

Collider - Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Brookhaven Science Associates
Upton, New York 11973

Specification No. CAD-1174

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REVISION **C**

SPECIFICATION

FOR

EBIS PLATFORM ISOLATION TRANSFORMER

Prepared by:



R. Lambiase

Approvals:



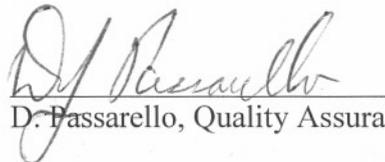
Jon Sandberg, Chief E.E.



Joseph Tuozzolo, Chief M.E.



Edward Beebee, Physics



D. Passarello, Quality Assurance

1.0 GENERAL

- 1.1 This specification defines the performance, design, construction, and testing of a 480V/480V, 200 kVA, 3 ϕ , 100 kV pulse isolation transformers. The transformer will be part of an Electron Beam Ion Source (EBIS) facility being constructed at Brookhaven National Laboratory.
- 1.2 The transformers shall be of the liquid immersed, inert gas sealed oil air cooled type.
- 1.3 The transformers supplied under this specification shall be in strict accordance with the latest standards, the Institute of Electrical and Electronic Engineers (IEEE) - specifically IEEE C57, and the National Electrical Manufacturers Association (NEMA), where applicable.

2.0 SCOPE OF WORK

- 2.1 The vendor shall supply all labor, materials and equipment necessary to design, manufacture, assemble and test the transformers described in this specification. The vendor shall also provide all labor and resources to produce detailed up to date documentation of the transformers as built.
- 2.2 The vendor shall prepare and load the transformers for shipment and deliver them undamaged to the F.O.B. destination: Brookhaven National Laboratory, Upton, New York 11973. The vendor is responsible for on time delivery of the transformers, and is liable for all damage incurred in shipment. The center of gravity of the crate must be clearly marked. Rigging instructions shall be provided by the vendor, and must precede delivery. The vendor shall install tilt and impact meters on the transformers, which will record any unusual mechanical shocks that may occur during shipment.

3.0 SUBMITTALS BY VENDOR

- 3.1 The Offerer shall fill out the attached form entitled "Vendor Data Sheet" and return it with his proposal.
- 3.2 A preliminary outline drawings showing the tank overall dimensions, terminations, component placement, and lifting / moving methods shall accompany the proposal.
- 3.3 The vendor shall specify in detail the guarantee period and its provisions in his proposal.

4.0 DESIGN REVIEWS

- 4.1 The vendor shall supply the BNL engineer with a preliminary acceptance test procedure at the final design review meeting. Three weeks prior to first article testing, the vendor

shall submit for BNL' s review and approval, a copy of the final test procedure.

- 4.2 A design review shall be held no later than six weeks after receipt of order and prior to commencement of fabrication. Sets of all electrical schematic drawings, mechanical assembly drawings, a formal manufacturing schedule and a complete parts list shall be made available to each BNL attendee at the design review date. Agreement shall be reached during the design review not only on the drawings and material submitted, but also on the vendor's manufacturing plan, test procedure and schedule. After BNL approval of the design review the vendor shall promptly begin the assembly of the transformer.

5.0 TRANSFORMER PERFORMANCE AND DESIGN CHARACTERISTICS

- 5.1 The transformers shall be of the liquid immersed, inert gas sealed, oil air (OA) cooled type.
- 5.2 The transformer impedance, based on the nominal convection cooled (OA) KVA rating, shall not differ from the value as specified on the transformer data sheet by more than +/- 7.5% of the nominal impedance listed in the transformer data sheet.
- 5.3 The transformers shall have a wye primary and a wye secondary. Both the primary and secondary shall have the neutral connections brought out.
- 5.4 The observed average winding temperature rise, by resistance measurements, shall not exceed 55 °C at full rated KVA. The hot spot winding temperature rise shall not exceed 80 °C for a 30 °C average ambient temperature (40 °C peak) over a 24-hour period without fans. The temperature rise of the insulating liquid shall not exceed 55 °C when measured near the top of the main tank.
- 5.5 The transformers shall be designed and braced to withstand the available short circuit currents as specified in the transformer data sheets.
- 5.6 All windings shall be made of high-grade electrical copper with a conductivity of 101% IACS as per ASTM standards. There shall be no bolted, soldered, or welded connections or splices in any of the windings except tap connections. They shall be sized and clamped to handle the rms operating, inrush and peak let-through currents.
- 5.7 The windings shall withstand induced and dielectric test voltages in accordance with ANSI C57 and as required in this specification.
- 5.8 The transformers shall have the primary line, secondary line and neutral leads brought out from the tank through bushings rated for full current and the appropriate voltages. The secondary bushings shall have a BIL rating of 150 kV and the primary bushings shall have a BIL rating of 30 kV.
- 5.9 The secondary winding shall be routinely pulsed at 100 kV with respect to the primary winding. The transformer shall be designed for this service, and shall withstand a DC

hipot of 100 kVDC at the secondary windings with the primary windings and all other elements at ground potential, for a period of one minute. The primary winding shall be hipot tested at 2.5kV, with the secondary windings and all other elements at ground potential, for a period of one minute.

- 5.10 The winding capacitance is defined in this specification as the capacitance between the secondary winding and the primary winding under the following conditions:

- 5.10.1 All secondary connections, line and neutral, are connected together.
- 5.10.2 All primary connections, line and neutral, are connected together and grounded.
- 5.10.3 The transformer core is grounded.
- 5.10.4 The transformer enclosure (tank) is grounded.

Under these conditions, the total winding capacitance shall be less than 1000 pF.

- 5.11 The offerer shall specify the expected capacitance on the attached Vendor Data Sheet. The offerer shall back up this estimate with calculations.
- 5.12 The tank shall be provided with a pressure relief diaphragm or valve of adequate size to protect the tank against an explosion due to arcing below the surface of the insulating fluid. The relief device shall be designed to minimize the discharge of insulating fluid and the entrance of air and water after it has opened. It shall be equipped with alarm contacts suitable for operation on 24 V DC circuits. The alarm contact leads shall be run via a suitable conduit to the main terminal box mounted on the tank.
- 5.13 The transformers shall be provided with a magnetic type fluid level gauge equipped with adjustable low-level alarm contacts (form C) suitable for operation on a 24 volt DC system. The alarm contact leads shall be run to the main terminal box in a suitable conduit.
- 5.14 The transformer shall be provided with an indicating dial thermometer to indicate the oil temperature. It shall be equipped with two adjustable alarm contacts (form C) suitable for operation on a 24 volt DC system. One alarm will be set to alarm, and the other will be set to trip the system. The vendor shall specify the two levels. The alarm contact leads shall be run to the main terminal box in a suitable conduit.
- 5.15 A winding temperature simulator device with a thermal element mounted in a well and responsive to the simulated winding hottest spot temperature of the transformer shall be provided. It shall be equipped with two adjustable alarm contacts (form C) suitable for operation on a 24 volt DC system. One alarm will be set to alarm, and the other will be set to trip the system. The vendor shall specify the two levels. The leads shall be run to the main terminal box in a suitable conduit.
- 5.16 The transformer shall be provided with a pressure-vacuum gauge. The scale range for the pressure-vacuum gauge shall be between 10 psi positive and negative. It shall be equipped with two adjustable alarm contacts (form C) suitable for operation on a 24 volt

DC system. One alarm will be set to alarm, and the other will be set to trip the system. The vendor shall specify the two levels.

- 5.17 The tank shall be provided with two NEMA standard stainless steel ground pads located diagonally opposite each other at the base of the tanks. These pads shall be drilled and tapped to accept NEMA 2 lugs.
- 5.18 All tanks shall be equipped with lifting eyes and skid rails suitable for frequent lifting and handling of the transformers by overhead crane and forklift. The center of gravity of the transformer shall be clearly marked. The vendor shall provide calculations for review that demonstrate that the lifting hardware, mounting points, and welds have been designed with a 3:1 safety factor.
- 5.19 The vendor shall supply a stainless steel type "C" nameplate for each transformer giving all standard information, including the following:
 - 5.19.1 Manufacturer's name and address.
 - 5.19.2 Manufacturer's part number.
 - 5.19.3 BNL's part number.
 - 5.19.4 Type, serial number and date of manufacture.
 - 5.19.5 Input voltage and current rating (OA).
 - 5.19.6 Output voltage and current rating (OA).
 - 5.19.7 KVA ratings.
 - 5.19.8 Percent Impedance.
 - 5.19.9 Total weight with and without oil, tank weight.
 - 5.19.10 Outline diagram including wiring and terminal designation in their relative location.
 - 5.19.11 Allowable temperature rise.
 - 5.19.12 x/r ratio at rated load and 40 °C ambient.
 - 5.19.13 BIL ratings
 - 5.19.14 Insulating fluid volume and type.
 - 5.19.15 Maximum tank pressure.
 - 5.19.16 The change in liquid level per 10 ° C change in temperature.
 - 5.19.17 The voltage isolation rating
- 5.20 A transformer / winding data sheet shall be provided.
- 5.21 Protective devices shall be placed on the transformer primary windings to absorb possible over-voltages caused by transients while the secondary is being pulsed.

6.0 ACCEPTANCE TESTING

- 6.1 The transformers shall be subject to the tests below.
- 6.2 All test data shall be recorded and compiled in a test report.

- 6.3 A factory heat run shall be performed to determine that the transformer meets the specified temperature rise for both OA and FA loading conditions, with additional load added to account for harmonics and core heating at rated voltage. This heat run shall be at least eight hours in duration, or until the temperature rise is less than 1 °C in three hours.
- 6.4 The transformer shall be tested by the standard ANSI open circuit test to determine core losses and the standard ANSI short circuit test to determine copper losses.
- 6.5 Winding resistance shall be measured for all windings and recorded.
- 6.6 The impedance at rated current and frequency shall be measured and recorded.
- 6.7 An impulse test shall be conducted at the BIL crest value of 150 kV on the secondary side terminals, including the secondary neutral.
- 6.8 No load turns ratio test shall be performed on each phase of the transformer and shall be recorded.
- 6.9 High potential tests shall be performed on the transformer. These tests shall be performed immediately after the heat run. These tests shall include the BIL test at 150 kV and a 100 kVDC high pot for one minute on the secondary windings, and the BIL test at 30 kV and a 2.5 kVDC high pot for one minute on the primary windings.

Both tests shall be applied between the secondary windings and ground, with the primary windings, the tank, and the core grounded during this test. The actual leakage current for the DC high pot test shall be recorded at the end of one minute while the specified voltage is applied to the winding.
- 6.10 A turn-to-turn insulation test shall be performed at 400 Hz or higher frequency. This test shall directly apply or induce a voltage on the primary winding whose value is equal to twice rated plus 1000 Volt for the duration of 7200 cycles of the applied frequency.
- 6.11 Tank pressure withstand test shall be performed on each tank. The test shall consist of pressurizing the tank to a pressure of +8 PSIG for eight (8) hours and recording the pressure loss readings. All seals and weld joints shall be tested using a soap water mixture during the pressure test.
- 6.12 The secondary to primary capacitance shall be measured. The core, electrostatic shield, all primary windings, and the tank are to be grounded. All secondary windings are to be connected together.
- 6.13 The cognizant BNL engineer and/or his representative shall, at BNL's option, witness all of the above tests. Copies of all certified test data, for each unit, shall be supplied to the cognizant BNL engineer as well as be included in each copy of the instruction manual.

- 6.14 The vendor shall inform the BNL cognizant engineer, in writing, ten (10) working days prior to any factory tests in order to complete travel arrangement to the vendor's facility for witnessing the tests.

7.0 DOCUMENTATION

- 7.1 Upon delivery of the transformer three sets of as built, signed, final prints shall be supplied by the vendor. These prints shall be made to the highest professional drafting standards. All drawings shall also be delivered on CD or DVD +R in AutoCAD DWG format.
- 7.2 Upon delivery of the transformer three copies of the final parts list shall be supplied by the vendor. This shall list all components used in the fabrication of the transformers, identifying those parts recommended by the vendor as required spare parts to insure efficient, reliable operation. The data shall include current unit price and supplier of all component parts. All parts lists shall also be delivered on CD or DVD +R in either MS Word or MS Excel format.
- 7.3 The information required under paragraphs 7.1 and 7.2 as well as all test results, technical descriptions, data sheets on gauges, meters, valves and other pertinent components shall be supplied in a bound design and operations manual. Three copies of this manual shall be supplied with transformer at the time of delivery. The design and operation manual shall also be delivered on CD in either MS Word or Adobe Acrobat format.

8.0 QUALITY ASSURANCE

- 8.1 These quality assurance requirements are in addition to the following quality assurance requirements, which will be found in Brookhaven document BNL-QA-101, attached to the purchase order. The following sections apply: 3.1.3.
- 8.2 With each shipment, the supplier shall submit a certificate of conformance. The certificate shall include the title of and be signed by an authorized representative of the company.
- 8.3 The supplier shall provide a documentation package with each shipment, which includes copies of all required or necessary inspections, examinations, and tests, properly validated by the supplier's authorized personnel.

9.0 200 KVA TRANSFORMER DATA SHEET

9.1	Rating, KVA (OA).....	200 kVA
9.2	Winding configuration.....	Wye-Wye
9.3	Primary Voltage, volts..... (+10% max, -5% min)	480 Vrms, 60Hz, 3 phase
9.4	Secondary Voltage, volts..... ($\pm 3\%$ at full load with 480VAC applied to primary)	480 Vrms, 60Hz, 3 phase
9.5	Secondary Voltage unbalance (max)..... Each winding	2% of nominal
9.6	Impedance	7.5% ($\pm 7.5\%$ of 7.5%)
9.7	Duty Cycle.....	Continuous
9.8	Fault duration time (max)	8 cycles
9.9	Available Short circuit current (To Primary Terminals)	15 kA
9.10	Efficiency.....	98%
9.11	Material; windings, bus bar, leads	copper
9.12	Cooling	Oil - Air
9.13	Ambient air temperature	- 30 °C to 50 °C
9.14	Altitude	<100 meters
9.15	Humidity	100%
9.16	Tank vacuum/pressure (max)	± 10 PSIG
9.17	BIL test voltage.....	Primary 30kV - Secondary 150 kV
9.18	DC isolation test Voltage	Primary 2.5kV - Secondary 100 kV
9.19	Maximum primary to secondary pulse duty	50 msec width at a 5 Hz rate

10.0 VENDOR DATA SHEET

- 10.1 Primary Voltage _____
- 10.2 Secondary Voltage _____
- 10.3 Core Losses _____
- 10.4 Copper Losses (200 kVA) _____
- 10.5 Total Losses @ 200 kVA _____
- 10.6 Transformer Efficiency @ 200 kVA _____
- 10.7 Impedance _____
- 10.8 X/R ratio _____
- 10.9 DC Resistance Secondary _____
- 10.10 DC Resistance Primary _____
- 10.11 Operating Core Flux Density _____
- 10.13 Winding Capacitance (see 6.12) _____
- 10.14 Weight of Core _____
- 10.15 Weight of Copper _____
- 10.16 Total Weight of Unit Dry _____
- 10.17 Total Weight of Unit with Oil _____
- 10.18 Transformer Tank Dimensions (W x D x H) _____
- 10.19 Gallons of Oil _____
- 10.20 Vacuum which Tank will Withstand _____
- 10.21 Isolation Voltage _____
- 10.22 Insulating Fluid _____
- 10.23 Type and Location of Input and Output Terminals _____