits, as well as cabinets, and shall use insulation that is both fire resistant and resistant to transformer insulating oil. All wires shall be labeled on both ends using the designation of the opposite end. Labels shall be heating shrinkable sleeves or approved equal.

All control cabinets shall be provided with thermostatically controlled heaters for anticondensation. Heaters shall be rated to operate at 120 Vac and each heater shall be on its own circuit, protected by an appropriate 20 A interrupting capacity circuit breaker. Heaters shall be positive temperature coefficient (PTC for temperature limiting) heater(s) of sufficient size to prevent moisture condensation. Fan-less PTC heaters, where used, shall be oriented to facilitate convective air flow over their fins to maximize heat transfer. The control cabinet shall include a 120 VAC GFCI receptacle and door-operated lighting.

SECTION 5: ACCESSORIES

The transformer shall be equipped with all accessories as indicated in following figure and be located as required by latest revision of ANSI C57.12.10.

IEEE Std C57.12.10-2017
IEEE Standard Requirements for Liquid-Immersed Power Transformers



Accessories	Locations	Clause ref.
DETC operating handle[a]	S1, S4, see Clause ref.	5.1.1
Liquid level indicator	S1	5.1.2
Liquid temperature indicator	S1	5.1.3
Winding temperature indicator	S1	5.1.4
Pressure-vacuum gauge[a]	S1 or S4	5.1.5
Pressure-vacuum bleeder valve[a]	S1	5.1.6
Pressure relief device	Cover	5.1.7
Drain and filter valves	S1	5.1.8
Jacking facilities	See ref.	5.3.4
Nameplate	S1	5.4
Ground pad(s)	See ref.	5.5
Auxiliary cooling control[a]	S1 or S2	5.9
OLTC equipment[a]	S1 or S2	6

[a]When furnished.

5.1 MONITORING EQUIPMENT

Magnetic liquid level Indicator 1 (for tripping offline) shall be equipped with the following:

- Form “C” alarm contacts and tripping contacts.
- Indicators that shall have a minimum of 6" diameter dials.
- Nonadjustable alarm contacts shall be provided and shall be set to close at the minimum safe operating level of the liquid.

Magnetic liquid level Indicator 2 (for alarming low oil level) shall be equipped with the following:

- Form “C” alarm contacts.
- Indicators that shall have a minimum 6" diameter dials.
- Nonadjustable alarm contacts shall be provided and shall be set to close at 2 in above the minimum safe operating level of the liquid.

Top liquid temperature indicator shall be equipped with the following:

- Shall be designed with a capillary tube for remote mounting of the indicator dial at a height within 6 ft of the base for convenience when reading the temperature and resetting the drag hands, while standing on the transformer foundation.
- With two Form “C” alarm contacts, which are independently adjustable.
- Indicator shall have a minimum of 6" diameter dials.

Winding hot-spot temperature indicator shall be equipped with the following:

- Shall be designed with a capillary tube for remote mounting of the indicator dial at a height within 6 ft of the base for convenience when reading the temperature and resetting the drag hands, while standing on the transformer foundation.
- With Form “C” alarm contacts and tripping contacts.
- Indicators shall have a minimum of 6" diameter dials.

Drain valve and oil sampling valve shall both be equipped with the following:

- One valve located at the bottom of the tank so that the tank can be drained of oil by gravity to within 1/4 in of the bottom and equipped with a sampling device suitable for removal of oil only when the main valve is open.
- Valves shall be guarded from inadvertent damage with shielding that does not interfere with typical oil handling equipment (hoses, fittings, etc.).

Mechanical pressure relief device shall have:

- Automatic resealing operation.
- Form “C” alarm contacts.
- Mechanical signal for indication of device operation.

Rapid pressure rise relay:

- A rapid pressure rise relay shall be provided that is consistent with the following:
  - Mounted below the oil level to monitor the transformer pressure in oil space.
  - The relay shall be sensitive to the rapid rate of pressure increase and consisting of a dc Form “C” contact that is rated for operation at 125 Vdc, wired to identified terminal points in the main control cabinet and shall be suitable for use in the transformer protection scheme. Actuation shall only occur based on rate of pressure rise and not occur under normal pressure variations caused by temperature change and vibration.
  - The relay shall be supplied as a seal-in relay, which reacts to input from a momentary signal and maintains that signal. Relay shall be configurable for 125 Vdc.

Monitoring provisions:

An SEL-2414 shall be provided and configured to monitor the following:

Analogs:

- Top oil temperature
- Bottom oil temperature
- Ambient temperature

Alarms:

- Fans manual/auto Stage 1
- Fans manual/auto Stage 2
- Fans on Stage 1
- Fans on Stage 2

- Top oil temperature high (from mechanical gauge)
- Top oil temperature high-high (from mechanical gauge)
- Pressure relief device status
- Liquid level low
- Winding hot-spot high
- N2 main tank pressure vacuum alarms
- N2 cylinder low
- Sudden pressure rise and seal-in relay status

5.2 MANHOLES

A minimum of two circular, bolted manhole covers with raised 3/4 in flanges shall be provided. They shall be located such that they are accessible, without the removal of any other equipment. Manholes shall be constructed with flush handles to reduce the tripping hazard when working on the transformer cover.

5.3 CORE GROUNDS

Core shall be grounded at only one point and the core grounds shall be brought to a convenient location for testing and also be brought out on the cover through bushings and grounded externally. Core ground bushing shall be enclosed. Core grounds for a series transformer or preventive automatic for transformers with LTCs shall also be brought out for testing when applicable.

5.4 RADIATORS

Removable radiators will be supplied with individual shut-off valves at each tank connection. Each radiator will be supplied with means for draining and venting. The radiators shall be constructed to withstand the tank operating pressure and a full vacuum. The radiators are to be hot- dipped galvanized.

5.5 JACKING AND MOVING PROVISIONS

- Lifting lugs for lifting complete oil-filled transformers.
- Lifting eyes for lifting the cover only.
- Facilities for lifting core and coil assembly from tank.
- Jacking facilities at four corners of the base.
- Provisions for rolling or sliding.

5.6 NAMEPLATE

The main nameplate shall be a durable corrosion-resistant, laser-etched metal nameplate that shall be permanently affixed to the equipment by the supplier. Main nameplates and instruction plates shall show all values in U.S. customary units and be visible from ground level, unless otherwise specified. Nameplate information shall also be provided on an RFID tag. It shall, at a minimum, bear the recommended information listed in the relevant ANSI/IEEE standard and the following information shall also be included:

- Purchaser company number

- Unique manufacturer serial number
- Manufacturer and manufacturer model number
- Month and year of manufacture
- Rated maximum voltage
- Rated power frequency
- Rated continuous current
- Rated short-time withstand current magnitude and duration
- Rated lightning impulse withstand voltage (BIL)
- Nominal rated current, voltage, MVAR, MW, MVA (as applicable) and fault current withstand
- Any special non-standard overload rating
- Design altitude (if over 3300 ft)
- Design seismic capability
- Temperature design ratings
- When applicable to the equipment, the following shall also be included:
  - Rated filling pressure for operation.
  - Total mass of equipment, insulating medium, total mass, mass of removable components (such as core and coil assembly, etc.).
  - Control voltages.
  - Polarity marks.
  - Winding configurations.
  - Number of phases.
  - Notification of oil being non-PCB, insulating fluid used, flammability classification, and volume of fluid.
  - Pounds of vacuum and filling pressures for which tank is designed.
  - Volume and weights of oil in the different compartments (i.e., main tank, conservator, and radiators listed separately) and the total volume and weight.
  - Location of the core grounding bushings.
  - Locations of sensing units and/or fuses in the main power circuit.
  - All winding ratios.
  - Accuracy class.
  - Thermal rating factor.
  - Any other information required herein or that the supplier deems necessary for proper installation, maintenance, and operation of the equipment.

CT Nameplates: A durable corrosion-resistant laser-etched metal nameplate shall be permanently affixed to the equipment by the supplier. CT nameplates and instruction plates shall show all values in U.S. customary units. CT nameplates shall be installed on the inside of the control cabinet door in the order

that the CTs are arranged on the equipment when the door is open (when viewed from the front of the open door). Nameplate information shall also be provided on an RFID tag. It shall at a minimum bear the recommended information listed in the relevant ANSI/IEEE standard and the following information shall also be included:

- Manufacturer, part number, serial number, date of manufacture
- All ratios
- Accuracy class
- Thermal rating factor
- Metering accuracy, if required.
- Polarity marking

The bushings provided with the equipment shall include nameplates. The same information shall also be provided on an RFID tag. It shall at a minimum bear the recommended information listed in the relevant ANSI/IEEE standard and the following information shall also be included:

- Manufacturer, part number, serial number, date of manufacture
- Rated maximum voltage (kV) and BIL
- Rated maximum current (A) (if applicable, include dual current ratings)
- C1 and C2 power factor and capacitance at 20°C
- Weight (lbs)
- Statement that the oil is PCB free for oil-impregnated bushing: “non-PCB”
- Seismic qualification level

5.7 SURGE ARRESTERS

Shall be provided at the appropriate MCOV ratings for all 115 kV windings not directly grounded. No arresters are required for the low side of the transformer. Station class metal-oxide type surge arresters shall be mounted on the primary side according to the supplier’s design. The surge arresters shall be in compliance with IEEE C62.11 and shall be ANSI 70, light gray in color. Aluminum NEMA 4-hole pads shall be furnished on the line terminals of all arresters.

Surge arrester brackets shall be furnished on the transformer. Arrester brackets shall be located on the side of the tank adjacent to their respective high- and low-voltage bushings. When possible, the height of the arrester terminals shall approximately match the height of associated bushings. Mounting holes are to be oriented such that the arrester vent points away from the tank.

When practical, the arrester grounds shall each be connected directly to the ground grid. When the connection to the ground grid is long, connecting arrester grounds to transformer tank ground pads may be required.

5.8 BUSHING CURRENT TRANSFORMERS

All BCT’s shall be 5-lead, multiratio, and conform to requirements listed as folows and shall also be in accordance with ANSI C57.13.

Bushing Number	CTs per Bushing	Ratio	Rating Factor	Accuracy Class
H1, H2, H3	1	1200:5 MR	1.0	C-800
H0	1	400:5 MR	1.0	C-800
X1, X2, X3	1	1200:5 MR	1.0	C-800
X1, X2, X3	1	1200:5 MR	1.0	0.3B1.8

All CTs shall have a dual rating with an accuracy class of C800 (relay) and 0.3B1.8 (meter), a continuous thermal current rating factor of 1.0, and be manufactured in accordance with IEEE C57.13.

All CTs shall be mounted inside the main tank of the transformer and below the flange of the bushings.

All CTs, including the CT(s) for winding hot spot control, shall have a continuous thermal current rating factor of 2.0 at an average ambient air temperature of 30°C. The insulation class designation shall be 120 degrees. The BCT polarity mark shall point toward the external bushing terminal. Secondary terminal blocks shall be installed in accordance with Section 7.4.3 of IEEE C57.148.

The CT leads running from the CT to the feedthroughs on the tank and from the feedthroughs on the tank to the terminal blocks shall not be spliced. All bushing CT secondary leads shall be a minimum 10 AWG copper and shall have insulation rated for a minimum of 150°C, such as PTFE or ETFE.

All CTs shall be constructed and tested according to IEEE C57.13. The inside diameter of the bushing current transformers shall accommodate the maximum bushing diameter shown as dimension D in Tables 2 and 3 of IEEE C57.19.01.

In addition to the CT tests listed in Section 4.8.1, Table 6 of IEEE C57.13, the following tests shall be performed while the transformer is fully assembled and immersed in oil: insulation tests, ratio tests (including each tap of a multiratio tap), polarity tests, excitation tests (including saturation curves), and winding resistance tests. The results shall be included in the transformer test report.

All bushings CTs shall be shipped shorted and bonded together.

5.9 CONDUIT

The wiring materials and installation, including the conductor fill in all conduit and associated fittings and enclosures, shall comply with the requirements of NFPA 70, except conduit fill shall not exceed 25 percent.

Rigid galvanized steel (RGS): All above grade, outdoor conduit shall be threaded, RGS, that shall consist of hot galvanized steel with threads hot galvanized after cutting that shall be listed to UL Safety Standard 6 by a nationally recognized testing laboratory and shall be manufactured in accordance with ANSI C80.1 (also known as galvanized rigid conduit [GRC] or rigid metallic conduit [RMC]).

Rigid aluminum equivalent conduit (ARC, as specified below) may be substituted for galvanized RGS and a UL listed, UV, water and oil resistant, full wall, PVC coated, liquid tight flexible metal conduit (LMFT) with hot-dipped galvanized low-carbon steel, or equivalent aluminum core conduit, may be substituted. If aluminum is substituted, all supplied rigid conduits and accessories shall be of a compatible

material. Aluminum 6063 alloy in temper designation T-1 shall be used. Fittings shall be of the same alloy.

ARC: when used, above-grade aluminum, outdoor conduit shall be threaded, electrical aluminum rigid conduit (ERMC-A/ARC) and NFPA 70, Type ARC (also known as RAC) aluminum rigid conduit complying with ANSI C80.5 and listed and labeled as complying with UL 6A.

Aluminum conduit used in concrete or in contact with soil requires supplementary corrosion protection. Examples of supplementary protection are paints approved for the purpose (bitumastic paint), tape wraps approved for the purpose, or PVC-coated conduit (2-layer tape or wrap and bitumastic paint, which may only be used for distances up to 10 ft).

Conduit to motors, fans, lights, or any vibrating equipment or short conduit runs no longer than 24 in in dry locations shall be FMC that complies with UL 1 and LFMC for wet locations that complies with UL 360 using high-grade galvanized steel strip of uniform gauge with an interlocking design formed from a continuous metal strip for integrity and flexibility. Reduced wall conduits shall not be used. UL compliance shall be verified by a third party, nationally recognized testing laboratory.

Thread Protectors: Color-coded end caps shall always be provided to keep threads clean, sharp, and help provide trade size.

In no cases shall conduits under 1/2 inch be used.

All conduit, fittings, and connections shall be weatherproof and liquid tight. All conduit and fitting connections shall be threaded; compression connections are not acceptable. All conduit ends shall be reamed or otherwise finished smooth to remove rough edges. For all conduits, a condulet outlet body (with an angled, gasketed, domed cover) shall be furnished at each 90° change of direction; 90° bends in the conduit itself are not acceptable. All conduit systems shall use accessories, fasteners, and unistrut made of the same or compatible material that are UL listed.

All conduit systems shall use threaded connections with conduit bushings with locknuts to terminate conduits. All conduit penetrations shall be appropriately sealed.

SECTION 6: FACTORY TESTS

Questionable test results or failure to meet any of the guaranteed values shall be brought immediately to the attention of the Owner for resolution prior to shipment.

6.1 REPORTS

Three certified copies of the Manufacturer's test report, including all test data, are required. Test results of individual units shall be submitted as individual test reports. The test reports shall be forwarded to the Owner within four weeks of the performance of the tests. Failure to provide these data as required may delay the payment for the unit.

Test reports shall be provided in both written and electronic format.

Insulation power factor tests shall be performed on all winding-to-winding and winding-to-ground insulation. Measured values exceeding 0.5 percent (corrected to 20°C) will not be accepted. Results of the power factor measurement and a description of the method used shall be recorded in the factory test report. ANSI Method II, per ANSI/IEEE C57.12.90, Table 1, (with guard circuit), is preferred.

The purchaser reserves the right to request through-fault testing (at extra cost) at any time prior to final testing of assembled unit.

The purchaser reserves the right to witness testing. The manufacturer shall notify the purchaser of the performance dates for all tests not less than five days prior to the date of the test to allow the purchaser to witness testing, if so desired.

The manufacturer shall notify the purchaser of any unusual event or damage occurring during the fabrication of the transformer and of all tests which do not meet the specified or guaranteed values. The purchaser reserves the right to inspect such damages or test failures. Corrective measures to overcome such damage or failure shall be reviewed with the Owner.

All routine tests listed in IEEE C57.12.00 and IEEE C57.12.90 for Class II substation power transformers, plus additional tests as specified herein, are required. Class II testing to include:

- Winding insulation resistance (both HV and LV) at the rated voltage tap position
- Core insulation resistance
- Ratio tests on all high-voltage tap positions
- Polarity and phase relation tests on the rated voltage connection
- Insulation power factor with Doble
- Control (auxiliary) cooling losses
- Excitation tests on the rated voltage connection
- No load losses and exciting current at 100 and 110 percent
- Impedance at rated MVA
- Dielectric tests, including:
  - Low-frequency testing including 1 hr induced test with partial discharge measurements
  - Low frequency on auxiliary devices control and CT circuits

  - Lightning impulse
  - Switching impulse
  - Partial discharge test
- Total dissolved gasses in oil

Short-Circuit Strength:

Without limiting in any way any obligation of the vendor under this agreement, the vendor shall demonstrate to the satisfaction of the Owner that the transformer to be furnished under this specification shall have sufficient mechanical strength to withstand, without failure, all through-fault currents. The vendor shall demonstrate that the transformer meets this requirement by the following method:

- Certified design test data showing that a transformer with a core and coil identical in design and construction and identical or similar with respect to kVA capacity, kV ratings, BIL, impedance, and voltage taps has been tested without failure for short-circuit strength. A description of the test code under which the transformer was tested for short-circuit strength will be provided by the vendor to the Owner.

SECTION 7: DOCUMENTATION

7.1 DRAWINGS

Approval drawings shall be made available to the Owner in electronic, AutoCAD 2023 format.

Final drawings shall be included with the documentation in AutoCAD 2023 format. The following drawings shall be furnished as a minimum for each unit:

- Outline
- Parts list (may be included on outline)
- Bushing outlines
- Wiring diagram
- Elementary diagram
- Nameplate
- BCT curves
- Internal assembly drawings and Special assembly requirements

Information on outline drawing shall include, but not be limited to following:

- All weights and dimensions (in English and metric units) for both the shipping and fully assembled condition.
- Center of gravity for both assembled and shipping conditions.
- Insulating fluid weights (in pounds and kilograms) and volumes (in gallons and liters).
- Center line dimensions of jacking pads and lifting lugs in at least two views, as well as pad and lug details.
- Size of the removable plate of the control cabinet and its location relative to the center line of the unit.
- All hinged cabinet door swing dimensions.
- Flood level (the bottom of the control cabinet will be assumed to be the flood level unless otherwise noted).
- Location and details of grounding pads at top and bottom of tank and clamps for #4/0 ground connection cable.
- Location(s) of the core ground bushing and means of access.
- Actual phase-to-phase and phase-to-ground strike distances of bushing and arrester grading rings, if supplied.
- Overall height to remove high-voltage bushings.
- Height to the top of the surge arrester mounting brackets and height to the top of the surge arrestors.
- Detailed dimensions of arrester mounting plate.
- Color of tank and of porcelain for the bushings and surge arrestors.

- Whether the apparatus will be shipped with or without fluid.
- Marked by asterisk all item numbers removed for shipment.

Required information on list of accessories:

- A list of all fittings, devices, gauges, indicators and accessories with Manufacturer and style number included (should be on the outline drawing, but may be furnished separately).
- Total number of fan and pump motors, ratings of individual motors and motor protective devices, and total maximum power requirements in motor kVA and kW (same for future forced cooling fans).
- kVA and kW requirements of LTC (if applicable).
- Valve types and sizes.
- Model or type number and rated current of tap changer mechanisms.

Required information on bushing outline note:

The following information shall be furnished either on the bushing drawing or the transformer outline:

- Nominal system voltage.
- BIL.
- Lead size and material.
- Current rating (dual rating where applicable).
- Top end cantilever strength (lbs and N) available for cable leads, etc.
- Minimum creep distance (inches and mm).
- Whether draw lead or bottom connected (if draw lead, give size, type of conductor, and current rating).

Required information on wiring and elementary diagrams:

- Terminal block arrangement (as discussed in Section 7.11) with each terminal block clearly marked with the designation of its associated bushing.
- Temperature and pressure settings of all devices using contacts.
- BCT ratio and accuracy classifications.
- Ratings of internal fuses.

Required information on nameplate:

- Provide details per ANSI C57.12.00 and include the following additional information;
  - Overall BCT ratios and accuracy classifications.
  - Bushing potential devices, surge arrestors, and arrester ratings, if supplied.

Instruction books:

- Two paper copies and one electronic copy are to be sent to Owner for each unit a minimum of one month prior to shipment of the equipment.

- One additional copy of instruction book, complete with drawings, shall be shipped with each transformer.
- Instruction books shall contain at least the following:
  - The cover shall indicate the transformer serial number, SEAPA purchase order number, date, and Manufacturer's shop order number.
  - A table of contents.
  - A list of instruction leaflets, their identification number, and latest revision date.
  - A complete set of instruction leaflets necessary for installation, operation, and maintenance.
  - A list of all Manufacturers' drawings with drawing revision numbers that apply to the specific unit.
  - A complete set of Manufacturer's drawings, including internal and external field assembly drawings.
  - A renewal parts list, which shall include appropriate identification (catalog number or drawing number and group) for all accessories shown on outline drawings, such as thermometers, gauges, relays, bushings, surge arresters, etc.
  - A copy of Manufacturer's specification for the insulating oil used in the transformer.
  - Certified test reports

Photographs:

- A set of electronic photographs sufficient in number and resolution to reveal the core and coil assembly details shall be made prior to tanking the transformer. Photographs shall be sent to the Owner in electronic format.

SECTION 8: SHIPMENT, ASSEMBLY, AND FIELD TESTING

The successful bidder shall furnish the transformer F.O.B. to the following location. Shipment shall be by truck and barge. The successful bidder's proposal shall include provisions for unloading and placing the transformer on an existing concrete pad foundation.

Pricing shall be provided separately for delivery to the following location. Field testing to be performed at the station site once final setup has taken place.

Deliver to Ketchikan Substation site in Ketchikan, Alaska.

Southeast Alaska Power Agency – Ketchikan Station Site

6500 N. Tongass Hwy

Ketchikan, AK 99901

Lat/Long coordinates: 55.403121, –131.718298.

The manufacturer shall be responsible for obtaining necessary permits, providing and verifying routing, and making all the necessary arrangements for transporting the transformer to destination.

Assembly of the transformer shall be by Owner using a contractor. Supplier shall provide supervisory direction for assembly, vacuum filling of transformer, and testing. In advance of assembly, supplier shall provide step-by-step instructions for transformer assembly to be used in the field, along with a list of special equipment necessary for erection and testing

Transformer shall be shipped disassembled with all material packaged and protected for shipping. Each shipping container or box shall be labeled externally identifying material enclosed. The transformer shall be shipped with all bushings and radiators removed. A detailed manifest shall be included with each shipping container or box. Each shipping container shall be labelled with the following information on a weatherproof label:

- Manufacturer's name,
- Description of the item,
- Catalog number of contents in the package,
- Purchaser's name,
- Purchase order number,
- Destination,
- Serialized equipment shall have the serial number of the equipment to which it belongs on the label.

All parts not attached to the transformer shall be adequately crated and shipped with the transformer in such a manner that the parts will be adequately protected. Radiators shall be shipped dis-assembled from the transformer, charged with 99.99% pure dry nitrogen under 2-4 psi positive pressure and pressure-tight seals shall be supplied on all valves, flanges, threaded couplings and openings.

All bulk and insulating fluid shipped to the site shall be included in the Contract Price and shall be delivered F.O.B. Point of Destination. Oil shall be delivered by tank truck for units shipped gas filled. Make-up oil shall be provided in 55-gallon, non-returnable containers. Make complete provision for delivery of oil and filling of transformer. Confirm that all necessary installation and assembly have been

completed and that unit is ready for filling.

Transformer oil prior to delivery shall be tested and certified PCB free. Prior to shipping, a sample oil dissolved gas analysis (DGA) report of the actual oil to be delivered shall be provided to Owner for review. Transformer supplier shall be required to assemble the transformer and vacuum fill on site. The Supplier's responsibility for the delivery of the unit shall end when the transformer is fully assembled, filled with oil, set on the Purchaser's substation pad, tested, and certified to be properly connected and ready to be energized.

Prior to shipment, the transformer tank shall be pressurized with dry air or nitrogen. Where a gas-filled unit is shipped, make complete provision for proper filling, monitoring, and maintenance of the gas fill. Provide suitable documentation of system fill and maintenance. The gas pressure gauge shall be installed so that the status of the internal pressure can be readily known upon arrival. The transformer tank shall be labeled with removable labels indicating that the transformer was "Shipped with Dry Air." The Supplier will provide the purchaser with the initial internal positive pressure level at which the transformer was charged at the time of shipping.

Packaging materials and methods shall provide protection from weather during shipment and in outdoor storage areas.

Provide impact detectors/recorders in all three planes of the transformer tank. Recorder system shall be tamper-proof, secure, and self-powered. Provide password-protected OWNER access. Furnish full instructions for interpretation of impact detectors/recorders. Record the entire trip duration to the Point of Destination without retracing. Provide maximum acceptable shock criteria prior to shipment. Make provision for return of recorders to SUPPLIER.

The Purchaser will check the entire unit including the gas pressure and any impact recorder(s) for visual evidence of shipping damage within seventy-two (72) hours after arrival. Otherwise, a representative of the Supplier will make this inspection. In either case, the Supplier shall notify the carrier of possible concealed damage. A copy of this notice shall be sent to the Purchaser. All impact recorders shall remain the property and responsibility of the Supplier.

Provide a nitrogen tank(s), as needed, and pressure-vacuum gauge to monitor the tank’s gas pressure during shipment.

Preparation for shipment shall be in accordance with SUPPLIER’s standards.

Provide MSDS with packing lists.

Deliver loose parts in plywood containers and ship as a unit with equipment. Identify shipping boxes by Purchase Order number, project name, project location, equipment number, and description of contents. Use ink, paint, or other indelible material markings. Securely affix a copy of completed packing list to each separate shipping package.

Provide instructions for proper unpacking.

Notification of delivery shall be a minimum of ninety-six (96) hours prior to delivery at Purchaser’s FOB destination point. The SUPPLIER shall notify Purchaser of: (1) the date unit is to be shipped; (2) the date and expected arrival time, carrier, and freight bill number when applicable.

After transformer assembly at the job site, the manufacturer shall provide routine field testing of the transformer as required. This testing shall include but not be limited to:

- Winding insulation resistance, winding-to-winding, and winding-to-ground.
- Core ground insulation resistance.
- Turns ratio at each DETC position.
- Polarity.
- Power factor (Doble) on all bushings (results to be provided to Owner as a baseline for future power factor tests).
- Power factor (Doble) on each winding at each DETC tap position (results to be provided to Owner as a baseline for future power factor tests).
- BCT tests (saturation, ratio, and polarity).
- Dissolved gas in oil to include total combustible gasses and water content (results to be provided to Owner as a baseline for future oil tests).
- Oil dielectric strength.

Field test results shall be provided in both written and electronic format.

SECTION 9: SPARE PARTS

The SUPPLIER shall prepare and submit a list of all spare parts being supplied. Spare parts provided shall include at a minimum:

- One set of all routine maintenance parts such as indicator lamps, small relay, filters, fluids, etc.
- One (1) primary voltage bushing, complete with gaskets
- One (1) secondary voltage bushing, complete with gaskets
- Three (3) primary voltage surge arrestors with surge counters
- Three (3) secondary voltage surge arrestors
- One (1) complete set of all gaskets for all tank openings
- One (1) complete set of gaskets required to replace shipping gaskets
- One (1) quart-size container of exterior finish paint
- One (1) complete set of special tools required to maintain, assemble, disassemble, or move the transformer
- One (1) complete cooling fan, complete with motor and guard assembly

If the SUPPLIER identifies other critical or important parts, not listed here, that he/she believes should be kept on hand by OWNER as spare parts, SUPPLIER shall provide a list of all such other critical spare parts to OWNER and OWNER will decide whether or not to purchase them at its expense.