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Intense Neutron Source High-Voltage Power Supply Specifications

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INTENSE NEUTRON SOURCE HIGH-VOLTAGE POWER SUPPLY SPECIFICATIONS

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ABSTRACT

This report explains the need for and sets forth the electrical, mechanical and safety specifications for a high-voltage power supply to be used with the intense neutron source. It contains sufficient information for a supplier to bid on such a power supply.

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INTRODUCTION

The original intense neutron source, high-voltage power supply was designed to work into a resistance load. This power supply soon failed when the intense neutron source was used as the load. The intense neutron source consists of an ion source, focusing and accelerating electrodes and a target in a vacuum chamber. It is natural for this system to spark over during electrode conditioning and sometimes during normal operation. This sparking, which collapses the high voltage across the accelerator, sends a steep voltage wavefront back through the distributed capacity of the high-voltage transformers. The amplitude of this voltage transient is sufficient to destroy the transformers electrical insulating material.

This experience prompted the effort to write specifications for a power supply that could operate under vacuum spark conditions.

These specifications were derived through personal experience and consultation with people at Sandia, Los Alamos and Oak Ridge who have worked with vacuum spark loads. Also of help were visiting and consulting high-voltage power supply manufacturers.

1. Purpose of Supply

   This power supply will be used to DC energize an ion beam accelerator. The accelerator will have internal HV vacuum breakdowns during the conditioning of the insulator and electrodes. It will also experience periodic arcing during normal operation. The arcing may occur ~10's of times per day.

2. Electrical Requirements

2.1 Input Power
   440/480 V, 3 Phase, 60 Hz

2.2 Output Characteristics
   250 kV, 0.3 amp DC, Polarity reversible
   Full wave rectification
   Less than 5% ripple RMS
   Load regulation: 10% no load to full load or better

2.2 Output Characteristics (continued)

Line regulation: voltage changes directly with line voltage

Output continuously variable from 0 to 250 kV

A minimum of .005 μf across output of power supply.

2.3 Short Circuit Capability

Must be capable of withstanding short circuits through a vacuum switch of 300 μsec duration without tripping power supply. This arcing condition is capable of generating a voltage wavefront that couples back through the distributed capacity of the HV transformer stressing the primary to secondary insulation near two times the normal voltage. The HV puncture and HV creep characteristics of the insulation must be sufficient to withstand five such arcs per hour for 10,000 hours.

3. Protective and Safety Requirements

3.1 Main circuit breaker with lock out feature.

3.2 Control circuit breaker.

3.3 Primary circuit AC overload relays. One in each phase.

3.4 Vernier variac input and output fuses.

3.5 Key interlock switch.

3.6 Fail-safe output shorting mechanism.

3.7 Overvoltage gaps on HV transformer primary and across meters.

3.8 Surge protection diodes across meters.

3.9 Safety interlocks on power rack doors and HV access.

3.10 Zero output voltage start interlock.

3.11 External interlock for customers HV room. Once interlock is operated, reset pushbutton must be depressed to reset circuit.

3.12 20 kΩ series resistor in HV DC circuit.

4. Power Supply Parts

4.1 HV Tank

4.2 Power Rack

4.3 Control Panel

5. HV Tank

5.1 Contains the HV transformer and full-wave rectifier assembly suspended from lid.

5.2 Must be built to withstand vacuum oil fill.

5.3 Oil to be of a compatible mineral base.

5.4 Tank less than 80-inches tall, weighing less than 23,000 pounds when filled with oil.

5.5 Must have provisions to lift full tank with crane or fork lift.

5.6 Must have voltage graded cable well.

5.7 Must have internal shorting bar to safely release charge on power supply when HV is off.

5.8 Must have liquid level gauge which gives a visual indication and an electrical mechanism which prevents operation if the oil level is low.

5.9 Must have over-temperature gauge which prevents HV application above 80°C.

5.10 Must have over-pressure valve to vent tank if pressure exceeds 8 PSI.

5.11 Must have external ground pad.

5.12 Capable of constant operation at 7500-feet altitude.

5.13 Operates in an environment 0°C to 45°C with 95% humidity.

5.14 50-feet of 300 kV rated cable to connect HV tank to load.

6. Power Rack Contents

6.1 Motorized power-stats which automatically home to zero after trip-out due to overload or when HV is turned off.

6.2 Power-stat speed adjust controls.

6.3 Overload relays on primary side of HV transformers.

6.4 Main circuit breaker with outside access on side of rack.

6.5 Interlocks on all doors.

6.6 Ground pad on outside.

6.7 Caster under rack.

6.8 20-Feet of Cable to connect power supply rack to HV tank.

6.9 All relays for interlock control.

6.10 Surge suppression varistors at appropriate points to prevent damage to components during high-voltage sparking.

7. *Control Panel Requirements*

7.1 Fit a 19-inch rack.

7.1.1 100-Feet of cable to interconnect panel to power rack.

7.2 No voltage greater than 120 V on panel.

7.3 Key switch.

7.4 HV on pushbutton.

7.5 HV Output Level Control pushbuttons, coarse and vernier for raise and lower.

7.6 HV Off-Reset pushbutton must be most conspicuous button on panel for panic access.

7.7 HV meter 0-250 kV low, medium and high scale must have meter relay overload needle setting for setting desired trip level. Meters will be provided with cable jacks on panel front and back for external high impedance monitoring. Maximum monitoring voltage 5 V. Meters to be protected with surge diodes.

7.8 Ammeter 0-300 mA low, medium and high scale must have meter relay overload needle setting for setting desired trip level. Meters will be provided with cable jacks on panel front and back for external high impedance monitoring. Maximum monitoring voltage 5 V. Meters to be protected with surge diodes.

7.9 Time accumulator to show how many hours power supply has been operated.

7.10 Indicator lights on panel.

7.10.1 Key switch open.

7.10.2 Controls on.

7.10.3 *Interlock open.*

7.10.4 HV access door open.

7.10.5 Power stats setting to zero.

7.10.6 Overvoltage.

7.10.7 AC overload.

7.10.8 DC overload.

7.10.9 Ready.

7.10.10 High voltage on.

7.11 Surge suppression varistors at appropriate points to prevent damage to components during high-voltage sparking.

8. Power Supply Acceptance Tests

8.1 Individual transformer Hi-Pot Test.

8.1.1 Each high-voltage transformer will be Hi-Pot tested at a positive polarity 250 kV before they are assembled with rectifier circuit. The test voltage will be applied to the output of secondary winding. The test power supply, the transformer core and one end of primary winding will have a common ground. The voltage will be applied for a minimum of 1 minute. If there is no insulation flashover puncture or corona damage, the transformers will be considered fit for assembly. Buyer will have option of witnessing these tests.

8.2 Chop Test.

8.2.1 A positive polarity 250 kV Chop test using an atmosphere pressure switch to short the load is to be performed 40 times on the power supply. A 50-ft., 300 kV rated cable will be used to connect the supply and load. A 1-megohm load and a 10-kilohm limiting resistor will be used. Buyer will have option to witness this test.

8.3 Supply Overvoltage Test.

8.3.1 A 300-kV open circuit test will be performed on the fully assembled power supply for one hour. Optional for buyer to witness this test.

8.4 Full-Load Test

8.4.1 A full-load test (250 kV, 0.3 amp) on the power supply will be performed at seller's plant for three hours. Buyer will have option to witness test.

8.5 Power Supply Inspection

8.5.1 If power supply withstands all previous tests, it will be opened for inspection. Any apparent degradation or physical movement of transformer windings, insulation, or rectifier components will be cause for rejection. Buyer will have the option to inspect. if all power supply components are satisfactory, the supply will be prepared for shipment to buyer.

8.6 Power Supply Test at Buyer's Plant.

8.6.1 Upon arrival at buyer's plant, the seller and buyer will prepare supply for operation. The buyer will have the option of testing the supply with the accelerator or the resistance load used at seller's plant. The supply will be tested for three hours. Should the power supply perform according to specifications at the end of the three-hour test, the supply will be accepted.

9. Instruction Manuals Contents

9.1 Supply preparation and operation.

9.2 Theory of operation.

9.3 Block diagram of supply

9.4 Schematic of each:

HV Tank
Power Rack
Control Panel

9.5 Pictorial layout of each:

HV Tank
Power Rack
Control Panel

9.6 Parts list and manufacturers name.

9.7 Trouble shooting instructions.

10 Bid Requirements

10.1 Must submit warranty and service policy.

10.2 Submit safety, electrical and mechanical codes the seller will use in building the supply.

10.3 Must be willing to submit proof of using all new components in building the supply and to assure the supply of these parts for a five-year period.

10.4 Submit approximate size and weight figures for the power supply along with instructions for preparing a housing and electrical installation for the supply.

10.5 Submit block diagram and theory of operation for proposed supply. Diagrams and theory sufficiently detailed to evaluate bid as described in 11.

11. Bid Evaluation

11.0.1 Cost 30% weight.

11.0.2 Technical evaluation 70% weight.

11.1 30% weight: Power Supply Cost - Cost will include testing power supply at buyer's installation

11.2 40% weight: HV Transformer Design - This will be determined by type and amount of insulation in transformer winding. Of particular importance is the insulation between low end of secondary and primary winding. Of equal importance is the creepage path over insulation between low end of secondary and ground.

11.3 20% weight: HV Rectifier Assembly - The rating and number of diodes will be the determining factors.

11.4 10% weight: Cable Well - Gradient networks to protect the cable from HV punctures will be looked at closely.

SUGGESTED POWER SUPPLY SOURCES

1. Universal Voltronics
   27 Radio Circle Drive
   Mount Kisco, NY 10549
   (914) 241-1300

2. Hipotronics, Inc.
   P. O. Drawer A
   Brewster, NY 10509

3. American High Voltage Test Systems
   Central Garrett Industrial Park
   Accident, MD 21520
   (301) 826-8651

4. Peschel Instruments, Inc.
   1412 Viscaya Parkway
   Cape Coral, FL 33904
   (813) [illegible]2-3164