TECHNICAL SPECIFICATION FOR BRUCE B 500 KV REVENUE METERING CURRENT TRANSFORMERS

NK29-TSE-51500-00001

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BrucePower

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Revision Summary

Rev #	Date	Description of Revision	Prepared/ Revised by
000	Mar 4, 2022	Initial Issue	Prateek Sikka, P.ENG, Azin Shahab, P.ENG,

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1 SCOPE

1.1 Introduction

The purpose of this technical specification is to cover the minimum requirements for the design, engineering, performance, manufacturing, assembly, inspection and testing, and delivery of the revenue metering current transformers to be installed at Bruce Power (BP) Bruce B (BB) 500 kV switchyard for Main Output Transformer (MOT) and System Service Transformer (SST) in Tiverton, Ontario.

1.1.1 Acronyms

AC	Alternating Current
ARO	After Receipt of Order
BB	Bruce B
BP	Bruce Power
CCRF	Continuous Current Rating Factor
CT	Current Transformer
CSA	Canadian Standards Association
DC	Direct Current
EOL	End of Life
FAT	Factory Acceptance Test
FMEA	Failure Mode and Effect Analysis
GPS	Global Positioning System
HONI	Hydro One Networks Inc.
HV	High Voltage
IEEE	Institute of Electrical and Electronic Engineers
IESO	Independent Electricity System Operator
ITP	Inspection and Test Plan
MC	Measurement Canada

MOT	Main Output Transformer
MSDS	Material Safety Data Sheet
NBCC	National Building Construction Corporation
P&C	Protection and Control
PCB	Polychlorinated Biphenyl
RIV	Radio Influence Voltage
SF6	Sulfur hexafluoride gas
SST	System Service Transformer
WHMIS	Workplace Hazardous Materials Information System

1.2 Scope of Supply and Related Services

1.2.1 Included in Scope of Supply

The scope of supply under this document includes design, engineering, manufacturing, inspection, testing, and delivery of following outdoor revenue metering current transformers:

- MOT revenue metering current transformers for measuring the power flowing out of the MOT.
- SST revenue metering current transformers for measuring the power flowing into the SST.

The current transformers shall be supplied complete with all accessories and necessary mounting hardware for complete installation at site and effective, trouble-free operation.

The materials and components not specifically stated in this specification that are nonetheless necessary for the satisfactory operation of the current transformer are deemed to be included in the scope supply unless specifically excluded.

The current transformers shall be in accordance with the content and specified standards of this document and to the satisfaction of Bruce Power, IESO and Measurement Canada.

1.2.2 Excluded from Scope of Supply

Off-loading, installation, and commissioning of the current transformer are excluded from the scope but may be supervised by Vendor upon request.

2 REFERENCE

[1] IESO Market Rules: Chapter 4: Grid Connection Requirements and Appendices

Chapter 6: Wholesale Metering and Appendices

[2] NK29-DM-51500-001 Bruce Nuclear Generating Station B Design Manual - 500 kV Switchyard Units 5-8

[3] NK29-DM-65020-00001 Electrical Power System Metering

[4] NK29-DG-29-60000-1 Design Guide – Instrumentation Grounding Requirements

[5] NK29-DG-29-60000-004 Design Guide – Instrumentation Terminal Blocks

[6] IEEE C57.13 IEEE Standard Requirements for Instrument Transformers

[7] IEEE C57.13.6 IEEE Standard for High-Accuracy Instrument Transformers

[8] CSA C61869-1 Instrument transformers — Part 1: General requirements

[9] CSA C61869-2 Instrument transformers — Part 2: Additional requirements for current transformers

[10] IESO 2008-EX409 Expedited System Impact Assessment

[11] NBCC-2015 Appendix C - Climatic Data: Snow & Seismic Design Data for Selected Locations in Canada

[12] CSA S6:19 Canadian Highway Bridge Design Code

[13] CSA S37-18 Antennas, Towers and Antenna-Supporting Structures

[14] Weather History in Kincardine, Ontario. Weather.gc.ca, https://weather.gc.ca/city/pages/on-28_metric_e.html

[15] National Building Code of Canada, Appendix C.

[16] IEEE C37.010 IEEE Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis

3 QUALITY ASSURANCE

The manufacturing and testing by the Vendor shall be performed under a quality program to meet the requirements of CSA N299.3, Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 3.

For Quality Assurance programs accredited by CSA, the Vendor shall state the level of accreditation and provide evidence of Certification.

The current transformers shall be manufactured of new material, free of defects, to the standards of the CSA N299.3 program.

The current transformers covered by this specification shall be standard units of proven ability as manufactured by competent organizations having extensive experience in the production of such current transformer/material. All third party manufactured/supplied items shall be standard catalogued products of the manufacturer and in compliance with applicable industrial standards.

4 GENERAL REQUIREMENT

4.1 Work to Be Done

Current transformers shall be designed and manufactured to fulfill the functional and performance requirements, according to the applicable codes and standards specified in Section 4.3.

4.1.1 Conformance to Specification

The current transformers to be supplied shall conform to this specification and any applicable codes and standards within this specification, specified in Section 4.3.

4.1.2 Exceptions to Specification

The Vendor shall state in its tender any exceptions taken, or non-compliance, to this specification. Vendor exceptions must be approved in writing by Bruce Power or its representative.

4.1.3 Offer of Alternatives

The Vendor is encouraged to offer an alternative current transformer(s)/solution(s) that provides for improved performance, reliability, quality and/or cost savings. These alternatives shall be separately identified with cost and description of the offered alternative(s) in Tender submissions.

4.2 Purpose

Bruce Power is in the process of doing a Major Component Refurbishment throughout the plant. The SST and MOT revenue metering current transformers in the Bruce Power switchyard are approaching end of life (EOL). Their replacement is necessary for the sustained reliability of Bruce Power 500kV nuclear generation station operation.

Additionally, the installed current transformers had obtained approval from Measurement Canada and shall be in compliance with IESO Ontario Market Rules, with specific attention to its updated Chapter 6 – Wholesale Metering (MDP_RUL_0002_06) and Chapter 6 Appendices (MDP_RUL_0002_06A).

4.3 Laws, Standards, and Codes

4.3.1 General Compliance Requirements

Current transformer equipment and its accessories shall be compliant with all applicable laws and codes, specified in Section 4.3. In addition, the current transformer equipment shall comply with the latest approved versions and amendments/corrigenda available at the time of supply of the standards identified here. Additional standards not listed below may also apply.

It shall be the Vendor's responsibility to be knowledgeable of the requirements of all applicable laws, standards, and codes, including those that are specific to the site location.

In addition to the primary standards noted herein, the current transformer equipment and its accessories shall comply with all applicable sections of the latest standards or codes governed by the following organizations and acts:

- Canadian Standards Association (CSA);
- American National Standards Institute (ANSI);
- Electrical and Electronic Manufacturers Association of Canada (EEMAC);
- National Electrical Manufacturers Association (NEMA);
- Canadian Electrical Code Regulations;
- Institute of Electrical and Electronic Engineers (IEEE);
- Workplace Hazardous Material Information System (WHMIS);
- American Welding Society (AWS);
- American Society of Testing and Materials (ASTM);
- Underwriters' Laboratories (UL);
- Occupational Health and Safety Act (OHSA); and,
- Other Laws, Codes, Standards, and Regulations as applicable.

The terminal box shall bear the seal of the CSA.

The Vendor may propose alternative codes and standards provided it is demonstrated that they provide an equivalent or better quality than the referenced codes and standards.

Acceptability of any alternative codes or standards is at the discretion of Bruce Power.

Where an apparent conflict exists between this specification, standards, and codes, the more stringent requirement shall apply.

4.3.2 Specific Compliance Requirements

The current transformer shall meet the requirements of the latest approved versions of the following standards:

Independent Electrical System Operator

MDP_STD_0004	Wholesale Revenue Metering Standard - Hardware
MDP_RUL_0002	Market Rules for the Ontario Electricity Market

Standards of Canadian Standards Association (CSA)

CSA C61869-1	Instrument Transformers – Part 1: General Requirements
CSA C61869-2	Instrument Transformers – Part 2: Additional Requirements for Current Transformers
CSA C22.1	Canadian Electrical Code Part I
CSA C22.2 No. 127-18	Equipment and Lead Wires
CSA C22.2 No. 158	Terminal Blocks
CSA C22.2 No. 75-17	Thermoplastic Insulated Wires and Cables
CAN3-C108.3.1-M84	Limits and Measurement Methods of Electromagnetic Noise from AC Power Systems, 0.15-30 MHz
CSA N299.3	Quality Assurance Program Requirements for the Supply of Items and Services for Nuclear Power Plants – Category 3

Institute of Electrical and Electronics Engineers (IEEE)

ANSI/IEEE C57.13.3	IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases
IEEE C57.13.6	IEEE Standard for High-Accuracy Instrument Transformers
IEEE C57.13	IEEE Standard Requirements for Instrument Transformers

Other Sources

Measurement Canada LMB-EG-01	Consolidation of the Electricity and Gas Inspection Act
Measurement Canada LMB-EG-07	Specifications for Approval of Type of Electricity Meters, Instrument Transformers and Auxiliary Devices
Measurement Canada S_E_07	Specifications for the approval of measuring instrument transformers

Ontario Electrical Safety Code

Transmission System Code, Ontario Energy Board

4.4 Interface Requirements

The current transformer and its accessories will interface with the 500 kV Bruce Power system.

4.5 Registration or Certification Requirements

- Notice of Approval by Measurement Canada. MC approval number shall be provided on the rating plate.
- Release for Installation certificates by CT Manufacturer
- Manufacturers Test Inspection Certificates per
    - CSA C61869 (Titled "Instrument Transformers")
    - IESO documents;
        - MDP_STD_0004 (Wholesale Revenue Metering Standard - Hardware),
        - MDP_RUL_0002_04A -Market Rules - Grid Connection Requirements,
        - MDP_RUL_0002_6A – Market Rules – Wholesale Metering Appendices
    - MC LMB-EG-07 (specification for Approval of type of electricity meters, instrument transformers and auxiliary devices)
- Relevant CSA and ESA approvals
- All registrations shall designate Bruce Power as Ultimate Owner

4.6 Bruce Power Site Service Conditions and Electrical System Data

Refer to Appendix A

4.7 Design Requirements

In addition to the requirements tabulated in Appendix A, the CT shall meet the following requirements as well.

4.7.1 Component Description

Each free standing CT unit is intended to have its primary conductor connected in series with the conductor carrying the current to be measured. The primary current is to be reproduced in the secondary circuits of each CT core within stated limits.

4.7.2 Performance Requirements

4.7.2.1 Loading Requirements

Current transformers shall maintain specified accuracy characteristics over the specified temperature range. The CT's shall be designed to comply with the requirements of CSA C61869 series.

The following loading characteristics for the CT shall be provided by the vendor:

- Continuous Current Rating factors for all available ratios and for various ambient temperatures (see CSA C61869-2).

- Short-Time Current Rating Factors for the CT operating at ambient temperatures of 30 °C for 5, 15, 30 and 60 minutes for preloading conditions of 50% and 100%. Corresponding data for ambient temperatures of 0 °C and 20 °C shall also be given.

4.7.2.2 Accuracy Requirements

Current transformers shall conform to IESO MDP_RUL_0002_06A -Market Rules – Wholesale Metering-Appendices Clause 1.7, which states in summary, that for any alternative metering installation, if the accuracy is not 0.3 as per ANSI C57.13, then the instrument transformer shall be of a type approved for use by Measurement Canada metering accuracy class.

4.7.2.3 Maximum Temporary Overvoltage

The current transformer is intended to be installed at Bruce B 500 kV switchyard and be subjected to switchyard temporary overvoltage. Thus, the current transformer shall withstand the maximum temporary overvoltage of the switchyard system for a specified time.

4.7.3 Operating Requirements

All components, irrespective of their environment and location of the equipment shall be designed to operate as specified in a temperature range of from -50 °C to +40 °C. For SF6 insulated current transformers, Bruce Power may accept equipment rated -40 °C to +40 °C.

Instrument transformers shall be able to withstand mechanical forces under the following conditions:

Wind velocity of 114.42 km/h with a gust factor of 1.3, Current transformers shall be capable of withstanding electro-mechanical forces associated with short-circuit currents.

Current transformers must have adequate insulation withstand strength to avoid 60 Hz flashovers under a variety of weather conditions. One of the most critical conditions, which appears to have a return period of 2 to 2.5 years in certain parts of Ontario, is associated with a prolonged period of freezing rain followed by a gradual increase in ambient temperature during high humidity conditions (= 100% RH) and with contamination on the insulator surfaces. During the freezing rain, ice forms on the insulator surfaces. During the rise in ambient temperature, the insulator surface remains cooler than ambient because of the iced insulator. This produces wetting of all insulator surfaces and can lead to high conduction currents and low withstand voltages.

Insulator designs which maximize the surface creepage distance and minimize the electrical surface gradient appear to be most effective under these special weather conditions. The Vendor shall indicate what alternative insulator designs are available and indicate their recommended solution.

The equipment will not be located at elevations higher than 1000m.

The Instrument transformers will be mounted on support structures installed on concrete foundations.

4.7.4 Fabrication and Material Requirements

1) For each core, each of the four sectional windings of the tapped secondary shall be fully distributed around the core. No compensating turns shall be used. The core shall be in the form of a ring and the axis of any internal bar primary shall coincide with the axis of the core. The effect of stray flux from adjacent cores, or from nearby current carrying parts shall be considered and minimized for each relaying and metering core.

2) Electrical connections of leads shall be brazed with filler metal, which conforms to American Welding Society (AWS) Standard A5.8/A5:SM. Alternatively, compression-type connectors may be used.

3) The current transformer shall be sealed, explosion proof, self supporting when installed and braced for electromagnetic forces and stresses associated with climatic conditions as well as expansion and contraction due to temperature changes.

4) The secondary leads shall be insulated and terminated to ensure that no leakage of insulating gas can occur along or through the leads. The lead insulation shall be compatible with insulating gas. Secondary leads shall be continuous without any joints from the current transformer to the terminal block and shall be labeled for polarity, taps and identification.

5) All materials in contact shall be mutually compatible under conditions of use.

6) The current transformer primary terminal shall be a flat pad with four (04) holes. The contractor will supply appropriate HV connectors for the connection of the CT terminals to either bus or flexible cable. With HV connectors installed, the terminal areas of the CT shall be free of visible corona. If necessary, corona ring (shield) shall be supplied with each unit.

4.7.4.1 Insulating gas requirements

New SF6 gas to be supplied and used as an insulating medium shall conform to the requirements of ASTM 02472.

4.7.4.2 Gas Leakage

The maximum SF6 or mixed gas leakage to atmosphere for the complete CT shall not exceed 0.5% per year, by weight, of the total gas.

4.7.4.3 Gas Monitoring

The manufacturer shall provide temperature compensated, gas density/pressure device (s) which continuously measure the gas in the CT as follows:

Level 1: First Alarm Level

Annunciation of a predetermined gas leakage ("Gas Refill") shall be provided at this level. The manufacturer shall provide two electrically separate, form 'a' contacts, rated 0.2A at 250V DC. The alarm contacts shall close on low SF6 density for remote annunciation.

Level 2: Second Alarm/ Gas Refill Level

This level is the minimum density at which the manufacturer will guarantee 85% of the rated dielectric strength of the CT.

The manufacturer shall provide two electrically separate, form 'a' contacts, rated 0.2A at 250V dc for remote annunciation of the second alarm level.

4.7.4.4 Terminal Box and Blocks

Terminal blocks shall be interruptible (isolating) type.

The terminal box shall be of solid construction, weather proof, and have provisions for padlocking. It shall contain a grounding stud for ground CT leads. The terminal box shall be provided with a drain hole and three outlets suitable for connection of metallic conduit size NPS 1.

4.7.4.5 Grounding

The CT grounding pad shall be of a material compatible with copper, aluminum or alloy type of grounding conductors i.e. stainless steel grounding pad, size 50 mm x 80 mm with two holes horizontally spaced on 45 mm centers and drilled and tapped for M14-2 thread (2-hole NEMA pad). Minimum thickness of copper facing shall be 0.38mm/ Minimum threaded depth of holes shall be 13 mm. The thread protection for the ground pad shall consist of a flanged cup of non-corrosive material suitable for press fitting into threaded openings.

Grounding of all High Voltage and Low Voltage equipment shall conform to the provisions of Ontario Electrical Safety Code, and Bruce Generating Station Grounding Standard.

Current Transformers shall conform to the ANSI C57.13.3 "IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases" (latest revision) for 0.3% accuracy class.

4.7.5 MARKING AND IDENTIFICATION

4.7.5.1 Rating Plates

Readily accessible rating-plate(s) shall be provided on the equipment showing the following:

- CT information as listed in CSA C61869
- The rating-plate markings of all CT
- CT or core designations and locations
- The terminal and lead markings and the current ratios (available ratios) obtainable from the various secondary connections
- For revenue metering CT's the Measurement Canada approval number

The rating plate material shall be stainless steel. The rating plate data shall be inscribed by etching, engraving, stamping or other methods and shall not fade for at least 30 years.

In addition to the data listed in CSA C61869, the rating plate shall include the following information:

- Total mass
- Mass of insulating gas
- Highest voltage for equipment (Um)
- Lighting impulse voltage
- Short time thermal current rating
- Short time mechanical current rating
- Winding development with polarity and terminal markings, all available current ratios,accuracy and burden
- Temperature rise type
- Filling pressure
- First alarm pressure
- Second alarm pressure
- Design pressure
- Reaction pressure of rupture disc
- Capacitance (measured)
- Insulation Power factor (measured)
- Remanence factor (if applicable)

The rating plate details shall be submitted for Bruce Power's approval before fabrication.

4.7.6 Electrical Connections

All joints, which must be disconnected to permit untanking of a core/winding assembly, shall be made by bolted connection only. All other joints shall be by compression connector, by welding or by brazing. If by brazing, the filler metal shall conform to ASTM 8260-56T.

The HV (primary) line terminals shall be NEMA Standard pad, Type V, 4-hole.

4.7.7 Terminal Markings and Polarity

The relative instantaneous polarity of the leads or terminals of instrument transformers including auxiliary transformers shall be clearly indicated by permanent markings that cannot be easily obliterated. Primary terminal polarity markings of transformers intended for installation on station structures should be clearly visible from ground level.

When the polarity is indicated by letters, the letter H shall be used to distinguish the leads or terminals connected to the primary or excited winding and the letter X (also Y and Z if multiple secondary windings are used) shall be used to distinguish the leads or terminals connected to the secondary winding. In addition, each lead shall be numbered such as: H1, H2, X1, X2. If more than three secondary windings are used they shall be identified as X, Y, Z and W for four windings; X, Y, Z, W and V for five windings, etc.

All terminals marked H1, X1, and Y1, etc., shall have the same polarity at the same instant.

When series-multiple windings are provided, the leads or terminals shall be designated by the appropriate letter along with consecutive pairs of numbers (H1 and H2, H3 and H4, etc). The odd-numbered leads or terminals of all windings shall be of the same polarity.

When taps or leads are provided on a winding, the leads or terminals shall be marked with appropriate letter and numbered in their relative order: H1, H2, H3, etc., or X1, X2, X3, etc. When either H1 or X1 is not used, the lowest numbered lead or terminal in use shall be considered as the polarity lead or terminal. If any windings have a lead or terminal common to all rated ratios, the common lead or terminal shall be the lowest number (e.g., H1 or X1) for current transformers.

4.7.8 Environmental Qualification Requirements

N/A

4.7.9 Supplementary Specifications

N/A

4.7.10 Reliability and Maintainability Requirements

The current transformer shall be designed for long lasting durability and shall, as far as possible, be maintenance free.

4.7.10.1 Conventional Health and Safety Requirements

The installation shall conform to the requirements of:

- Measurement Canada - standard drawings;
- The Ontario Electrical Safety Code;
- ANSI/IEEE C57.13.3 "IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases"

Below are the basic conventional health and safety requirements:

- The equipment shall be certified to CSA or equivalent safety standards.
- Standard industrial safety procedures such as using the right tools and equipment, observing adequate protection for isolating purposes, etc., shall be observed.
- Special precautions, as stated in the instruction and maintenance manuals, shall be observed.
- A secondary CT cable open circuit will produce very high voltages

4.7.11 Seismic Qualification Requirements

The current transformer shall be able to withstand seismic events which are typical of the Bruce Power region. No other specific formal seismic qualifications are required.

4.7.12 Radiation Safety Requirements

The current transformers will be installed outdoors at Bruce B 500 kV switchyard and are not subjected to any nuclear radiation. No radiation safety qualifications are required.

4.7.13 Software Requirements

N/A.

4.8 Protective Coating Requirements

Primer: All steel surface shall receive a double phosphatizing treatment prior to painting. Full protection shall be provided for external surfaces against corrosion; external and internal surface shall receive at least one coat of anti-corrosion paint.

The finish colour of the current transformer shall be:

Exterior: 2 coats of ANSI 70 gray

4.9 Workmanship

Workmanship and work practice shall conform to the best standard practice. The design of the current transformer shall be such that installation, replacement, and general maintenance may be undertaken with a minimum of time and expense. Each component shall be designed to be consistent with its duty.

5 TESTS AND TEST REQUIREMENTS

5.1 General

Vendor to supply all required test results as specified in CSA C61869-1:14 and CSA 61869-2:14 to Bruce Power for review before shipment.

5.2 Design Tests (Type Tests)

The type tests shall be conducted generally in accordance with CSA C61869 except as modified below. The type test shall be carried out on the first unit of a design. Under this scenario, per Section 5.4 Witness Test Requirement, Bruce Power reserves the right to witness, or to have an appointed representative witness, any and all tests.

1. Short-time Mechanical Rating Tests

Following the short-time mechanical rating tests, the CT shall be subjected to impulse and power frequency tests at full test voltage levels. An internal visual inspection shall then be carried out to determine any physical changes.

2. Impedance and Excitation Measurements

Impedance and excitation current measurement on all cores and all marked ratios. Excitation curves to be plotted with sufficient number of points to verify the curves on all marked ratios and all cores.

For Metering CT, sufficient measurements shall be made to plot the excitation-current curve over the range from 1% of the kneepoint voltage to a voltage at which the excitation current is 1.0A.

The test shall be performed on the windings associated with marked ratios.

3. Accuracy Tests

The type tests for accuracy shall be the same as routine tests, except that:

- All "developed ratios" shall be tested with the specified maximum standard burdens and with all lower standard burdens.
- Sufficient additional tests shall be performed for the accuracy ratings at the maximum continuous currents for available connections (for each available ratio, the rated current multiplied by the stated continuous current rating factor):
    - The CT shall also undergo extended accuracy tests at test points specified by Bruce Power; 1.0%, 2.5%, 5%, 10%, 100% and CRF, to demonstrate that the CT accuracy is:
        - Within the 0.3% parallelogram for Primary Currents of $\geq$1% through $\leq$ 5%, and

- Within the 0.15% parallelogram for Primary Currents of ≥5% through ≤ CRF.

- Additionally, the vendor shall demonstrate the CT's capabilities to detect very low primary currents, not for revenue measurements, but for special non-revenue applications, at the following test points on CT's lowest ratio only;
  - 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, and
  - 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and
  - 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 primary amps, and
  - Assemble test data into a chart with columns for Primary Current, Expected Secondary Current, Actual Measured Secondary Current and % Error (actual measured secondary current vs expected secondary current)

4. Power frequency wet test
5. Radio Influence voltage test (RIV)
6. Internal arcing test

5.3 Production Tests (Routine Tests)

All routine tests of CSA C61869-1:14 and CSA C61869-2:14 standards shall be performed on each production unit and results submitted in a certified test report. Under this scenario, per Section 5.4 Witness Test Requirement, Bruce Power reserves the right to witness, or to have an appointed representative witness, any and all tests.

1. Gas leakage test
2. Lightning impulse test shall consist of one reduced full wave, one full wave, two chopped waves, and one full wave. Lightning impulse test shall precede the low frequency tests. In addition to voltage waves, ground current shall also be recorded during reduced full wave and full wave tests.
3. Partial discharge measurements.
4. Applied potential test for primary winding.
5. Applied potential test for secondary winding (minimum volt r.m.s. is equal to the voltage during induced test).
6. Applied potential test to ground shield tap
7. Induced potential test for secondary winding (min 10,000 V crest or two times highest secondary terminal voltage rating across low voltage winding, whichever is lower).
8. Measurement of the resistance of secondary windings for all ratios.

9. Excitation characteristics (excitation curves to include check points below and above the knee on the rated tap and maximum ratio tap of all cores).

10. Metering Accuracy tests

The CT will undergo extended accuracy tests at test points specified by Bruce Power; 1.0%, 2.5%, 5%, 10%, 100% and CRF, to demonstrate that the CT accuracy is:

- Within the 0.3% parallelogram for Primary Currents of ≥1% through ≤ 5%, and
- Within the 0.15% parallelogram for Primary Currents of ≥5% through ≤ CRF.

Additionally, the vendor shall demonstrate the CT's capabilities to detect very low primary currents, not for revenue measurements, but for special non-revenue applications, at the following test points on CT's lowest ratio only;

- 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, and
- 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and
- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 primary amps, and
- Assemble test data into a chart with columns for Primary Current, Expected Secondary Current, Actual Measured Secondary Current and % Error (actual measured secondary current vs expected secondary current)

11. Polarity tests

12. Ratio tests

5.3.1 Additional Notes

5.3.1.1 Core Saturation

The Vendor shall state the approximate value of primary current at which any (or all) of the cores will saturate due to stray flux, when the secondary winding is short-circuited.

5.3.1.2 Partial Discharge Test

Following the impulse test sequence and as soon as practical an applied potential test shall be conducted during which a partial discharge level is to be measured.

There shall be no ionization above 5 pC detectable (with an instrument having a sensitivity similar to that of the Electrical Research Association detector) at a voltage value 50 percent greater than the highest operating phase-to-neutral value.

At 435kV, the partial discharge level shall not exceed 10 pC.

5.4 Witness Test Requirement

Prior to shipment, the equipment shall be assembled and shop tested. Bruce Power reserves the right to witness, or to have an appointed representative witness, any and all tests.

Bruce Power also reserves the right to visit, or to have an appointed representative visit, the factory and inspect equipment during the manufacturing and assembly process.

5.5 Test Location

The Vendor shall identify the test location of the current transformer. If the point of test location is changed after award of contract, the Vendor shall be responsible for any additional travel charges associated with meetings, inspections, and witness testing visits.

5.6 Inspection and Test Plan (ITP) and Factory Acceptance Test (FAT) schedule

The ITP shall include, but not be limited to, lists of tests to be performed, pass/fail criteria and applicable standard sections.

The FAT schedule shall include, but not be limited to, lists of tests to be performed, details of test procedures, sequence of tests, test equipment and test circuit, pass/fail criteria, applicable standard sections and forms for recording test values to be used during the actual performance of the tests. The FAT schedule shall also include the final date(s) of the testing and which unit and test(s) will be performed on each day.

The Vendor shall not start testing without both the ITP and FAT schedule being approved. Bruce Power will advise the Vendor of all mandatory check or hold points on approval of the ITP and FAT.

Any non-operational internal connection or disconnection proposed by the manufacturer to facilitate the tests must be approved by Bruce Power.

5.7 Failure to Pass Tests

Bruce Power reserves the right to reject the equipment in the event of failure during the factory acceptance tests.

5.8 FMEA Requirement

The Vendor shall provide an FMEA report of the current transformer being provided. The FMEA report shall use IEC 60812 “Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)” or Bruce Power approved equivalent standard as a guideline for providing a list of potential failure modes within their products. The FMEA report shall include but is not limited to the following information:

- Any relevant functional block diagrams.

- FMEA worksheet shall include the following information:
    - Item reference number.
    - Item description and function.
    - Failure mode.
    - Failure cause.
    - Local effect.
    - Recommended Action.
    - Risk Analysis – Risk Priority Number (RPN).

FMEA report shall be reviewed and accepted before receipt of product for the first time.

6 PRODUCT FORM AND IDENTIFICATION

Prior to disassembly of the equipment for shipment from the factory, all equipment removed must be match marked. These match marks must be permanent on both sides of the connection joints and clearly identified on the outline drawings to facilitate assembly on site.

Parts removed for shipment shall be clearly labelled. Package labels must clearly show which parts are for which specific unit.

Packing shall be marked with the following information:

- Manufacturer's name
- Country of Origin
- Bruce Power's equipment number and/or package number
- Quantity of equipment in the package
- Purchase order number
- Weight in kilograms
- Handling instructions

7 PACKAGING AND SHIPPING, HANDLING AND STORAGE

7.1 Packaging and Marking (Identification) for Shipping

Equipment shall be packed to ensure that no damage occurs to the equipment or material during shipping and handling.

The current transformer components shall be clean, dry and sealed when shipped from the factory.

The current transformer and accessories shall be shipped in standalone containers, braced and supported such that they can be lifted from the top by a crane or from the bottom by a forklift truck.

The equipment shall be factory assembled into integral shipping sections as complete as possible to minimize assembly requirements at the site. Installation hardware, such as anchor bolts, nuts and washers, shall be provided. All control wiring and terminations internal to the current transformer shall be completed.

Enclosures that operate under SF6 pressure shall be shipped under positive dry air, dry nitrogen, or SF6 pressure recognizing the possible need to ship such structures under pressures that are close to atmospheric pressure.

Labeling is required to enable correct operation and to facilitate easy maintenance and servicing of the equipment. All labels shall be clear, durable and securely fixed.

The following information shall be legibly marked on each of equipment module:

- Manufacturer’s name
- Model and serial number
- Specific Address
- Purchase order number
- Summary of contents or a slip of delivery list with Quantity
- Any additional information shown on the purchase order

7.2 Shipping

a) The outermost covering shall be clearly marked with the Purchase Order number; The marking shall also include the weight, specified in kg.

b) The equipment shall be manufactured and packed to prevent defects due to impacts, vibrations and movement during shipping or handling. All openings shall be covered to prevent dirt and dust entry. Packing shall include tamper evident seals for protection during transit.

c) The shipment shall be complete including all assembly materials, instruction manuals, spare parts, special tools and software tools (as ordered).

d) The Vendor shall ship the completed and packaged equipment free to the location specified from Purchaser. Bruce Power shall provide the address and contact information to Vendor before shipment. The Vendor shall arrange, secure, and pay for any permits, work, or security necessary to the movement of the equipment and its components.

e) Vendor shall be solely responsible for the shipping protection of the equipment to ensure safe and undamaged arrival of the equipment at the delivery site. The Vendor shall make the required arrangements for transport of the equipment to site. Appropriate transportation means (rail, road, etc.) shall be determined by the Vendor. Advance notice of delivery time shall be required to arrange lifting services.

f) The Vendor shall advise any constraints which would affect final shipping arrangements. Equipment will be eligible to return and replaced with a new one if observed any damage during receiving.

7.2.1 Impact Recorder

The Vendor shall attach to each current transformer a minimum of one (1) impact recorders to indicate if the equipment has experienced excessive shipping stresses.

If the vendor's impact recorder is digital, Bruce Power shall be provided with instructions and requisite software to download the impact recorder's historic record for the journey from vendor loading point to Bruce Power installation.

The digital impact recorders shall remain the property of the Vendor and will be returned by Bruce Power, if required, after the CT has been installed at site. If the CT is set aside as a SPARE or into TEMPORARY STORAGE pending installation, the impact recorder shall remain on the CT/shipping crate until the CT is installed.

If the vendor's impact recorder is comprised of several single-use self-adhesive mechanical type with 5G, 10G, 15G & 20G indicators, then a Travel Impact Log must accompany each CT with Date/Time, Status of each indicator and Activity for the journey from vendor's shipping dock to Bruce Power's installation site. The Log is intended to ensure that any excessive stresses during shipping/transport are logged and that a damaged CT is not installed/used. These impact recorders will not be returned to vendor.

7.3 Handling and Storage

Off-loading and site storage shall be by others. Requirement and procedures for long term handling and storage of the equipment shall be provided by the Vendor in advance.

8 MATERIAL SAFETY DATA SHEET (MSDS)

A Material Safety Data Sheet (MSDS) shall be provided for each hazardous material, including Sulfur Hexafluoride (SF6) gas.

MSDS shall contain information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with any chemical product used in the product. It should also contain the information on the use, storage, handling and emergency procedures all related to the hazards of the material per WHMIS requirement.

9 DOCUMENTATION REQUIREMENTS

The Vendor shall supply drawings/documents as listed in Appendix B: Drawing and Documentation Requirements. Contact information for submittals will be provided by Bruce Power.

9.1 Schedule

The schedule, one (1) electronic copy, shall be submitted by Vendor. The schedule has dates clearly marked and shall include, but not limited to the following information.

- Submittal of approval drawings and complete equipment details.
- Final assembly of the equipment.
- Test schedule including in progress and final tests.
- Submittal of draft operating and maintenance manuals for approval.
- Submittal of final drawing.
- Submittal of certified test reports.
- Delivery of the current transformer.

Bruce Power shall be advised immediately of any changes on the schedule and a revised schedule shall be provided with the notification.

9.2 Approval Drawings

Approval drawings shall be submitted by Vendor. This shall include one (1) electronic copy containing AutoCAD drawing and PDF set.

The Vendor shall allow times for Bruce Power's review. The Vendor shall then incorporate all comments within predetermined time frame after receipt of comments. This cycle shall be repeated until Bruce Power has no further comments. Manufacturing may commence only after all drawings are accepted. Bruce Power may at its own discretion provide manufacturing release prior to shop drawing review process completion.

Changes between revisions of drawings shall be identified on the drawings using revision triangles or revision clouds.

The required approval drawings shall include but not be limited to the listed in Appendix B: Drawing and Documentation Requirements.

9.3 Final Drawings

Final drawings including any "as-built" changes shall be submitted prior to the scheduled shipping date. Final drawings shall include, but are not limited to the drawings listed in Appendix B: Drawing and Documentation Requirements.

9.4 Test Plans, Reports and Certificates

Inspection & Test Plan (ITP), Factory Acceptance Test (FAT) Schedule and previous design test certificates shall be submitted before the tests.

Test reports from each unit shall be submitted after the test for Bruce Power review.

9.5 Instruction, Operation and Maintenance Manual(s)

Vendor shall submit all applicable technical, installation, operating and maintenance manuals to Bruce Power for information before the scheduled delivery date.

Appendix A: Tables

Table 1: Site Service Conditions

No.	Item	Unit	Value
1.	Elevation above sea level	m (ft.)	205 (673) [Ref. 15, Port Elgin Location]
2.	Min. operating temperature	°C (°F)	-50 (-58) [Ref. 14]
3.	Max. operating temperature	°C (°F)	40 (104) [Ref. 14]
4.	Wind: Max hourly speed	km/h (mph)	114.42 (71.1) [Ref. 12]
5.	Maximum snow loading (1/50) - Ss	kPa	2.8 [Ref. 12]
6.	Maximum Ice loading	mm (in.)	20 (0.79) [Ref. 13]
7.	Seismic condition	PGA	0.044 [Ref. 11] NBCC-2015 Post disaster category
8.	Pollution level	-	Class I – Light (IEEE: Areas without industry and low population density [Ref. 16]

Table 2: 500kV Switchyard Electrical System Data

No.	Type of Data	Unit	Value
1.	Nominal System Voltage	kV rms	500 [Ref. 2]
2.	Maximum voltage at normal operating condition (continuous)	kV rms	550 [Ref. 1]
3.	Minimum voltage at normal operating condition (continuous)	kV rms	490 [Ref. 1]
4.	Phases	-	3 [Ref. 2]
5.	Power Frequency	Hz	60 (57.5-61) [Ref. 2]
6.	Type of Neutral Grounding	-	Grounded [Ref. 2]
7.	Basic Insulation Level or Full Wave Withstand	kV peak	1800 [Ref. 2]
8.	Ultimate 3-phase Fault Current (Symmetrical)	kA rms	60 [Ref. 2]
9.	Minimum Creepage Distance	mm/kV ph-gnd	16 [Industry Standard for Class I – Light pollution level] [Ref. 8]
10.	Auxiliary AC Voltage	VAC	120/208 3PH [Ref. 2]
11.	Auxiliary DC Voltage	VDC	250 [Ref. 2]

Table 3: Current Transformer Technical Particulars

Item	Description	Unit	Required	Offered
1.	**Manufacturer's Data**			
1.1.	Manufacturer's name		To be provided by Vendor	
1.2.	Manufacturing, testing location		To be provided by Vendor	
1.3.	Type / Model Number		To be provided by Vendor	
1.4.	CSA N299.3 compliant	Yes/No	Yes	

2.	**Service Condition**			
2.1.	Indoor/outdoor		Outdoor	
2.2.	Insulation media		SF_6 or SF_6 and others mix or approved SF6-free	
2.3.	Type		Outdoor Free Standing	
2.4.	Operation service condition	°C	Min -50°C to +40°C (see 4.7.3)	
2.5.	Insulation class		E [Ref. 8]	
3.	**Rating**			
3.1.	Nominal system Ph-Ph voltage	kV rms	550 [Ref. 2]	
3.2.	Rated maximum service Ph-Gnd voltage	kV rms	1.1x550/√3=349	
3.3.	Rated frequency	Hz	60 [Ref. 2]	
3.4.	Number of phases		1 [Ref. 2]	
3.5.	1 min. power frequency withstand voltage (dry)	kV rms	830 [Ref. 6]	
3.6.	Rated lightning impulse withstand voltage	kV peak	1800 [Ref. 8]	
3.7.	Short time thermal current rating – 1sec	kA rms	80	
3.8.	Short time mechanical peak current rating – 3sec	kA peak	216 [Ref. 6]	
3.9.	Nominal Primary current	A	1000	
3.10.	Nominal Secondary current	A	5	
4.	**Current Transformer Type**			
4.1.	Number of CT cores		2	
4.2.	Type of Metering Cores		Closed (non-gapped)	
4.3.	Ratios Required (Multi-Ratio)		1000-500-250-125/5A	
4.4.	Accuracy Class		CL 0.15S B1.8 on all developed ratios. (Accuracy class shall cover up to the maximum rating with CCRF)	
4.5.	Continuous current rating factor at 30 °C ambient (for primary & secondary)		3.0 [Ref. 6]	

5.	**Mechanical Data**			
5.1.	Material (Insulator)		Porcelain or Polymer	
5.2.	Minimum creepage distance	mm	550kVx16mm/kV = 8800mm [Ref. 8 Table 6]	
5.3.	Primary terminal pad material		Aluminum	
5.4.	Primary terminal hole pattern		NEMA	
5.5.	Number of holes		4	
6.	**Terminal Box**			
6.1.	Construction		Outdoor, NEMA 4	
6.2.	Enclosure material		Painted Steel or Aluminum	
6.3.	Terminal block		Phoenix (preferred)	
6.4.	Rating of space heaters	W, V	To be provided by Vendor, 120 VAC [Ref. 2]	
6.5.	Auxiliary AC Voltage	VAC	120/208 3PH [Ref. 2]	
7.	**Rating plate**			
7.1.	Material		Stainless Steel; Lamacoid [Ref. 7]	
7.2.	Letter Size	mm	5 (min.)	
8.	**Construction**			
8.1.	Primary Terminal		Tin plated Al	
8.2.	Primary Terminal Type		NEMA 4 holes	
8.3.	Ground Terminal		Stainless Steel	
8.4.	Ground Terminal		NEMA 2 holes	
8.5.	Support Structure		Hot dip galvanized steel	
8.6.	Dimension	mm	To be provided by Vendor	
8.7.	Total weight	kg	To be provided by Vendor	
8.8.	Gas weight	kg	To be provided by Vendor	
8.9.	Gas volume	L	To be provided by Vendor	

Appendix B: Drawings and Documentation Requirements

Supplier:	Purchase Order Number:	
Documents and Drawings Required	**Date Draft Documents and Drawings Required by Bruce Power (Required for Review No Later than 8 Wks. After Receipt of Order & Prior to Fabrication)**	**Date Final Documents and Drawings Required by Bruce Power (Certified Copies Required at Time of Shipment)**
Dimensioned Outline & Foundation Design Info.	Yes	Yes
Assembly Cross Section with Parts List	Yes	Yes
Drawing Index & Schedule	Yes	Yes
Fabrication & Delivery Schedule	Yes	Yes
Completed Data Sheets	Yes	Yes
Calculations	Yes	Yes
Shop Detail Drawings with Bill of Material	Yes	Yes
Welding Procedures with Weld Map	Yes (if applicable)	Yes (if applicable)
CT Excitation Curves	Yes	Yes
Wiring & Schematic Diagrams	Yes	Yes
Q.A./Q.C. Manual	Yes	Yes
Inspection & Test Plan	Yes	Yes
Factory Acceptance Test report	Yes	Yes
Operation & Maintenance Manual	Yes	Yes
Installation & Erection Instructions	Yes	Yes
WHMIS - Material Safety Data Sheets	Yes	Yes
Priced Spare Parts List	Yes	Yes
Manufacturing Record Book	Yes	Yes
Packing and Shipping Procedures	Yes	Yes

Note: All documents must show a Bruce Power P.O.#. Drawings must indicate the current revision number and have an open space (4″ x 6″) near the bottom right corner to allow for Bruce Power's document approval stamp. Document and drawing review and acceptance does not relieve the Supplier of its responsibility to meet purchase order conditions relating to codes, standards, specifications, material design or manufacture and delivery requirements. All vendor documents are subject to the following conditions of review: 1.) ACCEPTED, 2.) REVISION REQUIRED, 3.) REJECTED.