

C-A DEPARTMENT / SNS RING SYSTEMS
BROOKHAVEN NATIONAL LABORATORY
Brookhaven Science Associates
Upton, New York 11973



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SPEC. SNS-0023
Revision A
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Specification
For
Spallation Neutron Source
Vacuum Systems Ion Pump Controllers

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SNS Ring System
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SPECIFICATION
FOR
SPALLATION NEUTRON SOURCE
VACUUM SYSTEMS ION PUMP CONTROLLERS

1. SCOPE

This specification defines the design requirements, configuration, materials, applicable Quality Assurance clauses, workmanship, and packaging of the Spallation Neutron Source (SNS) Vacuum Ion Pump Controllers (controllers hereafter).

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein: BNL-QA-101, BNL Sellers' Quality Assurance Requirements.

Unless otherwise specified, the issue date and revision level of applicable documents shall be that in effect on the date of the Request for Quote (RFQ). Exceptions shall be approved in writing.

It is the responsibility of the seller to determine that the specification used in the preparation of quotations by the seller and possible execution of the Purchase Order (P.O.) is the most current revision.

3. REQUIREMENTS

3.1. Controller Safety Compliance

The controllers shall be certified by a nationally recognized test laboratory, e.g., UL, CE or CSA. The controllers shall comply with EN 61010-1 "Safety requirements for electrical equipment for measurement, control and laboratory use."

3.2. Controller Input Power

The controller shall operate with single-phase $115 \pm 10\%$ Vac, 60 Hz input power. The controller shall have a main power switch.

The input power cable shall be terminated with a straight blade 2-pole, 3-wire grounding connector (plug) that meets or exceeds OSHA requirements. The input power cable shall be a minimum of 6 ft. long.

3.3. Controller Operating Environment

The controller shall be fully operational in the ambient temperature range from 0 °C to 40 °C with non-condensing relative humidity up to 50% maximum.

3.4. Hardware Mounting

The controllers shall be mountable in a DIN standard 19" rack. The vendor shall supply mounting hardware for installation in a DIN standard 19" rack. The maximum controller depth shall be 20 inches. The maximum controller height shall be 7".

3.5. Controller Configuration

The seller shall state the number of pumps the proposed controller will operate.

3.6. Ion Pump Operation

The controller shall have levels of protection appropriate for the start-up and operation of the ion pump loads specified in this technical specification. Upon start-up of the ion pump, the controller shall be protected against overheating by limiting the power dissipated in the controller. Once started, the ion pump shall be protected from thermal runaway by limiting the load current and power to the levels appropriate for the selected ion pump load. Automatic switchover from start-up to operate is not necessary. The seller shall recommend a cable suitable for operation of ion pumps located up to 500 feet from the controller.

3.7. Output Voltage and Current

3.7.1. Operating Voltage and Output Power

The controllers shall be capable of starting and operating ion pump loads up to 500 l/s. The controllers shall be capable of producing a fixed operating voltage of positive 5 kV with respect to ground. The controller shall be capable of supplying a minimum of 200 mA to each output. If the operating voltage is programmable, the controllers shall be shipped with the voltage set to positive 5 kV. If the controller design is transformer-based, the fixed voltage shall be a minimum of 5 kV with a maximum no higher than 6 kV, positive voltage with respect to ground.

3.7.2. Output Voltage Ripple and Drift

The maximum output voltage ripple shall be 0.25% of the operating voltage with no load. The controller shall not generate transient voltage spikes on the output. The maximum output voltage drift shall be 0.5% per hour, and not to exceed at any time 5% of the specified output voltage over the entire operating temperature range, under a no-load condition.

3.7.3. Current Resolution

The minimum detectable current shall be no higher than 100 nA.

3.8. Displays and Controls

3.8.1. Front Panel Display

Each controller shall have a digital front panel display that is capable of displaying the programmable or selectable ion pump parameters and readings of any ion pump powered by the controller. The controller shall have front panel controls to allow the display of each programmable parameter and error codes. The controller shall have provisions for locking out front panel controls.

3.8.2. Programmable Parameters

Programmable parameters shall be stored in non-volatile memory, which will retain the stored parameters for a minimum period of two (2) years continuous off time. If the memory is battery-backed, the battery lifetime and replacement instructions shall be included in the Operation/Maintenance Manual.

3.8.3. Remote and Local Control

The controller shall have provisions to select local or remote control. The controllers shall have the appropriate controls and indications for local operation of ion pumps. While the controller is in the local control mode, remote commands (requests to change parameters, or turn the output HV on or off) shall not be executed, while requests for status readings shall be honored.

3.8.4. Power Recovery

Upon recovery of input power, the output HV shall be off, and the controller shall be ready to turn the output HV on without local intervention.

3.8.5. Fault Latching

In the event of a hardware fault, the output HV shall be disabled and a significant error code shall be latched, remaining latched until the fault clears and the appropriate command sequence is issued. Only upon receiving the appropriate command sequence to re-enable the output HV shall the controller update the error status.

3.9. Interfaces

3.9.1. External Interlock Input

The controller shall have an external interlock input to prevent the HV from being turned on (e.g., in poor vacuum). The external interlock shall take precedence over front panel or serial communications commands. A closed contact (short) or control voltage level at the external interlock input(s) shall allow the local or remote HV On command to take effect. The controller shall provide the control voltage, if required. Absence of the short or voltage at the input shall disable the HV output. The controller shall have one external interlock input per HV output.

3.9.2. Set Point Outputs

The controller shall have a minimum of one (1) set point per ion pump. Output channels (isolated relays), rated to a minimum of 30 Vdc, 50 mA, with normally open (NO) contacts are required for each set point. The relays shall be energized when the ion pump pressure is lower than the set point to provide a fail-safe condition. The output channel shall be de-energized when the ion pump is off, or otherwise not fully functional. The set point response time is defined as the time

between the pressure change at the ion pump and the set point relay contact closure. The set point response time shall be less than 300 ms for pressures between 10^{-7} and 10^{-6} Torr.

3.9.3. Analog Outputs

The controllers shall have 0-to-10 volt analog outputs, from which it is possible to determine the ion pump voltage and current for all HV outputs. The seller shall disclose the voltage and current conversions in the operation and maintenance manuals specified herein.

3.9.4. Remote Serial Communication

The controllers shall have a remote serial communication port that allows either half-duplex RS-485 or DeviceNet communication. Each ion pump shall be individually accessible over the communication network. The communication protocol shall provide access to all programmable parameters that are accessible through the front panel controls. Recovery of remote communication upon power-up shall not require local intervention.

3.9.4.1. Communication Rates and Addressing

The controller shall have a minimum communication rate of 9600 bps. The host computer will support transmission rates up to 1.5 Mbps. The communication rate, if selectable, shall be either set by switches or programmable through the front panel. Programmable communication rates shall be stored in non-volatile memory. Each controller shall have a selectable or programmable address. A minimum of 32 address choices shall be available.

3.9.4.2. Error Detection and Handshaking

The communication protocol shall include error detection measure(s) such as a parity bit on each byte transmitted or a checksum byte within each transmission string. The controller serial communication shall not utilize hardware or software handshaking. The controller shall always be ready to accept a command from the host computer.

3.9.4.3. Command Acknowledgement and Response Time

The addressed controller shall reply to every valid command from the host computer. An acknowledgement reply shall be returned for commands that require no data.

The response time of the controller is the delay between the reception of a command and the beginning of the response transmission. The response time shall be no less than two (2) ms and no more than one hundred (100) ms for a valid command. If addressed, the controller shall activate or enable its communication driver only after the host command is fully transmitted. There shall be no delay between the stop and start bits of consecutive bytes until the end of the last byte transmitted. After the response is transmitted, the communication driver shall be deactivated within two (2) ms after the last stop bit of the information transfer.

3.10. Connector Sets

Each controller shall be shipped with connector sets that comprise the mating plug or receptacle for each bulkhead connector on the controller, including strain relief backshells. The connector set shall include: analog output connector(s), setpoint connectors(s), communication port connectors(s), external interlock connector(s), and one HV connector per available HV output.

3.10.1. Analog Output, Set Point and Communication Port Connectors

The analog output, set point and communication port connector contacts shall be crimp type with backshells suitable for cables up to 0.350" outer diameter.

3.10.2. HV Output Connectors

The HV connector shall be suitable for use on Type C or equivalent, or RG-142B/U or equivalent coaxial cable.

3.11. Cable termination

The seller shall supply the necessary procedures and technical support for termination of analog output, set point, communication, external interlock, and HV cables.

3.12. Maintainability

3.12.1. Replacement Parts

Controller printed circuit boards of the same type shall be interchangeable. Furthermore, all circuit boards of the same type shall be the same engineering revision or 100 percent compatible with earlier revisions, unless a later revision is approved in writing by SNS.

3.12.2. Operation/Maintenance Manuals

Operation and Maintenance manuals shall be provided. The manuals shall provide clear, complete, and concise instructions, written in English. The manuals shall include: theory of operation; setup and installation procedures; electronic circuitry descriptions and schematics; analog voltage-to-current and analog voltage-to-pressure conversions; troubleshooting instructions; safety information and directives; parts lists with part numbers; and, mechanical assembly drawings of the controller in paper format.

3.12.3. Serial Communication Documentation

The operation/maintenance manuals shall contain detailed documentation on the controller serial communication protocol including: addressing; transmission frame; error detection; command and response format; error and status codes, and the serial communication electrical connections.

3.12.4. Special Tools

The vendor shall specify special tools or test equipment necessary to diagnose, replace or repair controller components.

3.13. Nameplates and Serial Numbers

The controller nameplate shall bear information including: 1) manufacturer; 2) model number; 3) input voltage rating; 4) input current rating; 5) input voltage frequency; and, 6) serial number.

4. QUALITY ASSURANCE

Articles furnished in compliance with this Specification shall be produced under the controls established herein and as required by the applicable contract. The seller is responsible for providing controllers that are in complete compliance with this specification. Evidence of noncompliance with any requirement specified herein shall constitute cause for rejection.

Additional quality assurance requirements shall be in accordance with clauses provided in BNL Sellers' Quality Assurance Requirements, document BNL-QA-101. The following paragraphs of BNL-QA-101 apply: 3.1.2, 4.2, 4.3, 4.7, 4.7.1, 4.10, 4.10.1, 4.10.2, 4.10.5, 4.13, 4.16, 4.18, 4.18.2, 4.18.4, 4.19, 4.21, 4.33 and 4.34.

4.1. Warranty

All elements of the controllers specified herein shall be covered by a warranty against material and manufacturing faults. The warranty period shall be for a period of at least two (2) years from the date of receipt at SNS. The seller shall provide detailed warranty provisions in writing. Replacement controllers or parts shall be available for a minimum period of seven (7) years from the date of receipt at SNS. In the event that the controller product line is discontinued, SNS shall be notified in writing six (6) months before the production of the controller ceases.

4.2. Seller Acceptance Tests

The seller shall perform all necessary and sufficient tests to verify that all articles supplied meet the requirements specified in this contract.

4.3. Buyer Performed Tests

The Buyer reserves the right to perform any test on the controllers, at the Buyer's expense, and at Buyer facilities, for the purpose of verifying full compliance with any aspect of this specification. Failure of the controllers to meet any requirement shall be cause for rejection.

4.3.1. BNL Tests

First article controllers shall be tested for compliance with all requirements by BNL. Thereafter, the PLO controllers shall be tested by ORNL.

4.3.1.1. Communications

The controller serial communication will be tested for compliance with all timing requirements set forth in this specification.

4.3.1.2. Burn-in

The controllers will be submitted to an 8-hour burn-in with all HV outputs on, with ~1 mA resistive load, in a regulated ambient temperature of 40 ± 5 °C. The output voltage and current will be monitored for compliance with the performance requirements including output voltage drift.

4.3.2. ORNL Tests

Any controller may be tested for compliance with all requirements by ORNL.

5. PREPARATION FOR DELIVERY

Plastic "peanuts" or other loose packaging materials shall not be used by the seller in packaging the controllers or controller components. Packaging containing the controllers shall be plainly labeled with the gross package weight, Seller identification, Seller's part number(s), and Buyer's purchase order number. The packaging shall be durable and suitable for long-term storage. It is the responsibility of the seller to ensure the controllers are delivered to the buyer without damage.

6. NOTES

6.1. Definitions

6.1.1. Failure

Any occurrence including one-time non-repeatable anomalies either sudden or gradual in nature that causes the article performance to deviate from specified limits without adjustment of controls other than normal operating controls.

6.1.2. Non-Conformance

A condition of any article, material, or service in which one (1) or more characteristics do not conform to the specified requirements.

6.2. Seller Subcontracting

The Seller may subcontract all or part of the work defined by this specification and the contract. However, the Seller is responsible for fulfilling all of the conditions given in this specification and the requirements of the Terms and Conditions outlined in the RFQ.

6.3. Performance Objectives

The Seller is encouraged to bring to the attention of BNL/SNS any improvement in performance or reliability that might result from changes to any aspect of this specification. A request for approval of any such improvement shall be submitted in writing to SNS for consideration. Each request shall be accompanied by complete supporting information at least 14 days prior to the bid submittal date.