STRUM ENGINEERING ASSOCIATES LTD.

Dartmouth Office
80 Eileen Stubbs Ave.
Dartmouth, N.S. B3B 1Y6
Tel: (902) 468-7325
Fax: (902) 468-1908

Sydney Office
401 Esplanade
Sydney, N.S. B1P 1B2
Tel: (902) 562-3311
Fax: (902) 562-4152

038-022

November 13, 2015

Dear Sir/Madam:

Request for Quotation - 21/28/35MVA, 138/79.70kV/69/39.85kV–13.8/7.97kV Power Transformer
Strum Engineering Associates Ltd. Specification No. 038-022-1-15

Strum Engineering Associates Ltd., on behalf of the Fundy Ocean Research Center for Energy (FORCE), is soliciting quotations for the design, manufacture, testing, delivery, off-loading, site-assembly and warranty of one (1), 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV, oil-immersed power transformer based on the attached Technical Specification No. 038-022-1-15.

To meet the project schedule, your quotation must be received before 3:00 pm on 4 December 2015. Please forward a copy of your quotation to Mr. Rick McCarthy, P. Eng. at Strum Engineering Associates Ltd. Refer to Section A, Item 3 of the Specification for contact information.

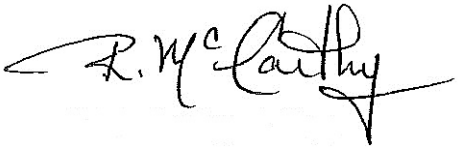
Your quotation shall include a completed copy of Section C of the Specification, as well any additional detailed technical information describing the equipment being proposed.

Quotations will be evaluated on both their technical and financial offerings.

If you require more detail or have any questions or comments, please contact our office at your earliest convenience.

Yours truly,

STRUM ENGINEERING ASSOCIATES LTD.



R. McCarthy, P. Eng.
Senior Electrical Engineer
(Email: r.mccarthy@strumengineering.ca)

Enc: Technical Specification No. 038-022-1-15

STRUM ENGINEERING ASSOCIATES LTD.

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NS

INTERTIE SUBSTATION UPGRADE PROJECT – PHASE 1

MANUFACTURE, TESTING, DELIVERY, OFF-LOADING AND SITE ASSEMBLY OF ONE (1) 21/28/35 MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV OIL-IMMERSED POWER TRANSFORMER

NOVEMBER, 2015 **SPECIFICATION No. 038-022-1-15**

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

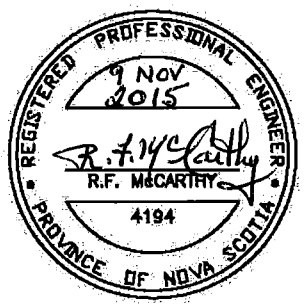
FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NS

INTERTIE SUBSTATION UPGRADE PROJECT – PHASE 1

MANUFACTURE, TESTING, DELIVERY,
OFF-LOADING AND SITE ASSEMBLY OF ONE (1)
21/28/35 MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV
OIL-IMMERSED POWER TRANSFORMER

SPECIFICATION No. 038-022-1-15

SIGNED AND SEALED:



R. McCARTHY, P. ENG.
SENIOR ELECTRICAL ENGINEER

SIGNED:

N. STRUM, P. ENG.
QA/QC ENGINEER

STRUM ENGINEERING ASSOCIATES LTD.

NOVEMBER, 2015

STRUM ENGINEERING ASSOCIATES LTD.

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SPECIFICATION

SECTION A

INFORMATION AND GENERAL REQUIREMENTS

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION A

INFORMATION AND GENERAL REQUIREMENTS

1. GENERAL

1.1 This Technical Specification, prepared by Strum Engineering Associates Ltd. on behalf of the Fundy Ocean Research Center for Energy (FORCE), consisting of the Information and General Requirements, the Technical Requirements, together with all Schedules, Drawings, and Addenda issued with and subsequent to the "Invitation to Tender", shall become a part of any Contract or Purchase Order to perform the work involved. In case of discrepancies between the work tendered to be performed and the work specified to be performed, the Technical Specification shall be final and binding unless there be mutual agreement to the contrary between the Fundy Ocean Research Center for Energy (FORCE) and the Vendor.

2. DESCRIPTION OF PROJECT

2.1 The scope of work of this aspect of the intertie substation upgrading project consists of the design, manufacture, factory testing, delivery to site, off-loading at site, oil-filling and conditioning, installation of bushings, conservator tank, fans and miscellaneous components and warranty of one (1), 21/28/35MVA, 138/79.70 / 69/39.85kV – 13.8/7.97kV outdoor, oil-immersed, three-phase, three winding power transformer, complete with all specified auxiliary equipment, **Tag: 90N-T51**.

3. DEFINITIONS

3.1 The **Owner's Engineer** shall mean:

Strum Engineering Associates Ltd.
80 Eileen Stubbs Ave.
Dartmouth, Nova Scotia B3B 1Y6

Contact: Mr. Rick McCarthy, P. Eng.

Telephone: (902) 468-7325
Fax: (902) 468-1908
E-Mail: r.mccarthy@strumengineering.ca

3./

3.2 The Vendor shall mean the Bidder as defined in the Fundy Ocean Research Center for Energy (FORCE) Terms and Conditions.

3.3 The **Owner's** information and contact will be:

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
1690 Hollis Street, 10th Floor
P.O. Box 2573
Halifax, Nova Scotia
B3J 1V7

Contact: Mr. Andrew Lowery
Telephone: 902-406-1166
E-Mail: andrew.lowery@fundyforce.ca

4. ERRORS AND OMISSIONS

4.1 Should any details necessary for a clear and comprehensive understanding be omitted, or any error appear in the tendering documents, it shall be the duty of the Bidder to obtain clarification from the Owner's Engineer before submitting his tender. All additions or corrections to the Technical Specification will be issued in writing to all Bidders as addenda thereto. Bidders shall list in their tenders all the addenda that were received and considered when their tender was prepared.

5. MATERIAL AND WORKMANSHIP

5.1 All materials shall be new. Workmanship and material shall be of the best quality.

5.2 Equipment of the same type shall be interchangeable. Listed spare parts shall be identical and inter-changeable with parts in service that they are intended to replace.

6. GUARANTEE/WARRANTY

6.1 The Vendor shall warrant that all materials, equipment, and workmanship furnished in accordance with the purchase documents shall comply in all respects with the Technical Specification, and shall guarantee in writing that the equipment will give successful and efficient service.

6.2 The Vendor shall, to the satisfaction of the Owner, rectify any defects which may appear in the equipment, or of which he shall receive notice from the Owner and for which he may have been responsible in the opinion of the Owner, for a period of twelve months after start-up or eighteen months after shipment, whichever occurs first.

6.3 Any equipment which fails to perform in accordance with the requirements of the Specification during this period may be rejected by the Owner. The Vendor shall proceed at once to make alterations or furnish new equipment, as may be necessary.

6.4 Costs of supplying any replacement equipment, or of modifications or alterations to equipment, in order to meet specified requirements shall be borne by the Vendor, including the costs, if any, of any work or materials provided by the Owner, and of any shipping charges incurred by the Owner.

6.5 Operation by the Owner of the equipment or any part thereof shall not constitute any waiver of the Owner's rights under this agreement.

6.6 The Vendor agrees that the Unit shall meet the requirements set out in the Specification and all relevant standards listed herein.

6.7 The Owner’s purchase order terms and conditions shall prevail.

7. MANUFACTURER'S DRAWINGS

7.1 General

7.1.1 Drawings shall be clear and legible and have a title block including the name of the Project, and the number and title of the drawing.

7.1.2 All drawings shall be prepared on A1 size sheets, 594 mm by 841 mm. Use of other size sheets shall be agreed by the Owner's Engineer.

7.2 System of Units

7.2.1 All dimensions shall be in the Imperial and Metric system.

7.3 Title Block

7.3.1 Drawing title blocks shall include the following information:

.1 Name of the Project as follows:

Intertie Substation Upgrade Project – Phase 1

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NOVA SCOTIA

Manufacture, Testing, Delivery, Off-Loading and Site Assembly of a 21/28/35MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV Oil-Immersed Power Transformer

Owner's Purchase Order No.

.2 Provide a 100 mm x 100 mm space to accommodate the Engineer's review stamp.

.3 Issue date and the drawing number.

.4 Space allotted for revisions including the number, description, and date.

7./

7.4 Review of Drawings

7.4.1 Drawings made by the Bidder or his sub-contractors defining the work shall be provided at appropriate times within the program of work as defined in the Specification.

7.4.2 Five (5) prints or the electronic file (in Autocad XXX.dwg file format) of each shop drawings shall be submitted to the Owner's Engineer, who will return, within 14 days after receipt, one copy of the reviewed drawings stamped as follows:

STRUM ENGINEERING ASSOCIATES LTD.

Date Received: _____ By:

This drawing has been reviewed for the sole purpose of determining conformance with the general requirements of the Contract Documents.

The Contractor shall remain responsible for all damages resulting from errors and/or omissions contained in this drawing and shall satisfy all obligations and liabilities connected therewith and with the Contract Documents.

Reviewed - Manufacturing May Proceed. ( )
Reviewed - Submit Final Drawing. Manufacturing May Proceed. ( )
Reviewed - Make Changes As Noted. Submit Final Drawing. Manufacturing May Proceed. ( )
Reviewed - Correct and Resubmit. ( )
Review Not Required - Manufacturing May Proceed. ( )

Date Review Completed: _____ By:

All drawings checked other than, "Reviewed - Manufacturing May Proceed", shall be corrected and recycled for review within 14 calendar days, and this procedure continued until final review is obtained.

7.4/

7.4.3 Before proceeding with construction, submit for review to the Owner's Engineer, assembly drawings, foundation and base plate details, layout and drilling details, drawings covering construction, complete control schematic diagrams, and other pertinent data for the equipment under consideration. Do not start construction until instructed by the Owner's Engineer.

7.4.4 Do not revise those drawings or portions of drawings which have been reviewed and stamped during the review process unless these drawings or portions are affected by comments made or revisions requested.

7.5 Final Drawings

7.5.1 These drawings shall incorporate any changes made during the construction and testing stages of the work, shall be exact drawings of the equipment as supplied, and shall be of such quality to enable electronic scanning without loss of detail.

7.5.2 Do not revise drawings given final review by the Owner's Engineer except by his prior written consent.

7.5.3 Submit six (6) prints and the electronic (in Autocad XXX.dwg file format) file of each final drawing to the Owner's Engineer.

8. OPERATION AND MAINTENANCE MANUALS

8.1 Prepare comprehensive instruction manuals describing in detail the construction and recommended procedures for assembling, dismantling, maintaining and operating all equipment and listing all replacement parts. These shall include copies of all pertinent bulletins and instructions prepared by the Vendors of component parts of the equipment, properly catalogued for easy reference.

8.2 Two (2) copies of the manuals shall be submitted in draft form to the Owner's Engineer for review at least one (1) month before the equipment is to be delivered. Five (5) copies of the finalized manual shall be submitted at the time the equipment is shipped.

9. WITNESSING OF TESTS AND TEST REPORTS

9.1 Advise the Owner's Engineer 14 days prior to the tests so that tests may be witnessed by the Engineer and Owner.

9.2 Submit six copies of duly certified test reports, to be forwarded by courier prior to equipment shipment.

10. PACKAGING AND SHIPPING

10.1 All parts shall be thoroughly cleaned to remove oil, grease, dust, and other foreign material and all equipment openings shall be capped to prevent entry of foreign materials or damage.

10.2 Equipment shall be suitably prepared and packed so as to prevent damage occurring during storage, transportation, and unloading operations and to ensure that the equipment is in perfect working condition, has suffered no damage, and that all parts are intact on arrival at the destination.

10.3 Packaging and crating shall include suitable weather protection, moisture control, temporary bracing, blocking straps, skids, etc.

11. ERECTION SUPERVISOR

11.1 The off-loading, erection, oil-filling and conditioning and installation (dressing) of loose-shipped components of the equipment at the site shall be the responsibility of the transformer manufacturer/supplier and shall be performed under his/her direction. The transformer manufacturer/supplier shall utilize a company that is acceptable to Fundy Ocean Research for Energy. The cost of off-loading, erection, oil-filling and conditioning, installation and supervision shall be included in the contract price. The erection supervisor shall also provide instruction to the Owner's personnel on the operation and maintenance of the supplied equipment.

12. SIGNING AND SEALING OF MANUFACTURER'S DRAWINGS

12.1 Execute design under the supervision of a licensed Engineer. The Engineer shall sign and seal:

12.1.1 Shop fabrication drawings and specifications;

12.1.2 Site erection drawings and specifications; and,

12.1.3 Assembly, schematic and wiring diagrams.

13. CORRESPONDENCE

13.1 In view of the urgency associated with this project, the tender shall be submitted by courier and all other correspondence shall be by courier, facsimile or electronic mail (E-Mail).

13.2 The Vendor shall allow for this requirement in the prices quoted herein.

14. SCHEDULE

14.1 All equipment associated with this specification is required on site not later than 1 July 2016. Refer to Schedule No. 5, Page C-17, for the specific schedule requirements.

15. REFERENCE DRAWINGS

15.1 Strum Engineering Drawing No. 038-022-SK-01 Rev A01, entitled “Intertie Substation Upgrade Project – Phase 1, Intertie Substation Transformer, Single Line Diagram” indicates the general requirements of the intertie transformer proposed for the Fundy Ocean Research Center for Energy (FORCE), Intertie Substation Upgrade Project – Phase 1 in Black Rock, Nova Scotia.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION B

TECHNICAL REQUIREMENTS

SPECIFICATION

SECTION B

TECHNICAL REQUIREMENTS

1. SCOPE OF WORK

1.1 Design, manufacture, test, deliver to the Fundy Ocean Research Center for Energy (FORCE), Intertie Substation in Black Rock (Parrsboro), Nova Scotia, off-load onto a transformer slab-on-grade equipment pad provided by the Owner, fill and condition with transformer oil, install bushings, conservator tank, fans and miscellaneous components and provide a written warranty for one (1) 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV, outdoor, three phase, three winding, oil-immersed power transformer complete with all specified auxiliary equipment.

1.2 Testing and commissioning of the power transformer and associated components will be carried out by others and does not form part of this Contract.

2. SERVICE CONDITIONS

2.1 Application

2.1.1 The transformer will be installed outdoors on a slab-on-grade equipment pad.

2.2 Existing Supply System Data

2.2.1 138/69kV System Data

Nominal service voltage	kV rms	**69**	**138**
Rated (maximum) voltage	kV rms	75	150
Rated frequency	Hz	60	
No. of phases and wiring		3/3	
Neutral grounding	solidly grounded at utility source transformer neutral and new 21/28/35 MVA transformer HV neutral		
3 phase momentary short circuit current at 138kV and 69kV	69kV: 1.5kA rms sym.	138kV: 2.5kA rms sym.	

2.2/

2.2.2 13.8/7.97kV System Data

Nominal service voltage	kV rms	13.8
Rated (maximum) voltage	kV rms	15.2
Rated frequency	Hz	60
No. of phases and wiring		3/3
Neutral grounding		solidly grounded at new 21/28/35 MVA transformer MV neutral
3 phase momentary short circuit current at 13.8kV terminals of transformer	kA rms sym	10.0

2.3 Environmental Data

2.3.1 Design and manufacture the transformer to be suitable for operation under the following conditions:

Elevation above sea level	m	50
Maximum ambient temperature	^{o}C	40
Minimum ambient temperature	^{o}C	-40

2.3.2 The transformer shall be designed for outdoor service.

2.4 Auxiliaries Power Supply

2.4.1 The following auxiliary power supply is available:

240/120Vac, 1Ø, 3W, 60 Hz or 208/120Vac, 3Ø, 4W, 60 Hz for heaters, lights, cooling fans, and convenience receptacles.

3. STANDARDS

3.1 Unless otherwise specified herein, design, manufacture, and test the transformer in accordance with the latest issue of the following standards:

CSA C22.1-15	Canadian Electrical Code; Part 1, Safety Standard for Electrical Installations
CSA C22.2 No. 94-M91 (R2011)	Special Purpose Enclosures
CSA C60044-1-07 (R2011)	Instrument Transformers- Part 1 Current Transformers
CSA C50-14	Mineral Insulating Oil, Electrical, for Transformers and Switches
CSA C71-1-99 (R2008)	Insulation Coordination - Part 1: Definitions, Principles and Rules
CSA C71-2-98 (R2011)	Insulation Coordination - Part 2: Application Guide
CSA C88-M90 (R2014)	Power Transformers and Reactors
CSA C88.1-96 (R2011)	Power Transformers and Reactor Bushings
CSA C108.3.1-M84 (R2014)	Limits and Measurement Methods of Electromagnetic Noise From AC Power Systems 0.15 - 30 MHz
CSA C802.3-01 (R2012)	Maximum Losses for Power Transformers
CSA W59-13 (R2008)	Welded Steel Construction (Metal-Arc Welding)
CSA Z299.2-85 (R2006)	Quality Assurance Program
IEEE No.1-2000 (R2011)	Recommended Practice - General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.

3.1/

ANSI C29.1-1988 (R2012)	Electrical Power Insulators - Test Methods
ANSI C57.12.00 (R2010)	IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
ANSI C57.12.80 (R2010)	IEEE Standard Terminology for Power and Distribution Transformers
ANSI C57.12.90 (R2010)	IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and IEEE Guide for Short Circuit Testing of Distribution and Power Transformers
ANSI C57.91-2011	IEEE Guide for Loading Mineral Oil-Immersed Transformers and Step Voltage Regulators
ANSI C57.93-2007	IEEE Guide for Installation and Maintenance of Liquid-Immersed Power Transformers
ANSI C57.98-2011	IEEE Guide for Transformer Impulse Tests
ANSI C57.113-2010	IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors
ANSI C57.123-2010	Guide for Transformer Loss Measurement
ANSI C57.120-1991 (R2006)	IEEE Loss Evaluation Guide for Power Transformers and Reactors
ANSI C63.2-2009	American National Standard for Electromagnetic Noise and Field Strength Instrumentation 10Hz to 40 GHz - Specifications
NEMA TR1-2013	Transformers, Regulators, and Reactors (Including Noise Level Requirements)
NEMA 107-1987 (R1993)	Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus
IEC 60076-SER ed1.0	Power transformers – All Parts

3./

3.2 Apply all reference publications and amendments listed within the above standards.

3.3 Other alternative standards may be used if reviewed and accepted by the Owner's Engineer.

4. DESIGN BASIS

4.1 Base the detailed design on this Specification. Produce detailed drawings and submit for review prior to the start of manufacture.

5. EQUIPMENT, APPARATUS AND MATERIAL SUPPLIED BY OTHERS

5.1 All power cables, control cables, protection cables and auxiliary supply cables external to the transformer assembly.

6. PRODUCT DELIVERY, STORAGE AND HANDLING

6.1 The transformer shall be shipped under pressure of dry air or an acceptable dry inert gas as agreed by the Owner's Engineer. The transformer shall be provided with a pressure gauge suitably protected from damage during transit. The pressure and temperature shall be recorded at the time the transformer leaves the factory. The recorded information shall be given to the Owner's Engineer so that it can be compared with the pressure and temperature readings obtained after the transformer has been received at site to ascertain if any leakage has occurred. Ensure that the transformer arrives at site in an uncontaminated condition. The manufacturer/ supplier is responsible for oil-filling and oil-conditioning the transformer at site.

6.2 The manufacturer/ supplier shall provide two (2), three-axis impact recorders for shipment. The impact recorders shall be attached to the transformer near the top of the main tank, shielded to prevent damage, with both time mechanisms charged for the complete duration of shipment. Failure to do so may result in the Owner not accepting the transformer. On arrival, the impact recorder shall be removed only in the presence of the Owner's Engineer.

6.3 Crate all transformer parts and components removed for shipment to prevent damage. Radiators shall be packed in such a way that it is not possible for any weight to be placed directly on the fins, tubes or panels. All parts and components are to be free from rust.

6.4 A spare set of gaskets for use during site assembly shall be shipped.

6.5 Transformer oil shall preferably be shipped in tank trucks but may be shipped by alternative methods if reviewed and accepted by the Owner's Engineer. The oil shall arrive at site at the same time as the transformer. Ensure that the oil arrives at site in a clean, uncontaminated condition.

7. TRANSFORMER INFORMATION

7.1 Ratings and Data

7.1.1 21/28/35 MVA, 138/79.7 x 69/39.85 – 13.8/7.97kV Power Transformer

Quantity		1
Type		3-phase, oil-immersed, conservator tank, pad-mounted, three winding
Rated frequency	Hz	60
Rated voltages of windings:		
- high voltage	kV rms	138 x 69 (nominal tap)
- medium voltage	kV rms	13.8 (nominal tap)
- buried tertiary	kV rms	4.16 @ 33% base MVA
Connection of windings:		
- high voltage		Grounded Wye
- medium voltage		Grounded Wye
- buried tertiary		Delta
Type of cooling		ONAN/ONAF/ONAF
Average temperature rise of any winding above 30°C ambient temperature, measured by resistance	°C	65

SPECIFICATION

7.1.1/

Power rating at high (138kV and 69kV) and medium (13.8kV) voltage terminals, nominal tap position at rated output voltage and 0.9 power factor lagging:

- ONAN 65°C Rise	MVA	21
- ONAF 65°C Rise	MVA	28
- ONAF 65°C Rise	MVA	35

Off-load series-paralleling switch on high voltage winding (138kV / 69kV) (at full capacity)

On-load tap changer on high voltage winding (138kV / 69kV)	11 full capacity taps, 5 x 1% above nominal voltage and 5 x 1% below nominal voltage
Winding material	copper (aluminum not acceptable)
HV Neutral grounding	solidly grounded
MV Neutral grounding	solidly grounded
Positive Sequence Impedance - 21 (65°C) MVA ONAN (Base)	% 7.0
Vector Group	Yy0 for wye windings and Yd1 for the buried tertiary delta winding
Sound level standard	Per NEMA and ANSI Standards

Rated Lightning-Impulse Withstand Voltage:

- HV winding	kV crest	650
- MV winding	kV crest	95
- Tertiary winding	kV crest	50
- HV phase bushings	kV crest	650
- HV neutral bushing	kV crest	110
- MV phase bushings	kV crest	110
- MV neutral bushing	kV crest	110
- Tertiary winding bushings	kV crest	75

7.1.1/

Rated long duration withstand voltage for HV winding	kV rms	1.7 x 138 for 7200 cycles followed by 1.5 x 138 for 1 hour

Rated Short Duration Power Frequency Withstand Voltage:

- Induced voltage for grounded Primary winding	kV rms	2.0 x 138 for 7200 cycles
- Induced voltage for grounded Secondary winding	kV rms	2.0 x 13.8 for 7200 cycles
- Induced voltage for grounded buried tertiary winding	kV rms	2.0 x 4.16 for 7200 cycles

Rated short duration power frequency withstand voltage (Dry, 1 minute, 60Hz):

- HV winding bushings	kV rms	275
- MV winding bushings	kV rms	50
- Tertiary winding bushings	kV rms	19

Minimum bushing creepage (kV based on phase to phase voltage)	mm/kV	25.0

7.1.2 Short Circuit Rating

.1 Transformer core and coils assembly shall be designed to withstand, without injury or permanent deformation, the mechanical and thermal stresses caused by a short circuit on the external terminals of any winding or windings with rated voltage maintained across the terminals of all other windings for a minimum duration of two seconds.

.2 Buried, delta connected tertiary winding shall be rated to withstand the zero sequence circulating currents that will result from a single phase to ground fault occurring on either the 138kV / 69kV or the 13.8kVwinding for a minimum of 10 seconds and for a buried tertiary phase-phase-ground fault for a period of 10 seconds.

8. CONSTRUCTION

8.1 Transformer Tank

8.1.1 The tank shall be of welded, sheet-steel construction, free from distortion, and constructed according to the transformer outline drawings submitted by the Vendor for review by the Owner's Engineer before construction.

8.1.2 The tank cover shall be welded to the tank using flanges to facilitate removal. Manholes shall be provided to permit removal or installation of bushings, inspection of core and windings, tap changer mechanism, and similar components. All openings in the cover shall have flanges to prevent entry of water when covers are removed. At least one manhole shall be 24 inches in size to allow entry into the tank for inspection.

8.1.3 Design the transformer tank and radiators to withstand without deformation, 35kPa positive pressure and full vacuum according to Clause 15.1.3.1 of the CSA-C88-M90 (R2014).

8.1.4 Bushing turrets and current transformer pockets shall be arranged to prevent the accumulation of gas or they shall be piped to the gas detector relay. Bleeder valves shall be provided to allow removal of entrapped air. Bushing turrets shall be water-tight and condensation proof. Current transformer terminal boxes shall be water tight.

8.1.5 Gasketed joints shall be designed to maintain an even and effective pressure to ensure oil tightness without overstressing the gasket. The material and thickness of all gaskets supplied shall be clearly shown in an appropriate table in the instruction book.

8.1.6 The bottom plate of the transformer tank shall be at least 1/8" thicker than that required by design strength requirements to allow for possible rusting.

8.1.7 Surge (lightning) arresters will be supplied by others and will be supported on independent structures near the transformer.

8.1.8 All box-type stiffeners on the tank wall shall be provided with drain holes.

8.1.9 Supply and install one (1), UCL Safety Systems mounting plate anchor, part number 17412 attached to the top of the transformer. The mounting plate shall be welded mounted to accommodate portable fall arrest equipment.

8./

8.2 Moving Facilities

8.2.1 Hook-type lifting lugs with rounded edges, drilled, for a shackle of sufficient size to lift the completely assembled and filled transformer shall be supplied.

8.2.2 Jacking steps shall be attached to the tank at each corner at a height not less than 12 inches or more than 20 inches.

8.2.3 Pulling eyes, minimum 2 inches diameter, shall be provided on the transformer base, two per side, to permit pulling the transformer in any direction and shall be braced to withstand the pull up to 15° from the horizontal.

8.2.4 The transformer base shall be reinforced to permit moving the assembled and filled transformer on rollers in any direction.

8.2.5 The location of the centre of gravity shall allow the transformer to be safely tilted to 15° either with or without oil and shall not result in dangerous overturning moments from the usual transporting, rolling, skidding, and jacking operation.

8.2.6 The location of the "shipping" and "dressed" centre of gravity shall be painted on the tank. The centre of gravity in both shipping and installed configurations shall be clearly shown on both the outline and shipping drawings for both longitudinal and transverse axes.

8.2.7 Information on the permissible vertical angle of slinging and any other handling restrictions shall be shown on the shipping drawing.

8.3 Conservator Tank

8.3.1 The conservator tank shall have sufficient capacity to accommodate the change in oil volume (oil will not be below the low oil level at minimum ambient temperature of -40ºC and will not overflow at maximum ambient temperature of +40ºC throughout its load range, including overload).

8.3.2 The conservator tank shall be fitted with a nitrile membrane to avoid all contact of ambient air with the transformer oil. A leakage detector shall be mounted on the conservator to signal a rupture of the membrane. The leakage detector alarm contact shall be wired to the SEL 2414.

8.3/

8.3.3 The conservator tank shall be provided with a manhole, a 2 inch IPS filling valve with plug and lifting eyes.

8.3.4 The conservator shall be mounted with a one-inch slope between the ends to assist in draining. A 1-1/4 inch pipe complete with IPS drain/filler valve and plug shall be brought from the bottom inside elevation of the lower end of the conservator tank to within 1.3m of ground level. The pipe shall be clamped to the main tank for support.

8.3.5 The connecting pipe between the conservator and the main tank shall be 2 inch minimum size. The pipe shall protrude 1 inch into the conservator tank to prevent sludge pickup. An indicating ("valve open" / "valve closed") shut-off gate valve shall be inserted into the line between the conservator and the main tank, on the conservator tank side of the gas detector relay. The valve positions shall be easily observable from ground level.

8.4 Radiators

8.4.1 The transformer shall be equipped with detachable radiators which are designed to withstand the same pressure and vacuum conditions as the main tank.

8.4.2 Attachment to the main tank shall be by means of oil-tight isolating valves with position indicators affixed to the main tank and capable of withstanding a full head of oil. The handles of the shut-off valves shall be arranged to indicate "valve open" when in line with the pipe and "valve closed" when at right angles to the pipe. Reusable blanking plates shall be supplied for all openings.

8.4.3 Radiators shall have lifting eyes and be equipped with drain valves and non-corrodible plugs at the bottom and non-corrodible vent plugs at the top.

8.4.4 The radiators shall be hot-dipped galvanized.

8.4.5 Bracing of radiator fins, tubes or panels shall not be by direct welding of the bracing to the fins, tubes or panels.

8.4.6 Minimum separation between radiators shall be 6 inches. Radiators shall not be positioned over manholes, handholes, inspection covers or test point covers.

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8.5 Valves and Pipes

8.5.1 All valves supplied shall be tabulated as to type, size, and Vendor on appropriate drawings and in the instruction books. Information leaflets shall be included for each type of valve.

8.5.2 Oil drain valve, 2 inch minimum gate valve with 1¼ inch connection, and non-corrodible plug shall be located on the main tank wall as close as possible to the main tank bottom to permit draining of oil and oil filtering operation.

8.5.3 A ½ inch globe valve and non-corrodible plug shall be provided for oil sampling from the main tank bottom and located near the oil drain valve for mechanical protection.

8.5.4 A 2 inch vacuum pump connection with 2 inch minimum gate valve with 1¼ inch connection and non-corrodible plug, for oil filtering operation, shall be located on top of the main tank above the oil drain valve identified in 8.5.2.

8.5.5 A 1¼ inch oil filling connection with a spray nozzle inside the main tank, equipped with non-corrodible plug shall be located at the top of the main tank diametrically opposite the oil drain valve.

8.5.6 An oil filter connection consisting of a 1-1/4 inch pipe running from the lowest point in the conservator tank to a point 52 inches above the transformer base shall be terminated with a 1-1/4 inch gate valve and non-corrodible plug.

8.5.7 The following valves and fittings shall be supplied for the On-Load Tap Changer (OLTC) diverter switch oil compartment:

.1 OLTC drain valve: 1-1/4 inch gate valve with non-corrodible plug at the lowest point in the OLTC compartment.

.2 Oil filter connection: top, 1-inch gate valve with non-corrodible plug located on the side of the OLTC tank, 75mm below the top of the OLTC oil level.

.3 Oil filter connection: bottom, 1-inch gate valve with non-corrodible plug located 22mm above the OLTC tank bottom.

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8.6 Painting and Finishing

8.6.1 The tank shall be cleaned of rust, loose mill scale and other foreign matters by near-white metal blast cleaning. Castings shall be properly smoothed and sharp edges shall be filed. Oil, paraffin, and grease shall be removed by use of solvent.

8.6.2 After cleaning, the exposed surfaces shall receive 4 coats of paint at the factory as follows:

.1 A primary coat of zinc-rich epoxy paint strictly applied in accordance with the instruction of the paint Vendor.

.2 Two coats of non-glossy, oil resistant paint compatible with primary coat. The second coat shall be applied on completion of factory tests.

.3 One final coat of glossy, oil resistant zinc-silicate (self-curing) paint, non-fading ASA 61 Gray

8.6.3 The interior of the transformer main tank shall be painted with an oil resistant paint of white or other accepted light colour.

8.6.3 The top of the transformer tank shall be painted with anti-skid paint.

8.6.4 The interior of the control cabinet shall be painted with 3 coats of which the final coat shall be a white or light grey anti-condensation finish.

8.6.5 Damage to paintwork incurred during transport shall be repaired by thoroughly cleaning the damaged portion and applying the full number of coats that had been applied before the damage was caused.

8.6.6 Two litres of touch-up paint shall be supplied for repair of damages incurred during installation.

8.6.7 Screws and bolts shall be rust-proof and shall not be subjected to deterioration by time and humidity. Unpainted steel shall be properly protected either by galvanizing, metallizing, or by thermal cadmium plating.

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8.7 Core

8.7.1 The core shall be manufactured of high-grade, grain-oriented, non-ageing silicon steel laminations having smooth insulated surfaces with edges free from burrs. The core and associated insulation shall be designed so that no detrimental changes in physical or electrical properties will occur during the life of the windings.

8.7.2 Core clamps shall be insulated from the core and electrically connected to the tank. Core bolts, where used, shall be suitably insulated, minimum Class B, and shall be capable of withstanding the maximum voltage and temperature conditions that occur in the core during the design life of the windings.

8.7.3 The core and windings shall be braced to prevent displacement or distortion during transportation. Temporary blocking, if required, shall be marked in red to facilitate identification for removal, and noted in the installation instructions.

8.7.4 The transformer core ground connection shall be brought through the top of the main tank via a 5kV bushing and shall be connected to ground through a resistor having a minimum rating of 250 ohms, 25 Watts continuous. The bushing resistor assembly shall be enclosed in its own oil-tight, air-filled, weatherproof compartment. The core ground conductor connection shall be removable for testing purposes.

8.7.5 The core ground lead and connections shall be of sufficient cross sectional area to withstand a fault current of 20 kA RMS for one second without fusing.

8.8 Windings

8.8.1 The winding connections and voltages shall be as indicated in Section 7.1 of this Specification.

8.8.2 The winding material shall be copper.

8.8.3 Angular displacement and polarity shall be in accordance with CSA-C88-M90 (R2014).

8.8.4 The neutral ends of the wye connected windings shall be brought through the cover via suitable neutral bushings.

8.8/

8.8.5 Polarity markings and schematic information of all windings shall be indicated on the nameplate.

8.8.6 The buried, Delta connected tertiary winding (stabilizing winding) shall be built based on CSA C88-M90 (R2014), 10.2.3.2. The buried tertiary shall be designed to withstand, without damage, the effects of all types of short circuits on the other windings up to their rated short circuit capabilities. One corner of the delta connected tertiary winding shall be brought through the top of the main tank via two 5kV bushings identified as Y3a and Y3b, connected together with a removable test link. The test link will be utilized to open the delta winding. Provide insulated copper bus, using non-hygroscopic insulating material, from Y3b bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor. The Y3a and Y3b bushings and link shall be located on the top of the transformer tank.

8.9 Bushings

8.9.1 The transformer shall be provided with tank top bushings, three phases and neutral for the HV winding, neutral for the MV winding and two bushings connected to one corner (Y3a and Y3b) of the tertiary winding for tertiary winding testing and grounding purposes, and with tank side-wall bushings (side and bottom accessible within a steel enclosure) for the three phases of the MV winding. The 138kV bushings shall have a power factor test tap and the power factor shall be stamped on the bushing nameplates. All bushings shall conform to CSA C88.1-96 (R2011).

8.9.2 The 138kV rated bushings shall be oil-filled condenser type and shall be provided with a site glass, visible and legible from ground level, and power factor and capacitance taps for test purposes.

8.9.3 The 138kV bushings shall be equipped with mechanical connectors to accept primary overhead conductors (556.5 ACSR (Dove), one per phase)

8.9.4 NEMA, four-hole compression lugs shall be provided for the connection of each 556.5 ACSR (Dove) conductor per phase to the 138kV bushings.

8.9.5 NEMA, two-hole compression lugs shall be provided for the connection of each of four (4), 500kcmil copper, 15kV 133% EPR insulated power conductors per phase to the 13.8kV bushings.

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8.9.6 Colour shall be gray, unless otherwise specified.

8.9.7 Power connections on all bushings in the live parts area shall be silicon bronze where contacting and mating surfaces are copper or copper alloy.

8.9.8 The bushing drop leads for HV, X0 and Tertiary windings shall be sufficiently long to allow the bushing flanges to be raised clear of the mounting studs for power factor testing of the transformer windings.

8.9.9 The H2 and X2 bushings shall be mounted on the same centreline.

8.9.10 Bushing current transformers shall be supplied as described in Section 10.13.

8.9.11 The installation of bushings shall be possible without lowering the oil below the top of the core and coils.

8.9.12 Provide insulated copper bus, using non-hygroscopic insulating material, from H0 bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. The H0 ground bus shall be separate from the X0 ground bus. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor.

8.9.13 Provide insulated copper bus, using non-hygroscopic insulating material, from X0 bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. The X0 ground bus shall be separate from the H0 ground bus. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor.

8.10 Control Cabinet

8.10.1 A weatherproof control cabinet affixed to the main tank and conforming to CSA Standard C22.2 No. 94-M91 (R2011) shall be supplied, the bottom located approximately 28 inches above the transformer base. It shall be rigidly braced and secured to avoid amplifying transformer sound level. The bottom of the cabinet shall have two removable aluminum entrance plates, 10 inches x 12 inches, to facilitate cable entry. The interior shall be insulated with non-combustible material and shall be complete with a 2" diameter screened ventilation opening to inhibit condensation.

8.10/

8.10.2 The cabinet shall be equipped with an exterior hinged and padlockable door (lockable with padlock having a 10mm diameter shackle) complete with three-point latch and shall be capable of being latched open or closed. The inside pocket on the door shall contain one copy of the instruction manual, complete with drawings.

8.10.3 The cabinet shall be sufficiently large to contain the following:

a) Bottom entry and termination of all control cables.
b) Power supply and control equipment for first and second stage fans.
c) Tapchanger control equipment for the 138kV / 69kV load tapchanger.

8.10.4 The control cabinet shall be fitted with an internal, thermostatically controlled anti-condensation heater (capable of maintaining a cabinet temperature of 5ºC in an ambient temperature of -40ºC), switched light, and an externally mounted NEMA 125V, 15A, 2P, 3W duplex U-ground convenience duplex receptacle (complete with weatherproof cover) mounted on the exterior of the cabinet. The transformer manufacturer shall supply terminals and all necessary switching and protection (molded case circuit breakers) devices, pre-mounted in the control cabinet.

8.10.5 All current transformer secondary wiring shall be a minimum No. 10 AWG copper and all other wiring shall be minimum No. 12 AWG copper. Wire markers shall be applied to all wires at both ends. Secondary wiring shall be protected from faults in the transformer's main power circuits.

8.10.6 All current transformer and control, power, and alarm circuits shall terminate at terminal blocks located in the control cabinet. Terminal blocks for current circuits shall be shorting type. The terminal blocks shall be located so as not to interfere with the wiring or cable connections. All available ratios of current transformers shall be wired to terminal blocks within the control cabinet.

8.10.7 Terminal blocks shall be of the stud type. All terminal blocks with voltages above 125V shall be fitted with insulating covers to prevent accidental contact. A minimum of 15% of spare terminal blocks shall be supplied for each terminal strip.

8.10.8 The layout of equipment in the control cabinet shall be arranged so that all devices and functions may be operated or performed by a person of average height, standing at the transformer base level.

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8.11 Miscellaneous

8.11.1 All nuts and bolts ½" in diameter and smaller shall be stainless steel or silicon bronze. Plated fastenings are not acceptable.

8.11.2 Wiring on the exterior of the transformer shall be protected by rigid aluminum conduit or non-ferrous, non-corroding PVC jacketed flexible armour.

8.11.3 Motor and control circuit protection shall, in the case of fuses, be HRC Form 1, and in the case of breakers consist of overload protection in each phase.

8.12 Terminal Arrangements and Connections for MV Underground Conductors

8.12.1 Provide a suitable, self-supporting weather tight steel terminal box, with side and bottom entry access via removable panels, on the MV side of the transformer for the bottom entry and termination of four (4), single 500 kcmil copper, 15kV 133% EPR insulated conductors per phase.

8.12.3 Provide a ground pad inside the terminal box for the purpose of grounding the MV cable shields.

8.12.4 All current carrying connections to be silver plated copper alloy. Aluminum and Cu/Al lugs are not acceptable.

8.12.5 If busbars are required to connect the MV bushings to the cable terminations, they shall be copper and shall be robust enough to prevent movement when the cables are attached. The busbar specification and cable requirements will be determined before manufacture.

8.12.6 Bushing terminal pads shall be drilled in accordance with ANSI C37-32 and shall be complete with terminal connectors and bolting hardware. The ampacity of the bushing terminal pads and connectors and interconnecting copper busbars shall not be less than the maximum ONAF rating of the transformer.

9. OFF-LOAD 138kV / 69kV SERIES-PARALLELING SWITCH

9.1 The off-load Series-Paralleling switch shall be located on the high voltage winding, in accordance with CSA C88-M90 (R2014).

9.2 The Series-Paralleling switch shall be capable of connecting the full high voltage windings in either series (138kV) or parallel (69kV).

9.3 Both configurations shall be continuously rated for the maximum ONAF rating.

9.4 The handle of the off-load Series-Paralleling switch shall preferably be located on the HV bushing side of the transformer tank and shall be lockable with a padlock having a 10mm diameter shackle.

9.5 A sign reading "**CAUTION – Off-Load Series-Paralleling Switch. Do Not Operate with Transformer Energized.**" shall be attached beside the operating handle.

10. ON-LOAD TAPCHANGING EQUIPMENT

10.1 On-Load Tapchanger (OLTC) Rating

10.1.1 An on-load tapchanger shall be installed in the high voltage windings. Complete details on the type, rating (MVA, V and A) of the OLTC shall be given with the tender quotation.

10.1.2 The tapchanger rating shall be sufficient to enable continuous operation of the transformer at its rated maximum load (2 stages of supplemental cooling).

10.1.3 The tapchanger shall be capable of carrying full capacity on all tap positions.

10.1.4 The tapchanger shall meet the over-voltage requirements of CSA-C88-M90 (R2014).

10.1.5 The tapchanger shall be able to accommodate the maximum ONAF (2^{nd} stage) rating at a temperature rise of 65ºC (35MVA).

10.1.6 The tapchanger nameplate shall show manufacturer, model number, serial number, current, and voltage as well as all items required by the applicable standards.

10.1.7 The individual tap positions shall be in accordance with Section 7.1.

10.2 Manual Control and Indication

10.2.1 All standard accessories and mechanical features described in CSA-C88-M90 (R2014), and applicable appendices, shall be supplied.

10.2.2 OLTC drive motor shall have thermal overload protection and means shall be provided for isolating the motor from the supply. Supply voltage shall be selected based on Section 2.4.1.

10.2.3 The following controls shall be provided in the control cabinet:

a) Switch for Off-Manual-Test-Auto control functions
b) Switch for Local-Remote
c) Mechanical Tap Position Indication
d) Operations counter
e) Raise/Lower Switch

10.2.4 An “external tap position indicator” system, including an output transducer to provide a 4-20mA signal to the Substation SCADA computer which can be used to indicate the tap position, shall be provided. This system shall be the “resistance to DC milliamp” transducer type, with transducer output 4mA to 12mA to 20mA for tap position -5 to N to +5.

10.3 Construction

10.3.1 Arcing/diverter switches shall be installed in a sealed tank with an oil system completely separate from the oil in the main tank.

10.3.2 The diverter switch tank shall be either of a "sealed tank" or free breathing conservator tank design, each type being provided with its own de-hydrating breather.

10.3.3 Design of the diverter switch shall be such that it will not stop between steps if the motor supply is interrupted before the step is completed.

10.3.4 The diverter switch contacts shall be rated for at least 200,000 transitions at their rated current, before requiring replacement; and the contacts shall be easily accessible.

10.3.5 Taps shall be so arranged that for a fixed secondary voltage, the lowest numbered tap gives the lowest primary voltage; and successive increasing tap numbers give increasing voltage steps.

10.3/

10.3.6 The tap changer mechanism shall cause the tap changer to move only one step per operation.

10.3.7 An operations counter shall be provided.

10.4 Control and Indication

10.4.1 Control and indication of the OLTC shall be provided in accordance with the simplified schematics illustrated in the reference drawing.

10.4.2 A complete control and indication schematic for the OLTC system shall be provided. This schematic will include and incorporate a simplified illustration of the schematic provided by the OLTC manufacturer.

Interface terminals shall clearly indicate the wiring connections between the main transformer control cabinet and the OLTC mechanism cabinet.

Interface terminals shall clearly indicate the wiring connections to be made by the Owner.

10.4.3 The following control equipment shall be provided in the OLTC control cabinet:

a) Switch for "Local" and "Remote" control functions ("Off" position optional)
b) Manual Raise/Lower Controls
c) Operations Counter
d) Tap Position Indicator with Drag Hands
e) Tap position indication equipment c/w analogue (4-20mA) output transducer
f) Terminal blocks for field run cable connections by others

10.4.4 The following control equipment shall be provided in the main control cabinet:

a) Switch for "Local-Manual", "Local", "Auto" and "Remote" control functions
b) Manual Raise/Lower Controls
c) Automatic voltage control equipment
d) Terminal blocks for field run cable connections for remote control by others

10.4.5 The OLTC drive motor shall have thermal overload protection; and a means shall be provided for isolating the motor from the supply. Supply voltage and number of phases will be as specified in the reference drawing.

10.4/

10.4.6 The tap position indication equipment shall be a slide-wire potentiometer comprising 1 W resistors (number of resistors same as the number of steps in the OLTC). Total resistance of the potentiometer shall not exceed 2,000 ohms. The three terminals of the potentiometer shall be wired to terminal blocks in the main control cabinet.

10.4.7 A slide wire transducer with a 4-20mA (Optional 0-1mA) output, compatible with the potentiometer resistance shall be installed in the control cabinet.

10.4.8 The power connection shall be 125VDC. The input power connection to the device shall be run through a two pole fuse holder and then be connected to terminals in the control cabinet.

10.4.9 A tap-change auxiliary contact, closed during tap changer travel, shall be wired to terminals in the control cabinet for a "tap-change-in-progress" indication.

10.4.10 Control cabinet for the on-load tap changer shall be near to and on the same side as the transformer control cabinet. Alternatively the two cabinets may be combined.

10.4.11 In the event of two control cabinets, the interconnecting wiring shall be via terminal blocks in the main control cabinet. Direct connections to devices within the main control cabinet are not acceptable. It is assumed that interconnection terminal blocks will be provided in the OLTC control cabinet by the manufacturer of the OTLC.

10.5 Tapchanger Control

10.5.1 The on-load tapchanger will be operated/controlled from the existing Substation SCADA computer.

10.5.2 The SCADA computer will issue a dry contact closure to either raise or lower the secondary (13.8kV) system voltage, one tap at a time.

10.6 Mechanical Features

10.6.1 Taps shall be so arranged that for a fixed primary voltage the lowest numbered tap gives the lowest secondary voltage and successive increasing tap numbers give increasing voltage steps.

10.6/

10.6.2 The tapchanger mechanism shall be so designed as to ensure the completion of a tap change once initiated irrespective of whether or not the motor or its power supply fails.

10.6.3 All oil-immersed diverter switches shall be housed in a separate compartment with an oil system separate from the main tank and equipped with a Qualitrol or equivalent pressure relief device with deflector mounted on the side. The diverter switch compartment shall be equipped with valves for filtering.

10.7 Resistance vs. Reactance Tapchangers

10.7.1 High-speed resistance type tapchangers are preferred and suppliers shall quote this type, if available. Alternative quotations on reactance-type tapchangers will be considered provided that complete information is supplied. For all reactance-type tapchangers, test results shall show the winding magnetizing current in the reactor-bridging as well as the non-bridging position.

10.8 Tapchanger Instruction Books

10.8.1 Prior to shipment, the supplier shall supply separate operation and maintenance instruction manuals for the tapchanger in bound book format. Quantity to be the same as for transformer instruction manuals, and final drawings. An additional copy shall be placed in the pocket of the OLTC control cabinet. The books shall include instructions, drawings, and descriptions of the various components together with complete data for ordering replacement parts.

11. ACCESSORIES

11.1 General

11.1.1 All standard accessories shall be supplied in accordance with CSA-C88-M90 (R2014) but subject to the modifications stated in this Specification.

11.2 Nameplate

11.2.1 The transformer nameplate shall be fabricated from stainless steel and permanently engraved in accordance with CSA-C88-M90 (R2014), with the following additional data included:

.1 The rating information shall be for 65°C temperature rise.

11.2.1/

.2 The nameplate shall state that the entire insulating oil system is capable of withstanding full vacuum.

.3 A schematic representation of all winding and CT connections shall be shown on the nameplate. Ratios and polarities shall be indicated for all current transformers.

.4 Insulation rating of the HV and MV neutral shall be stated if graded insulation is supplied.

.5 A phasor diagram of all windings shall be shown.

.6 Measured values of positive and zero sequence impedances shall be shown based on ONAN (65°C Rise), rating. Positive and zero sequence impedances between windings shall be shown HV-MV, HV-T, and MV-T.

.7 The overload capabilities at 0ºC ambient temperature shall be stated on the nameplate.

11.3 Transformer Auxiliary Control and Monitoring System

11.3.1 Monitoring and control functions for transformer accessories shall be achieved using an SEL 2414 Transformer Monitor System. Provide an SEL2414 suitable for 125VDC power supply, EIA-232/EIA-495 serial communications, DNP3, DNP3 LAN/WAN, minimum 16 digital inputs, 8 analog inputs and minimum 8 digital outputs.

11.4 Pressure Relief Device

11.4.1 A spring-loaded diaphragm-type relief device(s), Reinhausen or approved equal mounted on the top of the main tank, equipped with a deflector to direct oil downwards, shall be supplied. As an alternative, a pipe-type pressure relief vent having a diaphragm at the top and screen at the bottom will be considered, but this alternative shall be clearly stated in the tender. DPDT auxiliary contacts functioned by the operation of the pressure relief device shall be wired to the SEL2414.

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11.5 Conservator Tank Liquid Level Gauge

11.5.1 A magnetic liquid level gauge, Reinhausen or approved equal, visible from ground level, shall be mounted on the higher end of the conservator tank. The gauge shall be marked in 10ºC intervals between -45ºC and +95ºC to correspond with the normal conservator oil levels at those temperatures. The nominal oil level shall occur at 25ºC.

11.5.2 The liquid level gauge shall be equipped with three (3) DPDT contacts, wired to SEL2414. One contact shall operate to indicate high oil level and two contacts shall operate to indicate low oil level.

11.6 Main Tank Liquid Level Gauge(s)

11.6.1 A liquid level gauge(s), Reinhausen or approved equal, shall be mounted on the side of the main tank, equipped with two (2) DPDT contacts arranged to provide alarm and tripping functions. The alarm point, as determined by the transformer Vendor, shall be the limit at which the liquid level is at the minimum safe operating level, and shall be wired to the SEL2414. The trip point, as determined by the transformer Vendor, will cause the transformer to be de-energized and is the limit at which the liquid level is lower than the alarm point but still covering the core and coils. The trip contact shall be wired to a terminal block for external use. For clarity;

.1 During liquid filling: The trip contact opens when the level of the rising liquid exceeds the trip point on the level indicator and the alarm contact opens when the level of the rising liquid exceeds the alarm point on the level indicator.

.2 During normal operation: If the liquid level falls below the alarm point, the alarm contact closes to announce an alarm state. If the liquid level continues to fall below the trip point, the trip contact closes, causing the transformer to be de-energized, but with the liquid still above the core and coils.

11.6.2 If both functions described in 11.6.1 cannot be accommodated in one instrument, a separate instrument for each function shall be supplied.

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11.7 Winding Temperature Indicator

11.7.1 The transformer shall be equipped with winding temperature indicator, Reinhausen or approved equal, for controlling two stages of forced air cooling and providing alarm and trip functions as described below:

.1 Four (4) adjustable contacts shall be supplied, two to control two stages of forced air cooling, one for alarm 90-105°C and one for trip 105-120°C. An analog circuit from the winding temperature indicator shall be wired to the SEL2414. Fan control temperature settings (2 stages) will be supplied and installed on the instrument by the Vendor. The final temperature setpoints shall be determined by the Vendor.

11.7.2 The winding temperature indicator shall be designed for the reproduction of the "hottest-spot" winding temperature. An appropriately sized current transformer, with two secondary windings, shall be mounted in one of the phase windings of the transformer to provide the load-compensated input to the winding temperature indicator.

11.7.3 The heater and winding temperature current transformer leads shall be brought out to a suitable terminal block or test link box outside the transformer tank and within the control cabinet to facilitate measurement of the current under load injection of the heater element from an external power source. Supply voltage shall be selected based on Section 2.4.1.

11.7.4 The winding temperature indicator shall be supplied with all control contacts wired to the SEL2414 which will be configured, by the transformer manufacturer, to control the fans.

11.7.5 Provide analog circuit from the winding temperature indicator to the SEL2414.

11.8 Liquid Temperature Indicator

11.8.1 Liquid temperature indicator, Reinhausen or approved equal, shall be supplied with two form 'c' contacts wired to terminal blocks in the control cabinet, with settings 90ºC for alarm and 105ºC for trip (settings to be confirmed by transformer Vendor).

11.8.2 Provide analog circuit from the liquid temperature indicator to the SEL2414.

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11.9 Gas Accumulation and Sudden Pressure Relay

11.9.1 The transformer shall be equipped with a Gas Accumulation/Sudden Pressure Relay mounted between the main tank and the conservator tank as herein described, or an approved equivalent.

.1 The relay shall be of a two-element type with electrically separate DPST contacts for tripping on sudden pressure rise and for alarm on gas accumulation. The alarm contact shall be wired to the SEL2414 and the trip contact shall be wired to a terminal block for external use.

.2 The gas detector relay shall be mounted in the pipe between the transformer main tank and the bottom of the conservator tank. The relay shall be located to permit inspection from the ground.

.3 The gas relay shall be mounted to collect all the gas evolved. All pockets or spaces over $800cm^3$ which are vented to the transformer main tank shall be piped to the relay with piping having a minimum 5 degrees slope upward to the relay.

.4 A gate-valve shall be provided between the transformer main tank and the gas detector relay for isolation and shall allow free passage of gas when the valve is open. The valve handle shall face the direction of gas detector relay access.

.5 A copper tube 1/4 inch or larger inside diameter shall run from the gas accumulation element, secured to the side of the tank, to a sampling valve approximately 60 inches above ground level. The valve shall be suitable for attaching a rubber tube of 1/4 inch inside diameter.

.6 The relay shall be provided with a test petcock for testing purposes.

.7 The relay shall be provided with graduated site glass, indicating the volume of gas that has accumulated.

.8 A Buchholz type relay is preferred, but other relays will be considered. Provide complete information on the type and model of gas detection relay being proposed, with the tender documents.

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11.10 Sudden Pressure Relay

11.10.1 The transformer shall be equipped with Sudden Pressure Relay installed on the on-load tapchanger tank.

.1 The relay shall be of a single-element type with one form 'c' contact for tripping on sudden pressure rise. The sudden pressure relay shall be a Qualitrol 900/910 Rapid Pressure Rise relay, or approved equivalent.

.2 A gate-valve shall be provided between the transformer and the sudden pressure relay for isolation purposes.

11.11 On-Line Dissolved Gas Monitor/Analyser

11.11.1 The transformer shall be equipped with an on-line, real-time Dissolved Gases Monitor/Analyser capable of measuring fault gases, moisture-in-oil, oil temperature, and ambient temperature. The DGA monitor/analyser shall be connected directly to the main transformer tank with an isolation/ shut-off valve for removal, if required. The DGA monitor/ analyser shall include software to provide graphical representation and storage of data. The DGA monitor/analyser shall be a GE Kelman Transfix, or approved equivalent.

11.12 Access Ladder

11.12.1 A metal ladder shall be attached to the side of the transformer tank, conveniently located to allow easy access to the gas detector relay and the top of the tank. The ladder shall be provided with a barrier having padlocking facilities and devices to latch it when in the open position.

11.13 Connectors

11.13.1 Two tank grounding connection pads, drilled for NEMA two-hole connectors, shall be supplied on diagonally opposite sides of the transformer tank. A copper 2 hole, long barrel, Burndy crimp type copper connector suitable for 4/0 AWG copper shall be supplied for each connection pad.

11.14 Dehydrating Breather

11.14.1 A dehydrating breather to the conservator tank shall be supplied. The dehydrating breather shall be a Reinhausen Messko MTraB dehydrating breather, or approved equivalent.

11.14/

11.14.2 Separate tapchanger compartments shall also be equipped with dehydrating breathers.

11.14.3 Dehydrating breathers shall be piped to within 60 inches of ground level to facilitate maintenance.

11.14.4 Desiccant container style dehydrating breathers are not acceptable.

11.15 Current Transformers

11.15.1 Standard, multi-ratio bushing type current transformers (CTs) shall be supplied per CSA C60044-1-07 (R2011) as follows:

.1 Internally on the 69kV Neutral (H0) Bushing:
Quantity: 1
CTR: 600-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 600-5A ratio

.2 Internally on the Tertiary Winding Y3a Bushing:
Quantity: 2
CTR: 2000-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 2000-5A ratio

.3 Internally on the 13.8kV Neutral (X0) Bushing:
Quantity: 1
CTR: 2000-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 2000-5A ratio

.4 Internally on a 13.8kV Winding Bushing:
Winding Temperature Indicator System CT
Quantity: 1
CTR: 1600-5A (accuracy and ratio to be confirmed by Manufacturer)
As required for correct functioning with WTI system

11.15.2 A current transformer shall be installed externally in the buried delta tertiary ground conductor circuit, between the Y3b bushing and the tank ground pad. The current transformer shall be installed on a tank wall bracket located below the Y3b bushing for ease of routing the tertiary winding grounding conductor to the current transformer and to ground. The current transformer shall be supplied per CSA C60044-1-07 as follows:

11.15.2/

.1 Externally on the Ground Leg of the Tertiary Winding Connection:
Quantity: 1
CTR: 600-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 600-5A ratio

.2 In any case, the ratio and accuracy class shall be compatible with the maximum fault current that will result from a ground fault on the buried tertiary winding.

11.15.3 Ratio and polarity of all current transformers shall be shown on nameplates. In general, polarity and markings shall be toward the transformer bushing terminal.

11.15.4 The dielectric strength of the current transformer secondary wiring shall be sufficient to withstand the current transformer open circuit voltage for one minute and as defined in CSA C60044-1-07 (R2011). Current transformer secondary wiring to the control cabinet terminal blocks shall be considered an integral part of the current transformer for all test requirements. All wires shall be identified at each end with heat-shrinkable wire markers.

11.15.5 All current transformer current leads passing through the tank wall shall use bolted through-type bushings. Plug-in receptacle-type connections are not acceptable.

11.15.6 The continuous thermal current rating factor for bushing and neutral current transformers shall be 2.0 with the unit in free air, based on temperature rise in accordance with CSA C60044-1-07 (R2011).

11.15.7 All current transformers shall be adequately braced to prevent damage and movement during shipping. Instructions for removal of all temporary shipping braces shall be supplied.

11.15.8 All bushing type current transformers shall be removable without removing the transformer tank cover.

11.15.9 The following information shall be supplied for all current transformers:

.1 Specification number for replacement
.2 Ratio and accuracy on all taps
.3 Resistance of the full secondary winding
.4 Excitation curves on all ratios

11.16 Gaskets

11.16.1 Gaskets shall be of nitrile rubber or approved equivalent. Gaskets stops shall be provided to prevent over-compression of the gasket material. A sufficient quantity of gasket cement shall be supplied for initial installation. One spare gasket of each type necessary for field assembly shall be provided.

11.17 Transformer Oil

11.17.1 Sufficient transformer oil shall be supplied for filling the transformer and conservator tank to the proper level. The transformer oil shall comply with CSA C50-14. The transformer oil shall be PCB free and shall include acid inhibitors.

11.17.2 The transformer oil shall be Voltesso 35, or approved equivalent.

12. FORCED COOLING

12.1 Oil Immersed, Forced-Air Cooled (Type ONAF)

12.1.1 The transformer shall be provided with two stages of cooling fans to increase the transformer rating from 21 MVA ONAN to 35 MVA ONAF.

12.1.2 A full fan control system for control of cooling fans, including terminal blocks, automatic and manual control switches, contactors, and protective and control devices for two complete stages of fan cooling. The SEL2414 shall be used to perform fan control. Fan control equipment shall be located in the transformer control cabinet.

12.1.3 Fan motors shall be single phase 240Vac or 208Vac unless specified otherwise. Fan guards shall be galvanized.

12.1.4 Fan motors shall be equipped with waterproof plugs and receptacles so that individual units can be disconnected.

12.1.5 Fans shall not be located under radiators where they may be blocked by snow accumulation.

12.1.6 An alarm function shall be provided for each fan of each stage of cooling, for fan failure or loss of the fan power supply. The alarms shall be wired to SEL2414.

13. FACTORY TESTS

13.1 Unless otherwise specified, carry out all routine factory tests listed in CSA C88-M90 (R2014), Article 16.

13.2 In addition, the following factory tests shall be performed:

13.2.1 The excitation current and losses tests shall be performed at 90%, 95%, 100%, 105% and 110% of the rated voltage before the commencement of the dielectric tests.

13.2.2 The excitation current test shall be extended to include the saturation curve up to 115% rated volts and the curve shall be extrapolated to 130% of rated voltage.

13.2.3 Oil samples shall be taken before and after the excitation current test. Oil samples shall be subjected to gas analysis and the results of the two analyses compared.

13.2.4 Pressure tests on tank and cooling system shall be made employing hot oil at 50°C and 35 kPa maintained for a period of 24 hours. If any leaks appear, they shall be repaired and the test shall be repeated.

13.2.5 Insulation tests on auxiliary wiring shall include dielectric tests in accordance with ANSI C37.20.

13.2.6 Core insulation tests (minimum 1000 volt insulation tester) shall be repeated after transformer is loaded onto the carrier immediately prior to shipping. Test results and all relevant critical test information shall be recorded on standard field test report sheets.

13.2.7 After completion of all other tests and prior to shipment, the unit shall be energized at 110% voltage 60 Hz for one hour at no load. The results shall be within 5% of previous no load loss test results.

13.2.8 A vacuum test shall be performed on all tanks and cooling systems designed for vacuum filling.

13.2.9 Impulse tests shall be performed on all terminals including neutrals in accordance with ANSI C57.12.90 (R2010). Impulse test oscillograph records shall be made on transparent, fine grain film and shall have a minimum size of 75mm x 100mm. A digital format of the oscillograph record would also be acceptable.

13.2/

13.2.10 Partial discharge measurements shall be performed on the high voltage winding during the induced potential test. The magnitude of partial discharge shall be determined by measuring, at the high voltage terminal of the winding under test, the radio influence voltage (RIV) generated by the corona. A radio noise and field strength meter conforming to ANSI C63.2-2009 shall be used to measure the RIV generated by the partial discharge. The general method and procedure shall conform to the recommendations of NEMA 107-1987 (R1993).

13.2.11 Power factor tests shall be performed for all bushings with resulting power factor stamped on the bushing nameplate and recorded in the test results.

13.2.12 Sound level test shall be performed in accordance with IEC 60076-10 ed1.0.

13.2.13 The results of calibration tests on winding temperature devices (hot spot indicator) shall be shown on the test report.

13.2.14 Sweep Frequency Response Analysis shall be performed on the transformer. The results of sweep frequency response analysis shall be included in the certified transformer test report.

13.3 Advise the Owner's Engineer fifteen (15) working days prior to the tests so that he may attend.

13.4 All test facilities shall be available at the place the equipment is being manufactured.

13.5 Upon completion of tests, four copies of Vendor certified test results shall be supplied to the Owner. The test results shall show all tests conducted in accordance with this Specification.

14. SHIPPING TESTS

14.1 The following test procedure shall be performed on the transformer as a test for shipping damage:

14.1.1 At the factory prior to shipment:

a) After loading the transformer onto the common carrier, the Vendor shall measure the core insulation with a 1000V (minimum) bridge megger. The value of core insulation and the voltage of the megger shall be included in the certified transformer test report under "Core Insulation Resistance Test after Loading onto Carrier at Factory".

b) The dew point of the shipping gas inside the transformer shall be checked to ensure it is below -40ºC. The results shall be recorded on the test reports.

14.1.2 At the destination:

a) Prior to off-loading the transformer from the Carrier, the Owner's Engineer in the presence of the manufacturer's/supplier's representative shall measure the core insulation and the dew point of the gas. These readings shall be compared to the values obtained at the factory.

b) The recording from the impact recorders shall also be checked by the Vendor. Any discrepancies or concerns shall be rectified or explained to the Owner's Engineer's satisfaction. Failure to resolve these issues may lead to the unit being returned to the factory for retesting prior to acceptance; all at the manufacturer's/supplier's cost.

15. TOOLS

15.1 Supply a list and prices of a complete set of all special tools that may be required for the normal and proper maintenance of the equipment supplied.

16. CONSTRUCTION DOCUMENTS

16.1 Manufacturer's Drawings

16.1.1 Transformer drawings shall show basic details and dimensions, location of centre of gravity, height for untanking core and coils and for removal of bushings, gasket location, thickness and material, direction of air movement through fans as well as other details as necessary.

16.1.2 A separate shipping drawing shall be supplied for the transformer giving the following information:

a) Shipping heights, width, length, and base dimensions
b) Centres of gravity in shipping condition
c) Location of jack steps, rolling areas, and blocking areas
d) Slinging requirements and restrictions, if any, for crane off-loading of the transformer
e) Position of gas bottles, regulators, and gauges if shipped in gas
f) Position of core ground test link
g) Details of gas shipping conditions and pressure checks to be made
h) Complete Bill of Materials

16.1.3 Wiring diagrams, schematic diagrams, layout drawings, bills of material and product data sheets shall be provided.

16.2 Operation and Maintenance Manuals

16.2.1 Instruction manuals shall describe in detail the construction and recommended procedures for assembling, dismantling, maintaining, and operating all equipment and listing all replacement parts. These shall include copies of all pertinent bulletins and instructions prepared by the manufacturers, of component parts of the equipment, properly catalogued for easy reference.

17. EFFICIENCY EVALUATION

17.1 The Vendor shall guarantee the following transformer losses:

a) No-Load loss in kilowatts at rated voltage and rated frequency.
b) Total losses in kilowatts at rated output, rated voltage and rated frequency.

17.2 Load losses shall be evaluated on the ONAN rating for the transformer in accordance with CSA-C88-M90 (R2014).

17./

17.3 Transformer losses determined under tests shall be corrected to 85°C.

17.4 For comparison of tenders, the transformer losses will be evaluated on the basis of the capitalized cost figures calculated over a 30 year life expectancy of the transformer, as stated below, and are to be given on the base ONAN rating:

.1 No-Load Losses: $3,327.54 per kW
.2 Load Losses: $ 447.75 per kW

17.5 If the losses as tested exceed the losses as guaranteed by more than the tolerances specific in CSA Standard CSA-C88-M90 (R2014), the following shall apply:

.1 The capitalized cost of the loss(es) as guaranteed will be subtracted from the excess of capitalized cost of the loss(es) as tested and the excess of the capitalized cost will be assessed to the Vendor as a cost adjustment using the figures of Section 17.4.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION C

SCHEDULES

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION C

SCHEDULES

1. INSTRUCTIONS

1.1 Complete and submit with the tender and schedules contained in this section.

1.2 Incomplete schedules may render the tender inadmissible.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 1

TECHNICAL INFORMATION

1. 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV POWER TRANSFORMER

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer:

Manufacturer		_____
Type		_____
Rated capacity at low voltage terminals at 65°C rise:	MVA ONAN MVA ONAF MVA ONAF	_____ _____ _____
Rated primary (HV) voltage	kV rms	_____
Rated secondary (MV) voltage	kV rms	_____
Rated Tertiary voltage	kV rms	_____
Guaranteed positive sequence impedances, Z_1 on rated MVA base, at 85°C and mid tap	H-L % H-T % L-T %	_____ _____ _____
Guaranteed zero sequence impedances, Z_0 on rated MVA base, at 85°C and mid tap	H-L % H-T % L-T %	_____ _____ _____
Guaranteed no-load losses at rated frequency and rated voltage on mid tap, 85°C	kW	_____
Guaranteed load losses at rated frequency and the following currents on mid tap, 85°C:		
- at 125% ONAN load, 65°C rise	kW	_____
- at 100% ONAN load, 65°C rise	kW	_____
- at 100% ONAF load, 65°C rise	kW	_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Guaranteed load losses at rated frequency and the following currents on mid tap, 85° C: (Cont'd)		
- at 75% ONAN load, 65°C rise	kW	_____
- at 50% ONAN load, 65°C rise	kW	_____
- at 25% ONAN load, 65°C rise	kW	_____
Guaranteed cooling fan losses at 65°C rise, ONAF rating	kW	_____
Exciting Current:		
- at 100% rated voltage	A rms	_____
- at 110% rated voltage	A rms	_____
Efficiency at rated frequency and the following currents on mid tap, 8°C:		
- at 125% ONAN load, 65°C rise	%	_____
- at 100% ONAN load, 65°C rise	%	_____
- at 100% ONAF load, 65°C rise	%	_____
- at 75% ONAN load, 65°C rise	%	_____
- at 50% ONAN load, 65°C rise	%	_____
Regulation:		
- at 80% power factor	%	_____
- at 90% power factor	%	_____
- at 100% power factor	%	_____
Winding material		_____
Vector group		_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Rated lightning-impulse withstand voltage:

-	Primary (HV) winding	kV crest	_____
-	Secondary (MV) winding	kV crest	_____
-	Tertiary winding	kV crest	_____
-	Primary (HV) bushings	kV crest	_____
-	Secondary (MV) bushings	kV crest	_____
-	Tertiary bushings	kV crest	_____

Rated long duration power frequency withstand voltage:

-	Primary (HV) winding	kV rms	_____

Rated power frequency withstand voltage (dry, 1 min., 60 Hz):

-	Primary (HV) winding	kV rms	_____
-	Secondary (MV) winding	kV rms	_____
-	Tertiary winding	kV rms	_____
-	Primary (HV) bushings	kV rms	_____
-	Secondary (MV) bushings	kV rms	_____
-	Tertiary bushing	kV rms	_____

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Rated current:		
- Primary (HV) bushings	A rms	_____
- Secondary (MV) bushings	A rms	_____
- Tertiary bushing	A rms	_____
Bushing Leakage Distance:		
- Primary (HV) bushings	mm	_____
- Secondary (MV) bushings	mm	_____
- Tertiary bushing	mm	_____
Minimum corona inception voltage for 138V winding	kV rms	_____
Maximum sound level measured in accordance with IEC 551:		
- with auxiliaries	dB	_____
- without auxiliaries	dB	_____
Maximum RIV at 1 MHz measured at 5% above rated voltage in accordance with NEMA 107-1987	μV	_____
Short circuit current withstand ratings:		
- HV winding	A rms sym.	_____
- MV winding	A rms sym.	_____
- Buried Tertiary winding	A rms sym.	_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Maximum duration of rated short circuit withstand current:		
- HV winding	sec	_____
- MV winding	sec	_____
- Buried Tertiary winding	sec	_____
Type of steel core lamination		_____
Flux density of core at 69kV	Tesla	_____
Flux density of core at 34.5kV	Tesla	_____
Thickness of transformer plates:		
- main tank	mm	_____
- tapchanger tank	mm	_____
- radiator plates	mm	_____
- primary and secondary cable boxes	mm	_____
- control cabinet	mm	_____
Vacuum that tank and radiators can withstand	kPa	_____
Positive pressure that tank and radiators can withstand	kPa	_____

1.2 Terminal Arrangements and Conductor Connectors:

Connectors for HV Overhead Conductors:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connectors for MV Power Cable Conductors:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for H0 Bushing Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for X0 Bushing Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for Tertiary Winding (Y3a/Y3b) Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

1.3 Accessories:

Off-Load Series-Paralleling Switch (Primary HV Winding):

- Manufacturer _____
- Type _____
- Capacity of Switch contacts A _____

On-Load Tap Changer (OLTC) (Primary HV Winding):

- Manufacturer _____
- Type _____
- Number of Steps _____
- % Primary voltage variation % _____
- Capacity of taps A _____
- Drive Motor Rating V / kW _____
- Tap Position Indicator:

  Manufacturer _____

  Transducer Analog Output mA _____

Transformer Monitoring and Control System:

- Manufacturer _____
- Type _____
- Power Supply Voltage Vdc _____
- Number of Digital Inputs _____

1.3 Accessories (Cont'd):

Transformer Monitoring and Control System (Cont'd):

- Number of Analog Input Channels _____
- Number of Digital Outputs _____

Main Tank/Conservator Gas Accumulation/Sudden Pressure Relay:

- Manufacturer _____
- Type _____

On-Line Dissolved Gases Monitor/Analyzer:

- Manufacturer _____
- Type _____

Winding Temperature Indicator:

- Manufacturer _____
- Type _____
- Setting for Fans stage 1 ^{O}C _____
- Setting for Fans stage 2 ^{O}C _____
- Setting for Alarm ^{O}C _____
- Setting for Trip ^{O}C _____

1.3 Accessories (Cont'd):

Main Tank Liquid Temperature Indicator:

- Manufacturer _____
- Type _____
- Setting for Alarm ^{O}C _____
- Setting for Trip ^{O}C _____

Main Tank Liquid Level Gauge:

- Manufacturer _____
- Type _____
- Scale _____

Conservator Tank Liquid Level Gauge:

- Manufacturer _____
- Type _____
- Scale _____

Tapchanger Tank Sudden Pressure Relay:

- Manufacturer _____
- Type _____

1.3 Accessories (Cont'd):

Main Tank Pressure Relief Device:

- Manufacturer _____
- Type _____
- Setting for pressure relief _____

1.4 Insulating Oil:

- Manufacturer _____
- Type _____

1.5 Current Transformers:

HV Neutral CT (H0):

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

MV Neutral CT (X0):

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

1.5 Current Transformers (Cont'd):

Winding Temperature Indicator (WTI) CT:

- Manufacturer _____
- CT Ratio _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

Tertiary Winding Bushing CTs:

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

Tertiary Ground CT:

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

1.6 Cooling System:

- Number of radiators _____
- Total number of fans Stage 1 cooling _____
- Total number of fans Stage 2 cooling _____

1.6 Cooling System (Cont'd):

- Capacity of each fan	hp	_____
- Rated operating voltage	V	_____
- Number of phases		_____
- Starting current	A	_____
- Locked rotor current	A	_____

1.7 Transformer Weights, Dimensions, and Miscellaneous:

Overall height	m	_____
Overall width	m	_____
Overall length	m	_____
Weight of core and coils	kg	_____
Weight of tank and fittings	kg	_____
Weight of oil	kg	_____
Total weight of complete transformer	kg	_____
Method of oil shipment		_____
Maximum shipping weight (heaviest item)	kg	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 2

DOCUMENTS TO BE SUBMITTED WITH TENDER

	Drawing or Document Ref. No.
Completed Schedules	_____
Outline dimensions and layout of equipment and enclosures	_____
Bills of Material	_____
Catalogues	
Instruction Pamphlets (including fuse time/current curves)	_____
Painting Procedure Specification	_____
Certified "Type Test" Reports (including list of Type Tests to be performed)	_____
List of Recommended Spare Parts (Include prices for each item):	
- readily available	_____
- long delivery	_____
List of required Special Tools	_____
Bar chart progress schedule showing manufacture, delivery, issue of drawings, and all phase of the work	_____
Transportation method and route (including details of trailer and wheel loading)	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 3

TENDERED VARIATIONS FROM THE SPECIFICATION

The Tenderer shall detail hereunder, any variations from the terms and conditions of this Specification:

Signature: _____

Date: _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 4

ERECTION SUPERVISOR

The Vendor shall provide a qualified person(s) to supervise the erection of the power transformer as part of the contract.

Include the name(s) and professional experience of the person(s) proposed as the site erection supervisor / technician.

Also provide details of any specific terms and conditions applicable to each supervisor / technician.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 5

COMMENCEMENT AND COMPLETION DATES

		Required Dates	Tendered Dates
1.	Issue of Purchase Order	7 December 2015	_____
2.	Submit Bills of Material and Planning Schedule for review.	7 February 2016	_____
3.	Submit assembly drawings, foundation and base plate details, layout and drilling details, wiring diagrams, control schematics, and drawings for review.	27 March 2016	_____
4.	Submit performance curves and other supporting documentation.	27 March 2016	_____
5.	Submit final copies of shop drawings	27 April 2016	_____
6.	Submit draft copies of Operation and Maintenance Manuals.	1 June 2016	_____
7.	Delivery and Offloading, DDP, Fundy Ocean Research Center for Energy Intertie Substation Site Black Rock (Parrsboro), Nova Scotia	1 July 2016	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 6

SPARE PARTS LIST

Recommended Spare Parts	Quantity	Price (Cdn $)
1. High Voltage (138kV) Bushing	1	
2. Medium Voltage (15kV) Bushing	1	
3. Cooling Fan, complete with Motor	1	
4. Complete Set of Gaskets, together with Gasket Cement	1	
5.		
6.		
7.		
8.		
9.		
10.		

Total Price Carried to Schedule 8: $_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 7

ACCESSORIES AND SPECIAL TOOLS LIST

Recommended Accessories and Special Tools	Quantity	Price (Cdn $)
1. Impact Recorder (Supply, Mounting and Processing)	Lot	$ _____
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Total Price Carried to Schedule 8: $ _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 8

PRICE LIST

Item	Description	Qty	Price (Cdn $)
1.	Design, manufacture, test, deliver, off-load, erect, assemble and provide a written guarantee for one (1), 21/28/35 MVA, 138/79.7kV / 69/39.85–13.8/7.97kV Oil-Immersed, Three Winding Power Transformer	lot	$ _____
2.	Accessories and Special Tools (from Schedule No. 7)	lot	$ _____
	Total Equipment Supply & Assembly (Items 1 &2)		**$ _____**
	Transportation DDP Fundy Ocean Research Center for Energy (FORCE) Intertie Substation Site Black Rock (Parrsboro), Nova Scotia	lot	$ _____
	Canadian Customs Duty	lot	$ _____
	Harmonized Sales Tax (HST)	15%	$ _____
	Total Supply, Deliver & Assembly Fundy Ocean Research Center for Energy (FORCE) Intertie Substation Site Black Rock (Parrsboro), Nova Scotia		**$ _____**
3.	Tenders shall provide a separate Price for the following optional item:		
	Spare Parts List (from Schedule No. 6)	lot	$ _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 9

FORM OF TENDER

Item: One (1), 21/28/35 MVA, 138/79.7kV / 69/39.85–13.8/7.97kV Oil-Immersed Power Transformer

Vendor Ref. No.:

1.	Total Supply, Delivery, Off-Loading & Assembly: (From Schedule No. 8)	**$** _____
2.	Terms of Payment:	_____
3.	Customs Clearance by:	_____
4.	Point of Shipment:	_____
5.	Promised Shipping Date:	_____
6.	INCOTERMS 2000 Definition:	_____
7.	Recommended Methods of Shipment:	_____
8.	Estimated No. of Packages:	_____
	- Shipping Weight Each Package:	_____
	- Shipping Dimensions Each Package:	_____
9.	Conditions of Guarantee:	_____
10.	Other:	_____
		_____
		_____

Prepared by: _____

Date: _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

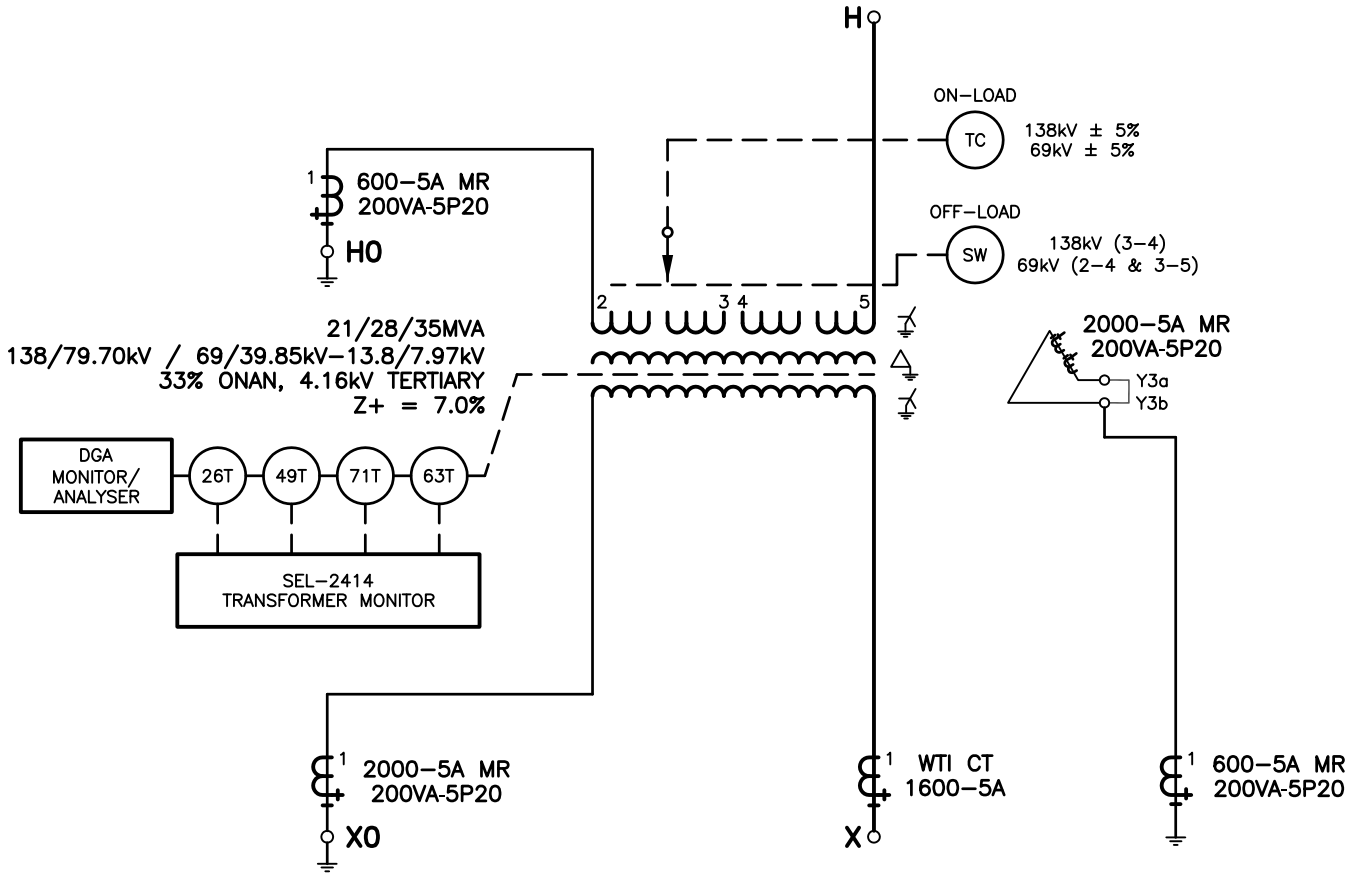
REFERENCE DRAWINGS

LEGEND

600–5A MR
200VA-5P20 — 3 — THREE 600–5A MULTI–RATIO CURRENT TRANSFORMERS, ACCURACY CLASS 200VA-5P20 @ 600–5A.

TC — ON–LOAD TAPCHANGER ASSEMBLY (138kV ± 5% & 69kV ± 5%)

SW — OFF–LOAD SERIES–PARALLELING SWITCH ASSEMBLY (138kV & 69kV)



STRUM ENGINEERING ASSOCIATES LTD.	
DARTMOUTH & SYDNEY NOVA SCOTIA	
DRAWN	P.M.
CKD	R.F.M.
P.MGR.	R.McCARTHY
QA/QC	N.S.
SCALE	N.T.S.
DATE (YYYY–MM–DD)	2015–11–09
CLIENT	FUNDY OCEAN RESEARCH CENTER FOR ENERGY HALIFAX, NOVA SCOTIA
TITLE	INTERTIE SUBSTATION UPGRADE PROJECT 21/28/35MVA POWER TRANSFORMER SINGLE LINE DIAGRAM
REF. DWGS.	
DWG. No.	038–022–SK–01
REV.	A01

038022SK01.DWG

STRUM ENGINEERING ASSOCIATES LTD.

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NS

INTERTIE SUBSTATION UPGRADE PROJECT – PHASE 1

MANUFACTURE, TESTING, DELIVERY, OFF-LOADING AND SITE ASSEMBLY OF ONE (1) 21/28/35 MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV OIL-IMMERSED POWER TRANSFORMER

NOVEMBER, 2015 **SPECIFICATION No. 038-022-1-15**

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

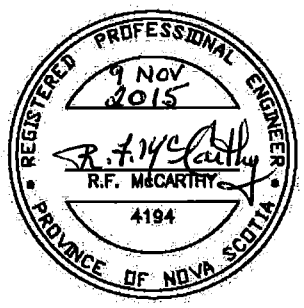
FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NS

INTERTIE SUBSTATION UPGRADE PROJECT – PHASE 1

MANUFACTURE, TESTING, DELIVERY,
OFF-LOADING AND SITE ASSEMBLY OF ONE (1)
21/28/35 MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV
OIL-IMMERSED POWER TRANSFORMER

SPECIFICATION No. 038-022-1-15

SIGNED AND SEALED:



R. McCARTHY, P. ENG.
SENIOR ELECTRICAL ENGINEER

SIGNED:

N. STRUM, P. ENG.
QA/QC ENGINEER

STRUM ENGINEERING ASSOCIATES LTD.

NOVEMBER, 2015

STRUM ENGINEERING ASSOCIATES LTD.

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SPECIFICATION

SECTION A

INFORMATION AND GENERAL REQUIREMENTS

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION A

INFORMATION AND GENERAL REQUIREMENTS

1. GENERAL

1.1 This Technical Specification, prepared by Strum Engineering Associates Ltd. on behalf of the Fundy Ocean Research Center for Energy (FORCE), consisting of the Information and General Requirements, the Technical Requirements, together with all Schedules, Drawings, and Addenda issued with and subsequent to the "Invitation to Tender", shall become a part of any Contract or Purchase Order to perform the work involved. In case of discrepancies between the work tendered to be performed and the work specified to be performed, the Technical Specification shall be final and binding unless there be mutual agreement to the contrary between the Fundy Ocean Research Center for Energy (FORCE) and the Vendor.

2. DESCRIPTION OF PROJECT

2.1 The scope of work of this aspect of the intertie substation upgrading project consists of the design, manufacture, factory testing, delivery to site, off-loading at site, oil-filling and conditioning, installation of bushings, conservator tank, fans and miscellaneous components and warranty of one (1), 21/28/35MVA, 138/79.70 / 69/39.85kV – 13.8/7.97kV outdoor, oil-immersed, three-phase, three winding power transformer, complete with all specified auxiliary equipment, **Tag: 90N-T51**.

3. DEFINITIONS

3.1 The **Owner's Engineer** shall mean:

Strum Engineering Associates Ltd.
80 Eileen Stubbs Ave.
Dartmouth, Nova Scotia B3B 1Y6

Contact: Mr. Rick McCarthy, P. Eng.

Telephone: (902) 468-7325
Fax: (902) 468-1908
E-Mail: r.mccarthy@strumengineering.ca

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3.2 The Vendor shall mean the Bidder as defined in the Fundy Ocean Research Center for Energy (FORCE) Terms and Conditions.

3.3 The **Owner's** information and contact will be:

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
1690 Hollis Street, 10th Floor
P.O. Box 2573
Halifax, Nova Scotia
B3J 1V7

Contact: Mr. Andrew Lowery
Telephone: 902-406-1166
E-Mail: andrew.lowery@fundyforce.ca

4. ERRORS AND OMISSIONS

4.1 Should any details necessary for a clear and comprehensive understanding be omitted, or any error appear in the tendering documents, it shall be the duty of the Bidder to obtain clarification from the Owner's Engineer before submitting his tender. All additions or corrections to the Technical Specification will be issued in writing to all Bidders as addenda thereto. Bidders shall list in their tenders all the addenda that were received and considered when their tender was prepared.

5. MATERIAL AND WORKMANSHIP

5.1 All materials shall be new. Workmanship and material shall be of the best quality.

5.2 Equipment of the same type shall be interchangeable. Listed spare parts shall be identical and inter-changeable with parts in service that they are intended to replace.

6. GUARANTEE/WARRANTY

6.1 The Vendor shall warrant that all materials, equipment, and workmanship furnished in accordance with the purchase documents shall comply in all respects with the Technical Specification, and shall guarantee in writing that the equipment will give successful and efficient service.

6.2 The Vendor shall, to the satisfaction of the Owner, rectify any defects which may appear in the equipment, or of which he shall receive notice from the Owner and for which he may have been responsible in the opinion of the Owner, for a period of twelve months after start-up or eighteen months after shipment, whichever occurs first.

6.3 Any equipment which fails to perform in accordance with the requirements of the Specification during this period may be rejected by the Owner. The Vendor shall proceed at once to make alterations or furnish new equipment, as may be necessary.

6.4 Costs of supplying any replacement equipment, or of modifications or alterations to equipment, in order to meet specified requirements shall be borne by the Vendor, including the costs, if any, of any work or materials provided by the Owner, and of any shipping charges incurred by the Owner.

6.5 Operation by the Owner of the equipment or any part thereof shall not constitute any waiver of the Owner's rights under this agreement.

6.6 The Vendor agrees that the Unit shall meet the requirements set out in the Specification and all relevant standards listed herein.

6.7 The Owner’s purchase order terms and conditions shall prevail.

7. MANUFACTURER'S DRAWINGS

7.1 General

7.1.1 Drawings shall be clear and legible and have a title block including the name of the Project, and the number and title of the drawing.

7.1.2 All drawings shall be prepared on A1 size sheets, 594 mm by 841 mm. Use of other size sheets shall be agreed by the Owner's Engineer.

7.2 System of Units

7.2.1 All dimensions shall be in the Imperial and Metric system.

7.3 Title Block

7.3.1 Drawing title blocks shall include the following information:

.1 Name of the Project as follows:

Intertie Substation Upgrade Project – Phase 1

FUNDY OCEAN RESEARCH CENTER FOR ENERGY (FORCE)
HALIFAX, NOVA SCOTIA

Manufacture, Testing, Delivery, Off-Loading and Site Assembly of a 21/28/35MVA, 138/79.70kV / 69/39.85kV – 13.8/7.97kV Oil-Immersed Power Transformer

Owner's Purchase Order No.

.2 Provide a 100 mm x 100 mm space to accommodate the Engineer's review stamp.

.3 Issue date and the drawing number.

.4 Space allotted for revisions including the number, description, and date.

7./

7.4 Review of Drawings

7.4.1 Drawings made by the Bidder or his sub-contractors defining the work shall be provided at appropriate times within the program of work as defined in the Specification.

7.4.2 Five (5) prints or the electronic file (in Autocad XXX.dwg file format) of each shop drawings shall be submitted to the Owner's Engineer, who will return, within 14 days after receipt, one copy of the reviewed drawings stamped as follows:

STRUM ENGINEERING ASSOCIATES LTD.

Date Received: _____ By:

This drawing has been reviewed for the sole purpose of determining conformance with the general requirements of the Contract Documents.

The Contractor shall remain responsible for all damages resulting from errors and/or omissions contained in this drawing and shall satisfy all obligations and liabilities connected therewith and with the Contract Documents.

Reviewed - Manufacturing May Proceed. ( )
Reviewed - Submit Final Drawing. Manufacturing May Proceed. ( )
Reviewed - Make Changes As Noted. Submit Final Drawing. Manufacturing May Proceed. ( )
Reviewed - Correct and Resubmit. ( )
Review Not Required - Manufacturing May Proceed. ( )

Date Review Completed: _____ By:

All drawings checked other than, "Reviewed - Manufacturing May Proceed", shall be corrected and recycled for review within 14 calendar days, and this procedure continued until final review is obtained.

7.4/

7.4.3 Before proceeding with construction, submit for review to the Owner's Engineer, assembly drawings, foundation and base plate details, layout and drilling details, drawings covering construction, complete control schematic diagrams, and other pertinent data for the equipment under consideration. Do not start construction until instructed by the Owner's Engineer.

7.4.4 Do not revise those drawings or portions of drawings which have been reviewed and stamped during the review process unless these drawings or portions are affected by comments made or revisions requested.

7.5 Final Drawings

7.5.1 These drawings shall incorporate any changes made during the construction and testing stages of the work, shall be exact drawings of the equipment as supplied, and shall be of such quality to enable electronic scanning without loss of detail.

7.5.2 Do not revise drawings given final review by the Owner's Engineer except by his prior written consent.

7.5.3 Submit six (6) prints and the electronic (in Autocad XXX.dwg file format) file of each final drawing to the Owner's Engineer.

8. OPERATION AND MAINTENANCE MANUALS

8.1 Prepare comprehensive instruction manuals describing in detail the construction and recommended procedures for assembling, dismantling, maintaining and operating all equipment and listing all replacement parts. These shall include copies of all pertinent bulletins and instructions prepared by the Vendors of component parts of the equipment, properly catalogued for easy reference.

8.2 Two (2) copies of the manuals shall be submitted in draft form to the Owner's Engineer for review at least one (1) month before the equipment is to be delivered. Five (5) copies of the finalized manual shall be submitted at the time the equipment is shipped.

9. WITNESSING OF TESTS AND TEST REPORTS

9.1 Advise the Owner's Engineer 14 days prior to the tests so that tests may be witnessed by the Engineer and Owner.

9.2 Submit six copies of duly certified test reports, to be forwarded by courier prior to equipment shipment.

10. PACKAGING AND SHIPPING

10.1 All parts shall be thoroughly cleaned to remove oil, grease, dust, and other foreign material and all equipment openings shall be capped to prevent entry of foreign materials or damage.

10.2 Equipment shall be suitably prepared and packed so as to prevent damage occurring during storage, transportation, and unloading operations and to ensure that the equipment is in perfect working condition, has suffered no damage, and that all parts are intact on arrival at the destination.

10.3 Packaging and crating shall include suitable weather protection, moisture control, temporary bracing, blocking straps, skids, etc.

11. ERECTION SUPERVISOR

11.1 The off-loading, erection, oil-filling and conditioning and installation (dressing) of loose-shipped components of the equipment at the site shall be the responsibility of the transformer manufacturer/supplier and shall be performed under his/her direction. The transformer manufacturer/supplier shall utilize a company that is acceptable to Fundy Ocean Research for Energy. The cost of off-loading, erection, oil-filling and conditioning, installation and supervision shall be included in the contract price. The erection supervisor shall also provide instruction to the Owner's personnel on the operation and maintenance of the supplied equipment.

12. SIGNING AND SEALING OF MANUFACTURER'S DRAWINGS

12.1 Execute design under the supervision of a licensed Engineer. The Engineer shall sign and seal:

12.1.1 Shop fabrication drawings and specifications;

12.1.2 Site erection drawings and specifications; and,

12.1.3 Assembly, schematic and wiring diagrams.

13. CORRESPONDENCE

13.1 In view of the urgency associated with this project, the tender shall be submitted by courier and all other correspondence shall be by courier, facsimile or electronic mail (E-Mail).

13.2 The Vendor shall allow for this requirement in the prices quoted herein.

14. SCHEDULE

14.1 All equipment associated with this specification is required on site not later than 1 July 2016. Refer to Schedule No. 5, Page C-17, for the specific schedule requirements.

15. REFERENCE DRAWINGS

15.1 Strum Engineering Drawing No. 038-022-SK-01 Rev A01, entitled “Intertie Substation Upgrade Project – Phase 1, Intertie Substation Transformer, Single Line Diagram” indicates the general requirements of the intertie transformer proposed for the Fundy Ocean Research Center for Energy (FORCE), Intertie Substation Upgrade Project – Phase 1 in Black Rock, Nova Scotia.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION B

TECHNICAL REQUIREMENTS

SPECIFICATION

SECTION B

TECHNICAL REQUIREMENTS

1. SCOPE OF WORK

1.1 Design, manufacture, test, deliver to the Fundy Ocean Research Center for Energy (FORCE), Intertie Substation in Black Rock (Parrsboro), Nova Scotia, off-load onto a transformer slab-on-grade equipment pad provided by the Owner, fill and condition with transformer oil, install bushings, conservator tank, fans and miscellaneous components and provide a written warranty for one (1) 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV, outdoor, three phase, three winding, oil-immersed power transformer complete with all specified auxiliary equipment.

1.2 Testing and commissioning of the power transformer and associated components will be carried out by others and does not form part of this Contract.

2. SERVICE CONDITIONS

2.1 Application

2.1.1 The transformer will be installed outdoors on a slab-on-grade equipment pad.

2.2 Existing Supply System Data

2.2.1 138/69kV System Data

Nominal service voltage	kV rms	**69**	**138**
Rated (maximum) voltage	kV rms	75	150
Rated frequency	Hz	60	
No. of phases and wiring		3/3	
Neutral grounding	solidly grounded at utility source transformer neutral and new 21/28/35 MVA transformer HV neutral		
3 phase momentary short circuit current at 138kV and 69kV	69kV: 1.5kA rms sym.	138kV: 2.5kA rms sym.	

2.2/

2.2.2 13.8/7.97kV System Data

Nominal service voltage	kV rms	13.8
Rated (maximum) voltage	kV rms	15.2
Rated frequency	Hz	60
No. of phases and wiring		3/3
Neutral grounding		solidly grounded at new 21/28/35 MVA transformer MV neutral
3 phase momentary short circuit current at 13.8kV terminals of transformer	kA rms sym	10.0

2.3 Environmental Data

2.3.1 Design and manufacture the transformer to be suitable for operation under the following conditions:

Elevation above sea level	m	50
Maximum ambient temperature	^{o}C	40
Minimum ambient temperature	^{o}C	-40

2.3.2 The transformer shall be designed for outdoor service.

2.4 Auxiliaries Power Supply

2.4.1 The following auxiliary power supply is available:

240/120Vac, 1Ø, 3W, 60 Hz or 208/120Vac, 3Ø, 4W, 60 Hz for heaters, lights, cooling fans, and convenience receptacles.

3. STANDARDS

3.1 Unless otherwise specified herein, design, manufacture, and test the transformer in accordance with the latest issue of the following standards:

CSA C22.1-15	Canadian Electrical Code; Part 1, Safety Standard for Electrical Installations
CSA C22.2 No. 94-M91 (R2011)	Special Purpose Enclosures
CSA C60044-1-07 (R2011)	Instrument Transformers- Part 1 Current Transformers
CSA C50-14	Mineral Insulating Oil, Electrical, for Transformers and Switches
CSA C71-1-99 (R2008)	Insulation Coordination - Part 1: Definitions, Principles and Rules
CSA C71-2-98 (R2011)	Insulation Coordination - Part 2: Application Guide
CSA C88-M90 (R2014)	Power Transformers and Reactors
CSA C88.1-96 (R2011)	Power Transformers and Reactor Bushings
CSA C108.3.1-M84 (R2014)	Limits and Measurement Methods of Electromagnetic Noise From AC Power Systems 0.15 - 30 MHz
CSA C802.3-01 (R2012)	Maximum Losses for Power Transformers
CSA W59-13 (R2008)	Welded Steel Construction (Metal-Arc Welding)
CSA Z299.2-85 (R2006)	Quality Assurance Program
IEEE No.1-2000 (R2011)	Recommended Practice - General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.

3.1/

ANSI C29.1-1988 (R2012)	Electrical Power Insulators - Test Methods
ANSI C57.12.00 (R2010)	IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
ANSI C57.12.80 (R2010)	IEEE Standard Terminology for Power and Distribution Transformers
ANSI C57.12.90 (R2010)	IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and IEEE Guide for Short Circuit Testing of Distribution and Power Transformers
ANSI C57.91-2011	IEEE Guide for Loading Mineral Oil-Immersed Transformers and Step Voltage Regulators
ANSI C57.93-2007	IEEE Guide for Installation and Maintenance of Liquid-Immersed Power Transformers
ANSI C57.98-2011	IEEE Guide for Transformer Impulse Tests
ANSI C57.113-2010	IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors
ANSI C57.123-2010	Guide for Transformer Loss Measurement
ANSI C57.120-1991 (R2006)	IEEE Loss Evaluation Guide for Power Transformers and Reactors
ANSI C63.2-2009	American National Standard for Electromagnetic Noise and Field Strength Instrumentation 10Hz to 40 GHz - Specifications
NEMA TR1-2013	Transformers, Regulators, and Reactors (Including Noise Level Requirements)
NEMA 107-1987 (R1993)	Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus
IEC 60076-SER ed1.0	Power transformers – All Parts

3./

3.2 Apply all reference publications and amendments listed within the above standards.

3.3 Other alternative standards may be used if reviewed and accepted by the Owner's Engineer.

4. DESIGN BASIS

4.1 Base the detailed design on this Specification. Produce detailed drawings and submit for review prior to the start of manufacture.

5. EQUIPMENT, APPARATUS AND MATERIAL SUPPLIED BY OTHERS

5.1 All power cables, control cables, protection cables and auxiliary supply cables external to the transformer assembly.

6. PRODUCT DELIVERY, STORAGE AND HANDLING

6.1 The transformer shall be shipped under pressure of dry air or an acceptable dry inert gas as agreed by the Owner's Engineer. The transformer shall be provided with a pressure gauge suitably protected from damage during transit. The pressure and temperature shall be recorded at the time the transformer leaves the factory. The recorded information shall be given to the Owner's Engineer so that it can be compared with the pressure and temperature readings obtained after the transformer has been received at site to ascertain if any leakage has occurred. Ensure that the transformer arrives at site in an uncontaminated condition. The manufacturer/ supplier is responsible for oil-filling and oil-conditioning the transformer at site.

6.2 The manufacturer/ supplier shall provide two (2), three-axis impact recorders for shipment. The impact recorders shall be attached to the transformer near the top of the main tank, shielded to prevent damage, with both time mechanisms charged for the complete duration of shipment. Failure to do so may result in the Owner not accepting the transformer. On arrival, the impact recorder shall be removed only in the presence of the Owner's Engineer.

6.3 Crate all transformer parts and components removed for shipment to prevent damage. Radiators shall be packed in such a way that it is not possible for any weight to be placed directly on the fins, tubes or panels. All parts and components are to be free from rust.

6.4 A spare set of gaskets for use during site assembly shall be shipped.

6.5 Transformer oil shall preferably be shipped in tank trucks but may be shipped by alternative methods if reviewed and accepted by the Owner's Engineer. The oil shall arrive at site at the same time as the transformer. Ensure that the oil arrives at site in a clean, uncontaminated condition.

7. TRANSFORMER INFORMATION

7.1 Ratings and Data

7.1.1 21/28/35 MVA, 138/79.7 x 69/39.85 – 13.8/7.97kV Power Transformer

Quantity		1
Type		3-phase, oil-immersed, conservator tank, pad-mounted, three winding
Rated frequency	Hz	60
Rated voltages of windings:		
- high voltage	kV rms	138 x 69 (nominal tap)
- medium voltage	kV rms	13.8 (nominal tap)
- buried tertiary	kV rms	4.16 @ 33% base MVA
Connection of windings:		
- high voltage		Grounded Wye
- medium voltage		Grounded Wye
- buried tertiary		Delta
Type of cooling		ONAN/ONAF/ONAF
Average temperature rise of any winding above 30°C ambient temperature, measured by resistance	°C	65

SPECIFICATION

7.1.1/

Power rating at high (138kV and 69kV) and medium (13.8kV) voltage terminals, nominal tap position at rated output voltage and 0.9 power factor lagging:

- ONAN 65°C Rise	MVA	21
- ONAF 65°C Rise	MVA	28
- ONAF 65°C Rise	MVA	35

Off-load series-paralleling switch on high voltage winding (138kV / 69kV) (at full capacity)

On-load tap changer on high voltage winding (138kV / 69kV)	11 full capacity taps, 5 x 1% above nominal voltage and 5 x 1% below nominal voltage
Winding material	copper (aluminum not acceptable)
HV Neutral grounding	solidly grounded
MV Neutral grounding	solidly grounded
Positive Sequence Impedance - 21 (65°C) MVA ONAN (Base)	% 7.0
Vector Group	Yy0 for wye windings and Yd1 for the buried tertiary delta winding
Sound level standard	Per NEMA and ANSI Standards

Rated Lightning-Impulse Withstand Voltage:

- HV winding	kV crest	650
- MV winding	kV crest	95
- Tertiary winding	kV crest	50
- HV phase bushings	kV crest	650
- HV neutral bushing	kV crest	110
- MV phase bushings	kV crest	110
- MV neutral bushing	kV crest	110
- Tertiary winding bushings	kV crest	75

7.1.1/

Rated long duration withstand voltage for HV winding	kV rms	1.7 x 138 for 7200 cycles followed by 1.5 x 138 for 1 hour

Rated Short Duration Power Frequency Withstand Voltage:

- Induced voltage for grounded Primary winding	kV rms	2.0 x 138 for 7200 cycles
- Induced voltage for grounded Secondary winding	kV rms	2.0 x 13.8 for 7200 cycles
- Induced voltage for grounded buried tertiary winding	kV rms	2.0 x 4.16 for 7200 cycles

Rated short duration power frequency withstand voltage (Dry, 1 minute, 60Hz):

- HV winding bushings	kV rms	275
- MV winding bushings	kV rms	50
- Tertiary winding bushings	kV rms	19

Minimum bushing creepage (kV based on phase to phase voltage)	mm/kV	25.0

7.1.2 Short Circuit Rating

.1 Transformer core and coils assembly shall be designed to withstand, without injury or permanent deformation, the mechanical and thermal stresses caused by a short circuit on the external terminals of any winding or windings with rated voltage maintained across the terminals of all other windings for a minimum duration of two seconds.

.2 Buried, delta connected tertiary winding shall be rated to withstand the zero sequence circulating currents that will result from a single phase to ground fault occurring on either the 138kV / 69kV or the 13.8kVwinding for a minimum of 10 seconds and for a buried tertiary phase-phase-ground fault for a period of 10 seconds.

8. CONSTRUCTION

8.1 Transformer Tank

8.1.1 The tank shall be of welded, sheet-steel construction, free from distortion, and constructed according to the transformer outline drawings submitted by the Vendor for review by the Owner's Engineer before construction.

8.1.2 The tank cover shall be welded to the tank using flanges to facilitate removal. Manholes shall be provided to permit removal or installation of bushings, inspection of core and windings, tap changer mechanism, and similar components. All openings in the cover shall have flanges to prevent entry of water when covers are removed. At least one manhole shall be 24 inches in size to allow entry into the tank for inspection.

8.1.3 Design the transformer tank and radiators to withstand without deformation, 35kPa positive pressure and full vacuum according to Clause 15.1.3.1 of the CSA-C88-M90 (R2014).

8.1.4 Bushing turrets and current transformer pockets shall be arranged to prevent the accumulation of gas or they shall be piped to the gas detector relay. Bleeder valves shall be provided to allow removal of entrapped air. Bushing turrets shall be water-tight and condensation proof. Current transformer terminal boxes shall be water tight.

8.1.5 Gasketed joints shall be designed to maintain an even and effective pressure to ensure oil tightness without overstressing the gasket. The material and thickness of all gaskets supplied shall be clearly shown in an appropriate table in the instruction book.

8.1.6 The bottom plate of the transformer tank shall be at least 1/8" thicker than that required by design strength requirements to allow for possible rusting.

8.1.7 Surge (lightning) arresters will be supplied by others and will be supported on independent structures near the transformer.

8.1.8 All box-type stiffeners on the tank wall shall be provided with drain holes.

8.1.9 Supply and install one (1), UCL Safety Systems mounting plate anchor, part number 17412 attached to the top of the transformer. The mounting plate shall be welded mounted to accommodate portable fall arrest equipment.

8./

8.2 Moving Facilities

8.2.1 Hook-type lifting lugs with rounded edges, drilled, for a shackle of sufficient size to lift the completely assembled and filled transformer shall be supplied.

8.2.2 Jacking steps shall be attached to the tank at each corner at a height not less than 12 inches or more than 20 inches.

8.2.3 Pulling eyes, minimum 2 inches diameter, shall be provided on the transformer base, two per side, to permit pulling the transformer in any direction and shall be braced to withstand the pull up to 15° from the horizontal.

8.2.4 The transformer base shall be reinforced to permit moving the assembled and filled transformer on rollers in any direction.

8.2.5 The location of the centre of gravity shall allow the transformer to be safely tilted to 15° either with or without oil and shall not result in dangerous overturning moments from the usual transporting, rolling, skidding, and jacking operation.

8.2.6 The location of the "shipping" and "dressed" centre of gravity shall be painted on the tank. The centre of gravity in both shipping and installed configurations shall be clearly shown on both the outline and shipping drawings for both longitudinal and transverse axes.

8.2.7 Information on the permissible vertical angle of slinging and any other handling restrictions shall be shown on the shipping drawing.

8.3 Conservator Tank

8.3.1 The conservator tank shall have sufficient capacity to accommodate the change in oil volume (oil will not be below the low oil level at minimum ambient temperature of -40ºC and will not overflow at maximum ambient temperature of +40ºC throughout its load range, including overload).

8.3.2 The conservator tank shall be fitted with a nitrile membrane to avoid all contact of ambient air with the transformer oil. A leakage detector shall be mounted on the conservator to signal a rupture of the membrane. The leakage detector alarm contact shall be wired to the SEL 2414.

8.3/

8.3.3 The conservator tank shall be provided with a manhole, a 2 inch IPS filling valve with plug and lifting eyes.

8.3.4 The conservator shall be mounted with a one-inch slope between the ends to assist in draining. A 1-1/4 inch pipe complete with IPS drain/filler valve and plug shall be brought from the bottom inside elevation of the lower end of the conservator tank to within 1.3m of ground level. The pipe shall be clamped to the main tank for support.

8.3.5 The connecting pipe between the conservator and the main tank shall be 2 inch minimum size. The pipe shall protrude 1 inch into the conservator tank to prevent sludge pickup. An indicating ("valve open" / "valve closed") shut-off gate valve shall be inserted into the line between the conservator and the main tank, on the conservator tank side of the gas detector relay. The valve positions shall be easily observable from ground level.

8.4 Radiators

8.4.1 The transformer shall be equipped with detachable radiators which are designed to withstand the same pressure and vacuum conditions as the main tank.

8.4.2 Attachment to the main tank shall be by means of oil-tight isolating valves with position indicators affixed to the main tank and capable of withstanding a full head of oil. The handles of the shut-off valves shall be arranged to indicate "valve open" when in line with the pipe and "valve closed" when at right angles to the pipe. Reusable blanking plates shall be supplied for all openings.

8.4.3 Radiators shall have lifting eyes and be equipped with drain valves and non-corrodible plugs at the bottom and non-corrodible vent plugs at the top.

8.4.4 The radiators shall be hot-dipped galvanized.

8.4.5 Bracing of radiator fins, tubes or panels shall not be by direct welding of the bracing to the fins, tubes or panels.

8.4.6 Minimum separation between radiators shall be 6 inches. Radiators shall not be positioned over manholes, handholes, inspection covers or test point covers.

8./

8.5 Valves and Pipes

8.5.1 All valves supplied shall be tabulated as to type, size, and Vendor on appropriate drawings and in the instruction books. Information leaflets shall be included for each type of valve.

8.5.2 Oil drain valve, 2 inch minimum gate valve with 1¼ inch connection, and non-corrodible plug shall be located on the main tank wall as close as possible to the main tank bottom to permit draining of oil and oil filtering operation.

8.5.3 A ½ inch globe valve and non-corrodible plug shall be provided for oil sampling from the main tank bottom and located near the oil drain valve for mechanical protection.

8.5.4 A 2 inch vacuum pump connection with 2 inch minimum gate valve with 1¼ inch connection and non-corrodible plug, for oil filtering operation, shall be located on top of the main tank above the oil drain valve identified in 8.5.2.

8.5.5 A 1¼ inch oil filling connection with a spray nozzle inside the main tank, equipped with non-corrodible plug shall be located at the top of the main tank diametrically opposite the oil drain valve.

8.5.6 An oil filter connection consisting of a 1-1/4 inch pipe running from the lowest point in the conservator tank to a point 52 inches above the transformer base shall be terminated with a 1-1/4 inch gate valve and non-corrodible plug.

8.5.7 The following valves and fittings shall be supplied for the On-Load Tap Changer (OLTC) diverter switch oil compartment:

.1 OLTC drain valve: 1-1/4 inch gate valve with non-corrodible plug at the lowest point in the OLTC compartment.

.2 Oil filter connection: top, 1-inch gate valve with non-corrodible plug located on the side of the OLTC tank, 75mm below the top of the OLTC oil level.

.3 Oil filter connection: bottom, 1-inch gate valve with non-corrodible plug located 22mm above the OLTC tank bottom.

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8.6 Painting and Finishing

8.6.1 The tank shall be cleaned of rust, loose mill scale and other foreign matters by near-white metal blast cleaning. Castings shall be properly smoothed and sharp edges shall be filed. Oil, paraffin, and grease shall be removed by use of solvent.

8.6.2 After cleaning, the exposed surfaces shall receive 4 coats of paint at the factory as follows:

.1 A primary coat of zinc-rich epoxy paint strictly applied in accordance with the instruction of the paint Vendor.

.2 Two coats of non-glossy, oil resistant paint compatible with primary coat. The second coat shall be applied on completion of factory tests.

.3 One final coat of glossy, oil resistant zinc-silicate (self-curing) paint, non-fading ASA 61 Gray

8.6.3 The interior of the transformer main tank shall be painted with an oil resistant paint of white or other accepted light colour.

8.6.3 The top of the transformer tank shall be painted with anti-skid paint.

8.6.4 The interior of the control cabinet shall be painted with 3 coats of which the final coat shall be a white or light grey anti-condensation finish.

8.6.5 Damage to paintwork incurred during transport shall be repaired by thoroughly cleaning the damaged portion and applying the full number of coats that had been applied before the damage was caused.

8.6.6 Two litres of touch-up paint shall be supplied for repair of damages incurred during installation.

8.6.7 Screws and bolts shall be rust-proof and shall not be subjected to deterioration by time and humidity. Unpainted steel shall be properly protected either by galvanizing, metallizing, or by thermal cadmium plating.

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8.7 Core

8.7.1 The core shall be manufactured of high-grade, grain-oriented, non-ageing silicon steel laminations having smooth insulated surfaces with edges free from burrs. The core and associated insulation shall be designed so that no detrimental changes in physical or electrical properties will occur during the life of the windings.

8.7.2 Core clamps shall be insulated from the core and electrically connected to the tank. Core bolts, where used, shall be suitably insulated, minimum Class B, and shall be capable of withstanding the maximum voltage and temperature conditions that occur in the core during the design life of the windings.

8.7.3 The core and windings shall be braced to prevent displacement or distortion during transportation. Temporary blocking, if required, shall be marked in red to facilitate identification for removal, and noted in the installation instructions.

8.7.4 The transformer core ground connection shall be brought through the top of the main tank via a 5kV bushing and shall be connected to ground through a resistor having a minimum rating of 250 ohms, 25 Watts continuous. The bushing resistor assembly shall be enclosed in its own oil-tight, air-filled, weatherproof compartment. The core ground conductor connection shall be removable for testing purposes.

8.7.5 The core ground lead and connections shall be of sufficient cross sectional area to withstand a fault current of 20 kA RMS for one second without fusing.

8.8 Windings

8.8.1 The winding connections and voltages shall be as indicated in Section 7.1 of this Specification.

8.8.2 The winding material shall be copper.

8.8.3 Angular displacement and polarity shall be in accordance with CSA-C88-M90 (R2014).

8.8.4 The neutral ends of the wye connected windings shall be brought through the cover via suitable neutral bushings.

8.8/

8.8.5 Polarity markings and schematic information of all windings shall be indicated on the nameplate.

8.8.6 The buried, Delta connected tertiary winding (stabilizing winding) shall be built based on CSA C88-M90 (R2014), 10.2.3.2. The buried tertiary shall be designed to withstand, without damage, the effects of all types of short circuits on the other windings up to their rated short circuit capabilities. One corner of the delta connected tertiary winding shall be brought through the top of the main tank via two 5kV bushings identified as Y3a and Y3b, connected together with a removable test link. The test link will be utilized to open the delta winding. Provide insulated copper bus, using non-hygroscopic insulating material, from Y3b bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor. The Y3a and Y3b bushings and link shall be located on the top of the transformer tank.

8.9 Bushings

8.9.1 The transformer shall be provided with tank top bushings, three phases and neutral for the HV winding, neutral for the MV winding and two bushings connected to one corner (Y3a and Y3b) of the tertiary winding for tertiary winding testing and grounding purposes, and with tank side-wall bushings (side and bottom accessible within a steel enclosure) for the three phases of the MV winding. The 138kV bushings shall have a power factor test tap and the power factor shall be stamped on the bushing nameplates. All bushings shall conform to CSA C88.1-96 (R2011).

8.9.2 The 138kV rated bushings shall be oil-filled condenser type and shall be provided with a site glass, visible and legible from ground level, and power factor and capacitance taps for test purposes.

8.9.3 The 138kV bushings shall be equipped with mechanical connectors to accept primary overhead conductors (556.5 ACSR (Dove), one per phase)

8.9.4 NEMA, four-hole compression lugs shall be provided for the connection of each 556.5 ACSR (Dove) conductor per phase to the 138kV bushings.

8.9.5 NEMA, two-hole compression lugs shall be provided for the connection of each of four (4), 500kcmil copper, 15kV 133% EPR insulated power conductors per phase to the 13.8kV bushings.

8.9/

8.9.6 Colour shall be gray, unless otherwise specified.

8.9.7 Power connections on all bushings in the live parts area shall be silicon bronze where contacting and mating surfaces are copper or copper alloy.

8.9.8 The bushing drop leads for HV, X0 and Tertiary windings shall be sufficiently long to allow the bushing flanges to be raised clear of the mounting studs for power factor testing of the transformer windings.

8.9.9 The H2 and X2 bushings shall be mounted on the same centreline.

8.9.10 Bushing current transformers shall be supplied as described in Section 10.13.

8.9.11 The installation of bushings shall be possible without lowering the oil below the top of the core and coils.

8.9.12 Provide insulated copper bus, using non-hygroscopic insulating material, from H0 bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. The H0 ground bus shall be separate from the X0 ground bus. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor.

8.9.13 Provide insulated copper bus, using non-hygroscopic insulating material, from X0 bushing terminal to bottom of the transformer tank, for connecting to substation ground grid. The X0 ground bus shall be separate from the H0 ground bus. Provide stand-off post insulators, as required, to adequately support the insulated bus. Provide connectors for connection to 4/0AWG copper substation ground grid conductor.

8.10 Control Cabinet

8.10.1 A weatherproof control cabinet affixed to the main tank and conforming to CSA Standard C22.2 No. 94-M91 (R2011) shall be supplied, the bottom located approximately 28 inches above the transformer base. It shall be rigidly braced and secured to avoid amplifying transformer sound level. The bottom of the cabinet shall have two removable aluminum entrance plates, 10 inches x 12 inches, to facilitate cable entry. The interior shall be insulated with non-combustible material and shall be complete with a 2" diameter screened ventilation opening to inhibit condensation.

8.10/

8.10.2 The cabinet shall be equipped with an exterior hinged and padlockable door (lockable with padlock having a 10mm diameter shackle) complete with three-point latch and shall be capable of being latched open or closed. The inside pocket on the door shall contain one copy of the instruction manual, complete with drawings.

8.10.3 The cabinet shall be sufficiently large to contain the following:

a) Bottom entry and termination of all control cables.
b) Power supply and control equipment for first and second stage fans.
c) Tapchanger control equipment for the 138kV / 69kV load tapchanger.

8.10.4 The control cabinet shall be fitted with an internal, thermostatically controlled anti-condensation heater (capable of maintaining a cabinet temperature of 5ºC in an ambient temperature of -40ºC), switched light, and an externally mounted NEMA 125V, 15A, 2P, 3W duplex U-ground convenience duplex receptacle (complete with weatherproof cover) mounted on the exterior of the cabinet. The transformer manufacturer shall supply terminals and all necessary switching and protection (molded case circuit breakers) devices, pre-mounted in the control cabinet.

8.10.5 All current transformer secondary wiring shall be a minimum No. 10 AWG copper and all other wiring shall be minimum No. 12 AWG copper. Wire markers shall be applied to all wires at both ends. Secondary wiring shall be protected from faults in the transformer's main power circuits.

8.10.6 All current transformer and control, power, and alarm circuits shall terminate at terminal blocks located in the control cabinet. Terminal blocks for current circuits shall be shorting type. The terminal blocks shall be located so as not to interfere with the wiring or cable connections. All available ratios of current transformers shall be wired to terminal blocks within the control cabinet.

8.10.7 Terminal blocks shall be of the stud type. All terminal blocks with voltages above 125V shall be fitted with insulating covers to prevent accidental contact. A minimum of 15% of spare terminal blocks shall be supplied for each terminal strip.

8.10.8 The layout of equipment in the control cabinet shall be arranged so that all devices and functions may be operated or performed by a person of average height, standing at the transformer base level.

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8.11 Miscellaneous

8.11.1 All nuts and bolts ½" in diameter and smaller shall be stainless steel or silicon bronze. Plated fastenings are not acceptable.

8.11.2 Wiring on the exterior of the transformer shall be protected by rigid aluminum conduit or non-ferrous, non-corroding PVC jacketed flexible armour.

8.11.3 Motor and control circuit protection shall, in the case of fuses, be HRC Form 1, and in the case of breakers consist of overload protection in each phase.

8.12 Terminal Arrangements and Connections for MV Underground Conductors

8.12.1 Provide a suitable, self-supporting weather tight steel terminal box, with side and bottom entry access via removable panels, on the MV side of the transformer for the bottom entry and termination of four (4), single 500 kcmil copper, 15kV 133% EPR insulated conductors per phase.

8.12.3 Provide a ground pad inside the terminal box for the purpose of grounding the MV cable shields.

8.12.4 All current carrying connections to be silver plated copper alloy. Aluminum and Cu/Al lugs are not acceptable.

8.12.5 If busbars are required to connect the MV bushings to the cable terminations, they shall be copper and shall be robust enough to prevent movement when the cables are attached. The busbar specification and cable requirements will be determined before manufacture.

8.12.6 Bushing terminal pads shall be drilled in accordance with ANSI C37-32 and shall be complete with terminal connectors and bolting hardware. The ampacity of the bushing terminal pads and connectors and interconnecting copper busbars shall not be less than the maximum ONAF rating of the transformer.

9. OFF-LOAD 138kV / 69kV SERIES-PARALLELING SWITCH

9.1 The off-load Series-Paralleling switch shall be located on the high voltage winding, in accordance with CSA C88-M90 (R2014).

9.2 The Series-Paralleling switch shall be capable of connecting the full high voltage windings in either series (138kV) or parallel (69kV).

9.3 Both configurations shall be continuously rated for the maximum ONAF rating.

9.4 The handle of the off-load Series-Paralleling switch shall preferably be located on the HV bushing side of the transformer tank and shall be lockable with a padlock having a 10mm diameter shackle.

9.5 A sign reading "**CAUTION – Off-Load Series-Paralleling Switch. Do Not Operate with Transformer Energized.**" shall be attached beside the operating handle.

10. ON-LOAD TAPCHANGING EQUIPMENT

10.1 On-Load Tapchanger (OLTC) Rating

10.1.1 An on-load tapchanger shall be installed in the high voltage windings. Complete details on the type, rating (MVA, V and A) of the OLTC shall be given with the tender quotation.

10.1.2 The tapchanger rating shall be sufficient to enable continuous operation of the transformer at its rated maximum load (2 stages of supplemental cooling).

10.1.3 The tapchanger shall be capable of carrying full capacity on all tap positions.

10.1.4 The tapchanger shall meet the over-voltage requirements of CSA-C88-M90 (R2014).

10.1.5 The tapchanger shall be able to accommodate the maximum ONAF (2^{nd} stage) rating at a temperature rise of 65ºC (35MVA).

10.1.6 The tapchanger nameplate shall show manufacturer, model number, serial number, current, and voltage as well as all items required by the applicable standards.

10.1.7 The individual tap positions shall be in accordance with Section 7.1.

10.2 Manual Control and Indication

10.2.1 All standard accessories and mechanical features described in CSA-C88-M90 (R2014), and applicable appendices, shall be supplied.

10.2.2 OLTC drive motor shall have thermal overload protection and means shall be provided for isolating the motor from the supply. Supply voltage shall be selected based on Section 2.4.1.

10.2.3 The following controls shall be provided in the control cabinet:

a) Switch for Off-Manual-Test-Auto control functions
b) Switch for Local-Remote
c) Mechanical Tap Position Indication
d) Operations counter
e) Raise/Lower Switch

10.2.4 An “external tap position indicator” system, including an output transducer to provide a 4-20mA signal to the Substation SCADA computer which can be used to indicate the tap position, shall be provided. This system shall be the “resistance to DC milliamp” transducer type, with transducer output 4mA to 12mA to 20mA for tap position -5 to N to +5.

10.3 Construction

10.3.1 Arcing/diverter switches shall be installed in a sealed tank with an oil system completely separate from the oil in the main tank.

10.3.2 The diverter switch tank shall be either of a "sealed tank" or free breathing conservator tank design, each type being provided with its own de-hydrating breather.

10.3.3 Design of the diverter switch shall be such that it will not stop between steps if the motor supply is interrupted before the step is completed.

10.3.4 The diverter switch contacts shall be rated for at least 200,000 transitions at their rated current, before requiring replacement; and the contacts shall be easily accessible.

10.3.5 Taps shall be so arranged that for a fixed secondary voltage, the lowest numbered tap gives the lowest primary voltage; and successive increasing tap numbers give increasing voltage steps.

10.3/

10.3.6 The tap changer mechanism shall cause the tap changer to move only one step per operation.

10.3.7 An operations counter shall be provided.

10.4 Control and Indication

10.4.1 Control and indication of the OLTC shall be provided in accordance with the simplified schematics illustrated in the reference drawing.

10.4.2 A complete control and indication schematic for the OLTC system shall be provided. This schematic will include and incorporate a simplified illustration of the schematic provided by the OLTC manufacturer.

Interface terminals shall clearly indicate the wiring connections between the main transformer control cabinet and the OLTC mechanism cabinet.

Interface terminals shall clearly indicate the wiring connections to be made by the Owner.

10.4.3 The following control equipment shall be provided in the OLTC control cabinet:

a) Switch for "Local" and "Remote" control functions ("Off" position optional)
b) Manual Raise/Lower Controls
c) Operations Counter
d) Tap Position Indicator with Drag Hands
e) Tap position indication equipment c/w analogue (4-20mA) output transducer
f) Terminal blocks for field run cable connections by others

10.4.4 The following control equipment shall be provided in the main control cabinet:

a) Switch for "Local-Manual", "Local", "Auto" and "Remote" control functions
b) Manual Raise/Lower Controls
c) Automatic voltage control equipment
d) Terminal blocks for field run cable connections for remote control by others

10.4.5 The OLTC drive motor shall have thermal overload protection; and a means shall be provided for isolating the motor from the supply. Supply voltage and number of phases will be as specified in the reference drawing.

10.4/

10.4.6 The tap position indication equipment shall be a slide-wire potentiometer comprising 1 W resistors (number of resistors same as the number of steps in the OLTC). Total resistance of the potentiometer shall not exceed 2,000 ohms. The three terminals of the potentiometer shall be wired to terminal blocks in the main control cabinet.

10.4.7 A slide wire transducer with a 4-20mA (Optional 0-1mA) output, compatible with the potentiometer resistance shall be installed in the control cabinet.

10.4.8 The power connection shall be 125VDC. The input power connection to the device shall be run through a two pole fuse holder and then be connected to terminals in the control cabinet.

10.4.9 A tap-change auxiliary contact, closed during tap changer travel, shall be wired to terminals in the control cabinet for a "tap-change-in-progress" indication.

10.4.10 Control cabinet for the on-load tap changer shall be near to and on the same side as the transformer control cabinet. Alternatively the two cabinets may be combined.

10.4.11 In the event of two control cabinets, the interconnecting wiring shall be via terminal blocks in the main control cabinet. Direct connections to devices within the main control cabinet are not acceptable. It is assumed that interconnection terminal blocks will be provided in the OLTC control cabinet by the manufacturer of the OTLC.

10.5 Tapchanger Control

10.5.1 The on-load tapchanger will be operated/controlled from the existing Substation SCADA computer.

10.5.2 The SCADA computer will issue a dry contact closure to either raise or lower the secondary (13.8kV) system voltage, one tap at a time.

10.6 Mechanical Features

10.6.1 Taps shall be so arranged that for a fixed primary voltage the lowest numbered tap gives the lowest secondary voltage and successive increasing tap numbers give increasing voltage steps.

10.6/

10.6.2 The tapchanger mechanism shall be so designed as to ensure the completion of a tap change once initiated irrespective of whether or not the motor or its power supply fails.

10.6.3 All oil-immersed diverter switches shall be housed in a separate compartment with an oil system separate from the main tank and equipped with a Qualitrol or equivalent pressure relief device with deflector mounted on the side. The diverter switch compartment shall be equipped with valves for filtering.

10.7 Resistance vs. Reactance Tapchangers

10.7.1 High-speed resistance type tapchangers are preferred and suppliers shall quote this type, if available. Alternative quotations on reactance-type tapchangers will be considered provided that complete information is supplied. For all reactance-type tapchangers, test results shall show the winding magnetizing current in the reactor-bridging as well as the non-bridging position.

10.8 Tapchanger Instruction Books

10.8.1 Prior to shipment, the supplier shall supply separate operation and maintenance instruction manuals for the tapchanger in bound book format. Quantity to be the same as for transformer instruction manuals, and final drawings. An additional copy shall be placed in the pocket of the OLTC control cabinet. The books shall include instructions, drawings, and descriptions of the various components together with complete data for ordering replacement parts.

11. ACCESSORIES

11.1 General

11.1.1 All standard accessories shall be supplied in accordance with CSA-C88-M90 (R2014) but subject to the modifications stated in this Specification.

11.2 Nameplate

11.2.1 The transformer nameplate shall be fabricated from stainless steel and permanently engraved in accordance with CSA-C88-M90 (R2014), with the following additional data included:

.1 The rating information shall be for 65°C temperature rise.

11.2.1/

.2 The nameplate shall state that the entire insulating oil system is capable of withstanding full vacuum.

.3 A schematic representation of all winding and CT connections shall be shown on the nameplate. Ratios and polarities shall be indicated for all current transformers.

.4 Insulation rating of the HV and MV neutral shall be stated if graded insulation is supplied.

.5 A phasor diagram of all windings shall be shown.

.6 Measured values of positive and zero sequence impedances shall be shown based on ONAN (65°C Rise), rating. Positive and zero sequence impedances between windings shall be shown HV-MV, HV-T, and MV-T.

.7 The overload capabilities at 0ºC ambient temperature shall be stated on the nameplate.

11.3 Transformer Auxiliary Control and Monitoring System

11.3.1 Monitoring and control functions for transformer accessories shall be achieved using an SEL 2414 Transformer Monitor System. Provide an SEL2414 suitable for 125VDC power supply, EIA-232/EIA-495 serial communications, DNP3, DNP3 LAN/WAN, minimum 16 digital inputs, 8 analog inputs and minimum 8 digital outputs.

11.4 Pressure Relief Device

11.4.1 A spring-loaded diaphragm-type relief device(s), Reinhausen or approved equal mounted on the top of the main tank, equipped with a deflector to direct oil downwards, shall be supplied. As an alternative, a pipe-type pressure relief vent having a diaphragm at the top and screen at the bottom will be considered, but this alternative shall be clearly stated in the tender. DPDT auxiliary contacts functioned by the operation of the pressure relief device shall be wired to the SEL2414.

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11.5 Conservator Tank Liquid Level Gauge

11.5.1 A magnetic liquid level gauge, Reinhausen or approved equal, visible from ground level, shall be mounted on the higher end of the conservator tank. The gauge shall be marked in 10ºC intervals between -45ºC and +95ºC to correspond with the normal conservator oil levels at those temperatures. The nominal oil level shall occur at 25ºC.

11.5.2 The liquid level gauge shall be equipped with three (3) DPDT contacts, wired to SEL2414. One contact shall operate to indicate high oil level and two contacts shall operate to indicate low oil level.

11.6 Main Tank Liquid Level Gauge(s)

11.6.1 A liquid level gauge(s), Reinhausen or approved equal, shall be mounted on the side of the main tank, equipped with two (2) DPDT contacts arranged to provide alarm and tripping functions. The alarm point, as determined by the transformer Vendor, shall be the limit at which the liquid level is at the minimum safe operating level, and shall be wired to the SEL2414. The trip point, as determined by the transformer Vendor, will cause the transformer to be de-energized and is the limit at which the liquid level is lower than the alarm point but still covering the core and coils. The trip contact shall be wired to a terminal block for external use. For clarity;

.1 During liquid filling: The trip contact opens when the level of the rising liquid exceeds the trip point on the level indicator and the alarm contact opens when the level of the rising liquid exceeds the alarm point on the level indicator.

.2 During normal operation: If the liquid level falls below the alarm point, the alarm contact closes to announce an alarm state. If the liquid level continues to fall below the trip point, the trip contact closes, causing the transformer to be de-energized, but with the liquid still above the core and coils.

11.6.2 If both functions described in 11.6.1 cannot be accommodated in one instrument, a separate instrument for each function shall be supplied.

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11.7 Winding Temperature Indicator

11.7.1 The transformer shall be equipped with winding temperature indicator, Reinhausen or approved equal, for controlling two stages of forced air cooling and providing alarm and trip functions as described below:

.1 Four (4) adjustable contacts shall be supplied, two to control two stages of forced air cooling, one for alarm 90-105°C and one for trip 105-120°C. An analog circuit from the winding temperature indicator shall be wired to the SEL2414. Fan control temperature settings (2 stages) will be supplied and installed on the instrument by the Vendor. The final temperature setpoints shall be determined by the Vendor.

11.7.2 The winding temperature indicator shall be designed for the reproduction of the "hottest-spot" winding temperature. An appropriately sized current transformer, with two secondary windings, shall be mounted in one of the phase windings of the transformer to provide the load-compensated input to the winding temperature indicator.

11.7.3 The heater and winding temperature current transformer leads shall be brought out to a suitable terminal block or test link box outside the transformer tank and within the control cabinet to facilitate measurement of the current under load injection of the heater element from an external power source. Supply voltage shall be selected based on Section 2.4.1.

11.7.4 The winding temperature indicator shall be supplied with all control contacts wired to the SEL2414 which will be configured, by the transformer manufacturer, to control the fans.

11.7.5 Provide analog circuit from the winding temperature indicator to the SEL2414.

11.8 Liquid Temperature Indicator

11.8.1 Liquid temperature indicator, Reinhausen or approved equal, shall be supplied with two form 'c' contacts wired to terminal blocks in the control cabinet, with settings 90ºC for alarm and 105ºC for trip (settings to be confirmed by transformer Vendor).

11.8.2 Provide analog circuit from the liquid temperature indicator to the SEL2414.

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11.9 Gas Accumulation and Sudden Pressure Relay

11.9.1 The transformer shall be equipped with a Gas Accumulation/Sudden Pressure Relay mounted between the main tank and the conservator tank as herein described, or an approved equivalent.

.1 The relay shall be of a two-element type with electrically separate DPST contacts for tripping on sudden pressure rise and for alarm on gas accumulation. The alarm contact shall be wired to the SEL2414 and the trip contact shall be wired to a terminal block for external use.

.2 The gas detector relay shall be mounted in the pipe between the transformer main tank and the bottom of the conservator tank. The relay shall be located to permit inspection from the ground.

.3 The gas relay shall be mounted to collect all the gas evolved. All pockets or spaces over $800cm^3$ which are vented to the transformer main tank shall be piped to the relay with piping having a minimum 5 degrees slope upward to the relay.

.4 A gate-valve shall be provided between the transformer main tank and the gas detector relay for isolation and shall allow free passage of gas when the valve is open. The valve handle shall face the direction of gas detector relay access.

.5 A copper tube 1/4 inch or larger inside diameter shall run from the gas accumulation element, secured to the side of the tank, to a sampling valve approximately 60 inches above ground level. The valve shall be suitable for attaching a rubber tube of 1/4 inch inside diameter.

.6 The relay shall be provided with a test petcock for testing purposes.

.7 The relay shall be provided with graduated site glass, indicating the volume of gas that has accumulated.

.8 A Buchholz type relay is preferred, but other relays will be considered. Provide complete information on the type and model of gas detection relay being proposed, with the tender documents.

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11.10 Sudden Pressure Relay

11.10.1 The transformer shall be equipped with Sudden Pressure Relay installed on the on-load tapchanger tank.

.1 The relay shall be of a single-element type with one form 'c' contact for tripping on sudden pressure rise. The sudden pressure relay shall be a Qualitrol 900/910 Rapid Pressure Rise relay, or approved equivalent.

.2 A gate-valve shall be provided between the transformer and the sudden pressure relay for isolation purposes.

11.11 On-Line Dissolved Gas Monitor/Analyser

11.11.1 The transformer shall be equipped with an on-line, real-time Dissolved Gases Monitor/Analyser capable of measuring fault gases, moisture-in-oil, oil temperature, and ambient temperature. The DGA monitor/analyser shall be connected directly to the main transformer tank with an isolation/ shut-off valve for removal, if required. The DGA monitor/ analyser shall include software to provide graphical representation and storage of data. The DGA monitor/analyser shall be a GE Kelman Transfix, or approved equivalent.

11.12 Access Ladder

11.12.1 A metal ladder shall be attached to the side of the transformer tank, conveniently located to allow easy access to the gas detector relay and the top of the tank. The ladder shall be provided with a barrier having padlocking facilities and devices to latch it when in the open position.

11.13 Connectors

11.13.1 Two tank grounding connection pads, drilled for NEMA two-hole connectors, shall be supplied on diagonally opposite sides of the transformer tank. A copper 2 hole, long barrel, Burndy crimp type copper connector suitable for 4/0 AWG copper shall be supplied for each connection pad.

11.14 Dehydrating Breather

11.14.1 A dehydrating breather to the conservator tank shall be supplied. The dehydrating breather shall be a Reinhausen Messko MTraB dehydrating breather, or approved equivalent.

11.14/

11.14.2 Separate tapchanger compartments shall also be equipped with dehydrating breathers.

11.14.3 Dehydrating breathers shall be piped to within 60 inches of ground level to facilitate maintenance.

11.14.4 Desiccant container style dehydrating breathers are not acceptable.

11.15 Current Transformers

11.15.1 Standard, multi-ratio bushing type current transformers (CTs) shall be supplied per CSA C60044-1-07 (R2011) as follows:

.1 Internally on the 69kV Neutral (H0) Bushing:
Quantity: 1
CTR: 600-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 600-5A ratio

.2 Internally on the Tertiary Winding Y3a Bushing:
Quantity: 2
CTR: 2000-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 2000-5A ratio

.3 Internally on the 13.8kV Neutral (X0) Bushing:
Quantity: 1
CTR: 2000-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 2000-5A ratio

.4 Internally on a 13.8kV Winding Bushing:
Winding Temperature Indicator System CT
Quantity: 1
CTR: 1600-5A (accuracy and ratio to be confirmed by Manufacturer)
As required for correct functioning with WTI system

11.15.2 A current transformer shall be installed externally in the buried delta tertiary ground conductor circuit, between the Y3b bushing and the tank ground pad. The current transformer shall be installed on a tank wall bracket located below the Y3b bushing for ease of routing the tertiary winding grounding conductor to the current transformer and to ground. The current transformer shall be supplied per CSA C60044-1-07 as follows:

11.15.2/

.1 Externally on the Ground Leg of the Tertiary Winding Connection:
Quantity: 1
CTR: 600-5A, multi-ratio
Minimum Accuracy: 200VA–5P20 @ 600-5A ratio

.2 In any case, the ratio and accuracy class shall be compatible with the maximum fault current that will result from a ground fault on the buried tertiary winding.

11.15.3 Ratio and polarity of all current transformers shall be shown on nameplates. In general, polarity and markings shall be toward the transformer bushing terminal.

11.15.4 The dielectric strength of the current transformer secondary wiring shall be sufficient to withstand the current transformer open circuit voltage for one minute and as defined in CSA C60044-1-07 (R2011). Current transformer secondary wiring to the control cabinet terminal blocks shall be considered an integral part of the current transformer for all test requirements. All wires shall be identified at each end with heat-shrinkable wire markers.

11.15.5 All current transformer current leads passing through the tank wall shall use bolted through-type bushings. Plug-in receptacle-type connections are not acceptable.

11.15.6 The continuous thermal current rating factor for bushing and neutral current transformers shall be 2.0 with the unit in free air, based on temperature rise in accordance with CSA C60044-1-07 (R2011).

11.15.7 All current transformers shall be adequately braced to prevent damage and movement during shipping. Instructions for removal of all temporary shipping braces shall be supplied.

11.15.8 All bushing type current transformers shall be removable without removing the transformer tank cover.

11.15.9 The following information shall be supplied for all current transformers:

.1 Specification number for replacement
.2 Ratio and accuracy on all taps
.3 Resistance of the full secondary winding
.4 Excitation curves on all ratios

11.16 Gaskets

11.16.1 Gaskets shall be of nitrile rubber or approved equivalent. Gaskets stops shall be provided to prevent over-compression of the gasket material. A sufficient quantity of gasket cement shall be supplied for initial installation. One spare gasket of each type necessary for field assembly shall be provided.

11.17 Transformer Oil

11.17.1 Sufficient transformer oil shall be supplied for filling the transformer and conservator tank to the proper level. The transformer oil shall comply with CSA C50-14. The transformer oil shall be PCB free and shall include acid inhibitors.

11.17.2 The transformer oil shall be Voltesso 35, or approved equivalent.

12. FORCED COOLING

12.1 Oil Immersed, Forced-Air Cooled (Type ONAF)

12.1.1 The transformer shall be provided with two stages of cooling fans to increase the transformer rating from 21 MVA ONAN to 35 MVA ONAF.

12.1.2 A full fan control system for control of cooling fans, including terminal blocks, automatic and manual control switches, contactors, and protective and control devices for two complete stages of fan cooling. The SEL2414 shall be used to perform fan control. Fan control equipment shall be located in the transformer control cabinet.

12.1.3 Fan motors shall be single phase 240Vac or 208Vac unless specified otherwise. Fan guards shall be galvanized.

12.1.4 Fan motors shall be equipped with waterproof plugs and receptacles so that individual units can be disconnected.

12.1.5 Fans shall not be located under radiators where they may be blocked by snow accumulation.

12.1.6 An alarm function shall be provided for each fan of each stage of cooling, for fan failure or loss of the fan power supply. The alarms shall be wired to SEL2414.

13. FACTORY TESTS

13.1 Unless otherwise specified, carry out all routine factory tests listed in CSA C88-M90 (R2014), Article 16.

13.2 In addition, the following factory tests shall be performed:

13.2.1 The excitation current and losses tests shall be performed at 90%, 95%, 100%, 105% and 110% of the rated voltage before the commencement of the dielectric tests.

13.2.2 The excitation current test shall be extended to include the saturation curve up to 115% rated volts and the curve shall be extrapolated to 130% of rated voltage.

13.2.3 Oil samples shall be taken before and after the excitation current test. Oil samples shall be subjected to gas analysis and the results of the two analyses compared.

13.2.4 Pressure tests on tank and cooling system shall be made employing hot oil at 50°C and 35 kPa maintained for a period of 24 hours. If any leaks appear, they shall be repaired and the test shall be repeated.

13.2.5 Insulation tests on auxiliary wiring shall include dielectric tests in accordance with ANSI C37.20.

13.2.6 Core insulation tests (minimum 1000 volt insulation tester) shall be repeated after transformer is loaded onto the carrier immediately prior to shipping. Test results and all relevant critical test information shall be recorded on standard field test report sheets.

13.2.7 After completion of all other tests and prior to shipment, the unit shall be energized at 110% voltage 60 Hz for one hour at no load. The results shall be within 5% of previous no load loss test results.

13.2.8 A vacuum test shall be performed on all tanks and cooling systems designed for vacuum filling.

13.2.9 Impulse tests shall be performed on all terminals including neutrals in accordance with ANSI C57.12.90 (R2010). Impulse test oscillograph records shall be made on transparent, fine grain film and shall have a minimum size of 75mm x 100mm. A digital format of the oscillograph record would also be acceptable.

13.2/

13.2.10 Partial discharge measurements shall be performed on the high voltage winding during the induced potential test. The magnitude of partial discharge shall be determined by measuring, at the high voltage terminal of the winding under test, the radio influence voltage (RIV) generated by the corona. A radio noise and field strength meter conforming to ANSI C63.2-2009 shall be used to measure the RIV generated by the partial discharge. The general method and procedure shall conform to the recommendations of NEMA 107-1987 (R1993).

13.2.11 Power factor tests shall be performed for all bushings with resulting power factor stamped on the bushing nameplate and recorded in the test results.

13.2.12 Sound level test shall be performed in accordance with IEC 60076-10 ed1.0.

13.2.13 The results of calibration tests on winding temperature devices (hot spot indicator) shall be shown on the test report.

13.2.14 Sweep Frequency Response Analysis shall be performed on the transformer. The results of sweep frequency response analysis shall be included in the certified transformer test report.

13.3 Advise the Owner's Engineer fifteen (15) working days prior to the tests so that he may attend.

13.4 All test facilities shall be available at the place the equipment is being manufactured.

13.5 Upon completion of tests, four copies of Vendor certified test results shall be supplied to the Owner. The test results shall show all tests conducted in accordance with this Specification.

14. SHIPPING TESTS

14.1 The following test procedure shall be performed on the transformer as a test for shipping damage:

14.1.1 At the factory prior to shipment:

a) After loading the transformer onto the common carrier, the Vendor shall measure the core insulation with a 1000V (minimum) bridge megger. The value of core insulation and the voltage of the megger shall be included in the certified transformer test report under "Core Insulation Resistance Test after Loading onto Carrier at Factory".

b) The dew point of the shipping gas inside the transformer shall be checked to ensure it is below -40ºC. The results shall be recorded on the test reports.

14.1.2 At the destination:

a) Prior to off-loading the transformer from the Carrier, the Owner's Engineer in the presence of the manufacturer's/supplier's representative shall measure the core insulation and the dew point of the gas. These readings shall be compared to the values obtained at the factory.

b) The recording from the impact recorders shall also be checked by the Vendor. Any discrepancies or concerns shall be rectified or explained to the Owner's Engineer's satisfaction. Failure to resolve these issues may lead to the unit being returned to the factory for retesting prior to acceptance; all at the manufacturer's/supplier's cost.

15. TOOLS

15.1 Supply a list and prices of a complete set of all special tools that may be required for the normal and proper maintenance of the equipment supplied.

16. CONSTRUCTION DOCUMENTS

16.1 Manufacturer's Drawings

16.1.1 Transformer drawings shall show basic details and dimensions, location of centre of gravity, height for untanking core and coils and for removal of bushings, gasket location, thickness and material, direction of air movement through fans as well as other details as necessary.

16.1.2 A separate shipping drawing shall be supplied for the transformer giving the following information:

a) Shipping heights, width, length, and base dimensions
b) Centres of gravity in shipping condition
c) Location of jack steps, rolling areas, and blocking areas
d) Slinging requirements and restrictions, if any, for crane off-loading of the transformer
e) Position of gas bottles, regulators, and gauges if shipped in gas
f) Position of core ground test link
g) Details of gas shipping conditions and pressure checks to be made
h) Complete Bill of Materials

16.1.3 Wiring diagrams, schematic diagrams, layout drawings, bills of material and product data sheets shall be provided.

16.2 Operation and Maintenance Manuals

16.2.1 Instruction manuals shall describe in detail the construction and recommended procedures for assembling, dismantling, maintaining, and operating all equipment and listing all replacement parts. These shall include copies of all pertinent bulletins and instructions prepared by the manufacturers, of component parts of the equipment, properly catalogued for easy reference.

17. EFFICIENCY EVALUATION

17.1 The Vendor shall guarantee the following transformer losses:

a) No-Load loss in kilowatts at rated voltage and rated frequency.
b) Total losses in kilowatts at rated output, rated voltage and rated frequency.

17.2 Load losses shall be evaluated on the ONAN rating for the transformer in accordance with CSA-C88-M90 (R2014).

17./

17.3 Transformer losses determined under tests shall be corrected to 85°C.

17.4 For comparison of tenders, the transformer losses will be evaluated on the basis of the capitalized cost figures calculated over a 30 year life expectancy of the transformer, as stated below, and are to be given on the base ONAN rating:

.1 No-Load Losses: $3,327.54 per kW
.2 Load Losses: $ 447.75 per kW

17.5 If the losses as tested exceed the losses as guaranteed by more than the tolerances specific in CSA Standard CSA-C88-M90 (R2014), the following shall apply:

.1 The capitalized cost of the loss(es) as guaranteed will be subtracted from the excess of capitalized cost of the loss(es) as tested and the excess of the capitalized cost will be assessed to the Vendor as a cost adjustment using the figures of Section 17.4.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION C

SCHEDULES

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SECTION C

SCHEDULES

1. INSTRUCTIONS

1.1 Complete and submit with the tender and schedules contained in this section.

1.2 Incomplete schedules may render the tender inadmissible.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 1

TECHNICAL INFORMATION

1. 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV POWER TRANSFORMER

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer:

Manufacturer		_____
Type		_____
Rated capacity at low voltage terminals at 65°C rise:	MVA ONAN MVA ONAF MVA ONAF	_____ _____ _____
Rated primary (HV) voltage	kV rms	_____
Rated secondary (MV) voltage	kV rms	_____
Rated Tertiary voltage	kV rms	_____
Guaranteed positive sequence impedances, Z_1 on rated MVA base, at 85°C and mid tap	H-L % H-T % L-T %	_____ _____ _____
Guaranteed zero sequence impedances, Z_0 on rated MVA base, at 85°C and mid tap	H-L % H-T % L-T %	_____ _____ _____
Guaranteed no-load losses at rated frequency and rated voltage on mid tap, 85°C	kW	_____
Guaranteed load losses at rated frequency and the following currents on mid tap, 85°C:		
- at 125% ONAN load, 65°C rise	kW	_____
- at 100% ONAN load, 65°C rise	kW	_____
- at 100% ONAF load, 65°C rise	kW	_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Guaranteed load losses at rated frequency and the following currents on mid tap, 85° C: (Cont'd)		
- at 75% ONAN load, 65°C rise	kW	_____
- at 50% ONAN load, 65°C rise	kW	_____
- at 25% ONAN load, 65°C rise	kW	_____
Guaranteed cooling fan losses at 65°C rise, ONAF rating	kW	_____
Exciting Current:		
- at 100% rated voltage	A rms	_____
- at 110% rated voltage	A rms	_____
Efficiency at rated frequency and the following currents on mid tap, 8°C:		
- at 125% ONAN load, 65°C rise	%	_____
- at 100% ONAN load, 65°C rise	%	_____
- at 100% ONAF load, 65°C rise	%	_____
- at 75% ONAN load, 65°C rise	%	_____
- at 50% ONAN load, 65°C rise	%	_____
Regulation:		
- at 80% power factor	%	_____
- at 90% power factor	%	_____
- at 100% power factor	%	_____
Winding material		_____
Vector group		_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Rated lightning-impulse withstand voltage:

-	Primary (HV) winding	kV crest	_____
-	Secondary (MV) winding	kV crest	_____
-	Tertiary winding	kV crest	_____
-	Primary (HV) bushings	kV crest	_____
-	Secondary (MV) bushings	kV crest	_____
-	Tertiary bushings	kV crest	_____

Rated long duration power frequency withstand voltage:

-	Primary (HV) winding	kV rms	_____

Rated power frequency withstand voltage (dry, 1 min., 60 Hz):

-	Primary (HV) winding	kV rms	_____
-	Secondary (MV) winding	kV rms	_____
-	Tertiary winding	kV rms	_____
-	Primary (HV) bushings	kV rms	_____
-	Secondary (MV) bushings	kV rms	_____
-	Tertiary bushing	kV rms	_____

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Rated current:		
- Primary (HV) bushings	A rms	_____
- Secondary (MV) bushings	A rms	_____
- Tertiary bushing	A rms	_____
Bushing Leakage Distance:		
- Primary (HV) bushings	mm	_____
- Secondary (MV) bushings	mm	_____
- Tertiary bushing	mm	_____
Minimum corona inception voltage for 138V winding	kV rms	_____
Maximum sound level measured in accordance with IEC 551:		
- with auxiliaries	dB	_____
- without auxiliaries	dB	_____
Maximum RIV at 1 MHz measured at 5% above rated voltage in accordance with NEMA 107-1987	μV	_____
Short circuit current withstand ratings:		
- HV winding	A rms sym.	_____
- MV winding	A rms sym.	_____
- Buried Tertiary winding	A rms sym.	_____

SPECIFICATION

SCHEDULE No. 1 (Cont'd)

1.1 21/28/35MVA, 138/79.70kV / 69/39.85kV–13.8/7.97kV Power Transformer (Cont'd):

Maximum duration of rated short circuit withstand current:		
- HV winding	sec	_____
- MV winding	sec	_____
- Buried Tertiary winding	sec	_____
Type of steel core lamination		_____
Flux density of core at 69kV	Tesla	_____
Flux density of core at 34.5kV	Tesla	_____
Thickness of transformer plates:		
- main tank	mm	_____
- tapchanger tank	mm	_____
- radiator plates	mm	_____
- primary and secondary cable boxes	mm	_____
- control cabinet	mm	_____
Vacuum that tank and radiators can withstand	kPa	_____
Positive pressure that tank and radiators can withstand	kPa	_____

1.2 Terminal Arrangements and Conductor Connectors:

Connectors for HV Overhead Conductors:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connectors for MV Power Cable Conductors:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for H0 Bushing Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for X0 Bushing Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

Connector for Tertiary Winding (Y3a/Y3b) Ground Conductor:

- Manufacturer _____
- Designation or Catalogue No. _____
- Type _____

1.3 Accessories:

Off-Load Series-Paralleling Switch (Primary HV Winding):

- Manufacturer _____
- Type _____
- Capacity of Switch contacts A _____

On-Load Tap Changer (OLTC) (Primary HV Winding):

- Manufacturer _____
- Type _____
- Number of Steps _____
- % Primary voltage variation % _____
- Capacity of taps A _____
- Drive Motor Rating V / kW _____
- Tap Position Indicator:

  Manufacturer _____

  Transducer Analog Output mA _____

Transformer Monitoring and Control System:

- Manufacturer _____
- Type _____
- Power Supply Voltage Vdc _____
- Number of Digital Inputs _____

1.3 Accessories (Cont'd):

Transformer Monitoring and Control System (Cont'd):

- Number of Analog Input Channels _____
- Number of Digital Outputs _____

Main Tank/Conservator Gas Accumulation/Sudden Pressure Relay:

- Manufacturer _____
- Type _____

On-Line Dissolved Gases Monitor/Analyzer:

- Manufacturer _____
- Type _____

Winding Temperature Indicator:

- Manufacturer _____
- Type _____
- Setting for Fans stage 1 ^{O}C _____
- Setting for Fans stage 2 ^{O}C _____
- Setting for Alarm ^{O}C _____
- Setting for Trip ^{O}C _____

1.3 Accessories (Cont'd):

Main Tank Liquid Temperature Indicator:

- Manufacturer _____
- Type _____
- Setting for Alarm ^{O}C _____
- Setting for Trip ^{O}C _____

Main Tank Liquid Level Gauge:

- Manufacturer _____
- Type _____
- Scale _____

Conservator Tank Liquid Level Gauge:

- Manufacturer _____
- Type _____
- Scale _____

Tapchanger Tank Sudden Pressure Relay:

- Manufacturer _____
- Type _____

1.3 Accessories (Cont'd):

Main Tank Pressure Relief Device:

- Manufacturer _____
- Type _____
- Setting for pressure relief _____

1.4 Insulating Oil:

- Manufacturer _____
- Type _____

1.5 Current Transformers:

HV Neutral CT (H0):

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

MV Neutral CT (X0):

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

1.5 Current Transformers (Cont'd):

Winding Temperature Indicator (WTI) CT:

- Manufacturer _____
- CT Ratio _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

Tertiary Winding Bushing CTs:

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

Tertiary Ground CT:

- Manufacturer _____
- CT Ratios _____
- Accuracy Class _____
- Continuous Current Rating Factor _____

1.6 Cooling System:

- Number of radiators _____
- Total number of fans Stage 1 cooling _____
- Total number of fans Stage 2 cooling _____

1.6 Cooling System (Cont'd):

- Capacity of each fan	hp	_____
- Rated operating voltage	V	_____
- Number of phases		_____
- Starting current	A	_____
- Locked rotor current	A	_____

1.7 Transformer Weights, Dimensions, and Miscellaneous:

Overall height	m	_____
Overall width	m	_____
Overall length	m	_____
Weight of core and coils	kg	_____
Weight of tank and fittings	kg	_____
Weight of oil	kg	_____
Total weight of complete transformer	kg	_____
Method of oil shipment		_____
Maximum shipping weight (heaviest item)	kg	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 2

DOCUMENTS TO BE SUBMITTED WITH TENDER

	Drawing or Document Ref. No.
Completed Schedules	_____
Outline dimensions and layout of equipment and enclosures	_____
Bills of Material	_____
Catalogues	
Instruction Pamphlets (including fuse time/current curves)	_____
Painting Procedure Specification	_____
Certified "Type Test" Reports (including list of Type Tests to be performed)	_____
List of Recommended Spare Parts (Include prices for each item):	
- readily available	_____
- long delivery	_____
List of required Special Tools	_____
Bar chart progress schedule showing manufacture, delivery, issue of drawings, and all phase of the work	_____
Transportation method and route (including details of trailer and wheel loading)	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 3

TENDERED VARIATIONS FROM THE SPECIFICATION

The Tenderer shall detail hereunder, any variations from the terms and conditions of this Specification:

Signature: _____

Date: _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 4

ERECTION SUPERVISOR

The Vendor shall provide a qualified person(s) to supervise the erection of the power transformer as part of the contract.

Include the name(s) and professional experience of the person(s) proposed as the site erection supervisor / technician.

Also provide details of any specific terms and conditions applicable to each supervisor / technician.

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 5

COMMENCEMENT AND COMPLETION DATES

		Required Dates	Tendered Dates
1.	Issue of Purchase Order	7 December 2015	_____
2.	Submit Bills of Material and Planning Schedule for review.	7 February 2016	_____
3.	Submit assembly drawings, foundation and base plate details, layout and drilling details, wiring diagrams, control schematics, and drawings for review.	27 March 2016	_____
4.	Submit performance curves and other supporting documentation.	27 March 2016	_____
5.	Submit final copies of shop drawings	27 April 2016	_____
6.	Submit draft copies of Operation and Maintenance Manuals.	1 June 2016	_____
7.	Delivery and Offloading, DDP, Fundy Ocean Research Center for Energy Intertie Substation Site Black Rock (Parrsboro), Nova Scotia	1 July 2016	_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 6

SPARE PARTS LIST

Recommended Spare Parts	Quantity	Price (Cdn $)
1. High Voltage (138kV) Bushing	1	
2. Medium Voltage (15kV) Bushing	1	
3. Cooling Fan, complete with Motor	1	
4. Complete Set of Gaskets, together with Gasket Cement	1	
5.		
6.		
7.		
8.		
9.		
10.		

Total Price Carried to Schedule 8: $_____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 7

ACCESSORIES AND SPECIAL TOOLS LIST

Recommended Accessories and Special Tools	Quantity	Price (Cdn $)
1. Impact Recorder (Supply, Mounting and Processing)	Lot	$ _____
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Total Price Carried to Schedule 8: $ _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 8

PRICE LIST

Item	Description	Qty	Price (Cdn $)
1.	Design, manufacture, test, deliver, off-load, erect, assemble and provide a written guarantee for one (1), 21/28/35 MVA, 138/79.7kV / 69/39.85–13.8/7.97kV Oil-Immersed, Three Winding Power Transformer	lot	$ _____
2.	Accessories and Special Tools (from Schedule No. 7)	lot	$ _____
	Total Equipment Supply & Assembly (Items 1 &2)		**$ _____**
	Transportation DDP Fundy Ocean Research Center for Energy (FORCE) Intertie Substation Site Black Rock (Parrsboro), Nova Scotia	lot	$ _____
	Canadian Customs Duty	lot	$ _____
	Harmonized Sales Tax (HST)	15%	$ _____
	Total Supply, Deliver & Assembly Fundy Ocean Research Center for Energy (FORCE) Intertie Substation Site Black Rock (Parrsboro), Nova Scotia		**$ _____**
3.	Tenders shall provide a separate Price for the following optional item:		
	Spare Parts List (from Schedule No. 6)	lot	$ _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

SCHEDULE No. 9

FORM OF TENDER

Item: One (1), 21/28/35 MVA, 138/79.7kV / 69/39.85–13.8/7.97kV Oil-Immersed Power Transformer

Vendor Ref. No.:

1.	Total Supply, Delivery, Off-Loading & Assembly: (From Schedule No. 8)	**$** _____
2.	Terms of Payment:	_____
3.	Customs Clearance by:	_____
4.	Point of Shipment:	_____
5.	Promised Shipping Date:	_____
6.	INCOTERMS 2000 Definition:	_____
7.	Recommended Methods of Shipment:	_____
8.	Estimated No. of Packages:	_____
	- Shipping Weight Each Package:	_____
	- Shipping Dimensions Each Package:	_____
9.	Conditions of Guarantee:	_____
10.	Other:	_____
		_____
		_____

Prepared by: _____

Date: _____

STRUM ENGINEERING ASSOCIATES LTD.

SPECIFICATION

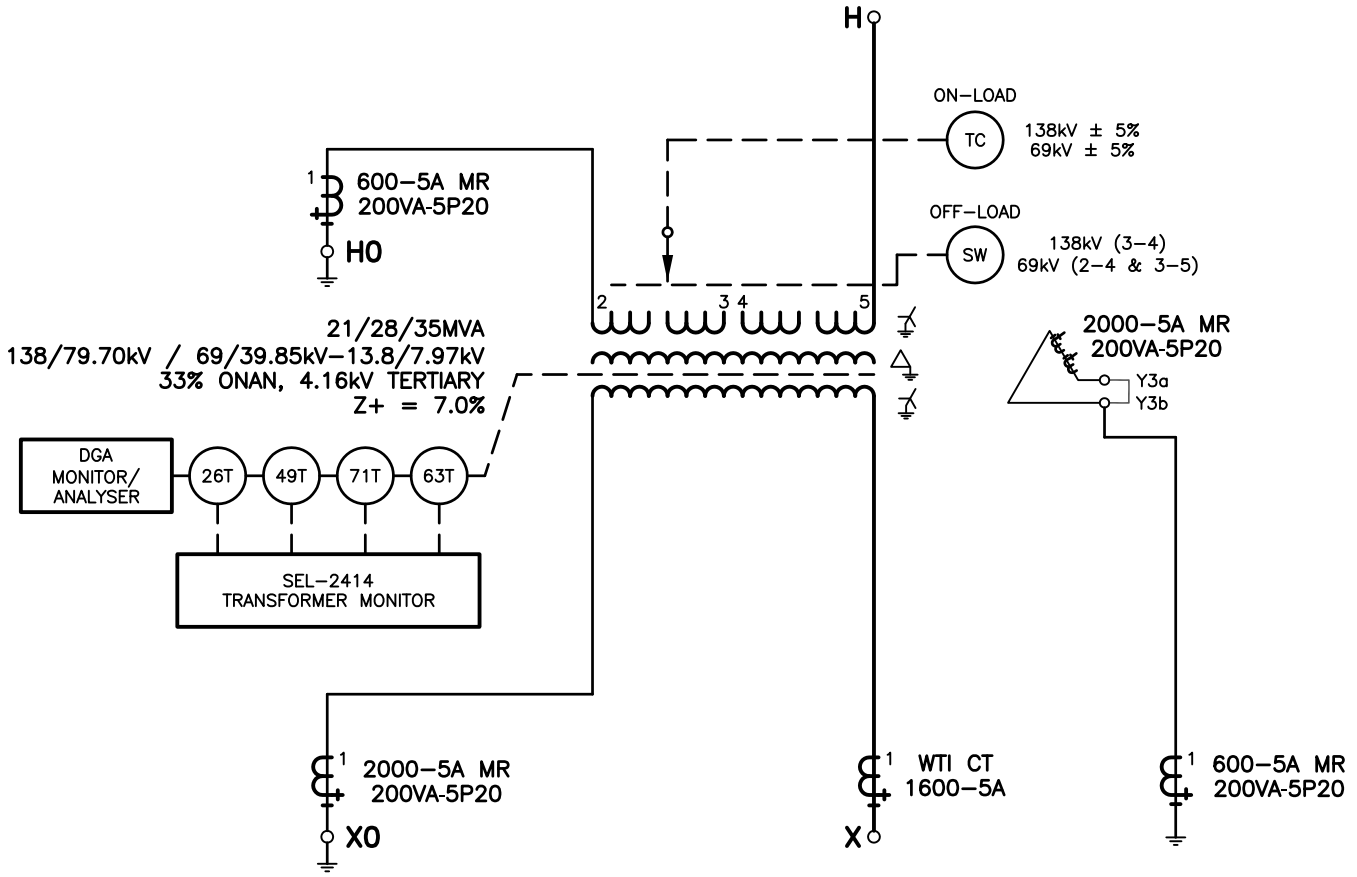
REFERENCE DRAWINGS

LEGEND

600–5A MR
200VA-5P20 — 3 — THREE 600–5A MULTI–RATIO CURRENT TRANSFORMERS, ACCURACY CLASS 200VA-5P20 @ 600–5A.

TC — ON–LOAD TAPCHANGER ASSEMBLY (138kV ± 5% & 69kV ± 5%)

SW — OFF–LOAD SERIES–PARALLELING SWITCH ASSEMBLY (138kV & 69kV)



STRUM ENGINEERING ASSOCIATES LTD.	
DARTMOUTH & SYDNEY NOVA SCOTIA	
DRAWN	P.M.
CKD	R.F.M.
P.MGR.	R.McCARTHY
QA/QC	N.S.
SCALE	N.T.S.
DATE (YYYY–MM–DD)	2015–11–09
CLIENT	FUNDY OCEAN RESEARCH CENTER FOR ENERGY HALIFAX, NOVA SCOTIA
TITLE	INTERTIE SUBSTATION UPGRADE PROJECT 21/28/35MVA POWER TRANSFORMER SINGLE LINE DIAGRAM
REF. DWGS.	
DWG. No.	038–022–SK–01
REV.	A01

038022SK01.DWG