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Spallation Neutron Source

PPS Interface Control Document

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PPS INTERFACE CONTROL DOCUMENT

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1. INTRODUCTION

Accelerator operations can produce hazardous-to-lethal levels of radiation inside the beam-line tunnels. Hazards are also present inside the tunnels because of radio-frequency (RF) klystron operation and exposed energized electrical conductors. In the event of equipment malfunction or improperly configured shielding, hazardous levels of radiation could be present outside the beam-line tunnel shielding. The Accelerator Personnel Protection System (APPS) is provided to protect workers from these hazards.

The majority of the APPS equipment is "safety significant," which means that it protects workers from facility hazards. The APPS will be designed, procured, installed, and tested according to rigorous standards and procedures to provide a high level of system performance.

The APPS will be installed in stages as the accelerator equipment is commissioned. The Radiation Safety Committee will provide oversight, ensuring that sufficient APPS equipment is present to provide protection against potential hazards from the installed equipment before operation.

Figure 1 shows the interfaces between the APPS and the other technical subsystems.

2. CONVENTIONAL FACILITIES

2.1 BEAM LINES

A significant amount of the APPS equipment will be installed in or near the beam lines. Sections 2.1.1 through 2.1.4 address major systems associated with the beam lines.

2.1.1 Lighting

Area lighting inside the beam lines shall be capable of changing state upon command from the APPS. The APPS will command a significant change in the illumination level inside the beam lines before permitting equipment to be energized or beam operation.

Lighting control shall be divided so that lights can be dimmed in one segment while remaining at normal levels in other segments. The accelerator is divided into four segments: LINAC A (1st half of LINAC), LINAC B [2nd half of LINAC and high-energy beam transport (HEBT)], ring, and ring-to-target beam transport system (RTBT).

Conventional Facilities shall determine the normal and reduced lighting levels. However, the change in level shall be immediately obvious to personnel located inside the beam lines.

2.1.2 Beam Line Doors and Gates

All access points to the beam lines will be instrumented by the APPS to detect unauthorized access to the beam lines. Access points fall into the following categories:

- Normal entrance doors
- Emergency exit doors
- Equipment access doors

Access control methods (gates) will also be installed in the beam lines to isolate one beam line segment from another.

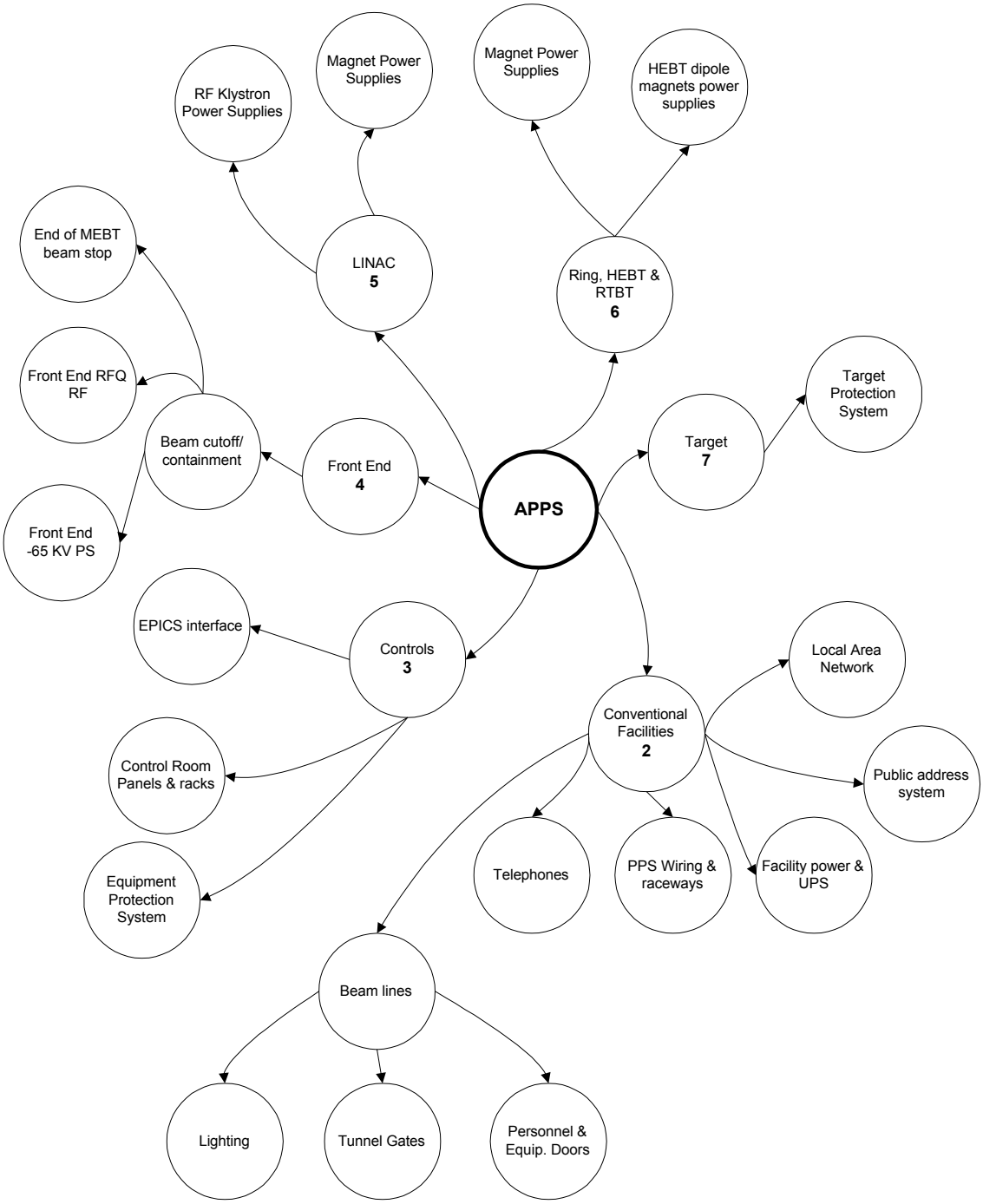

Fig. 1. Interface diagram.

2.1.2.1 Normal entrance door requirements

Normal personnel entrances shall consist of an alcove requiring entry through two doors to gain access to the beam line. The alcove shall be sized to hold up to five people at one time. Entrance doors shall meet the following requirements:

- Outer doors only shall be half-glass doors.
- Door shall be of heavy-duty construction, designed to operate reliably under high usage.
- Each door shall have a heavy-duty door closer.
- Doors will be magnetically locked, eliminating the need for conventional locks.
- Door design shall not preclude the installation of APPS components such as position switches, crash bars, and magnetic locks.

2.1.2.2 Emergency exit doors

Emergency exit doors shall have locks to prevent uncontrolled entrance into beam lines. These doors shall allow the installation of position switches.

2.1.2.3 Equipment access doors

Equipment access doors shall have provisions for physically locking the door. These locks shall be designed to keep the door closed even if power operators are acting to open the door. These doors shall allow the installation of position switches.

2.1.2.4 Segmentation gates

Gates will be installed inside the beam lines to control personnel access from one tunnel segment to another. These gates shall meet the following requirements:

- Gates design shall prevent personnel from crawling around, on top of, or under the gate.
- Open construction shall allow personnel to see through to the adjacent segment.
- Gate design shall allow the installation of position switches and magnetic locks.

2.1.3 Telephones

Telephones are required at each entrance door and segmentation gate. These phones are required for communications to the control room and may be based on an internal phone system.

2.1.4 Local Area Network

A conventional facilities network connection is required at each entrance door. APPS data shall be transported over a dedicated subnet.

2.2 APPS WIRING AND RACEWAYS

Work Breakdown Structure (WBS) 1.9.9.1 will be responsible for all safety-related wiring. WBS 1.9.9.1 and Conventional Facilities will provide conduit and cable tray.

Major conduit and cable trays (raceway) shall be provided for interconnecting cabling for APPS equipment. WBS 1.9.9.1 will provide raceway for interconnecting wiring in a local area

[i.e., wiring field devices at an entrance door to a central junction box or input/output (I/O) device].

Wiring designated as a part of the Safety Instrumented System (SIS) shall be run in a separate raceway from other facility cabling. Non-SIS APPS cable may be run with APPS SIS cable. Cables for other SISs (such as the target protection system) may be run in the same tray as APPS SIS cable if a divider is used.

2.3 FACILITY POWER AND UPS

The APPS equipment will require nominal 120 VAC power. Power provided to APPS equipment shall be maintained without interruption during a facility electrical outage. Electrical power supplied to the APPS shall conform to IEEE 519 and IEEE 1100.

2.4 PUBLIC ADDRESS SYSTEM

The public address (PA) system located in the beam lines shall be capable of playing prerecorded messages based on inputs from the APPS. The PA system shall provide five messages types.

3. GLOBAL CONTROLS

3.1 PPS EPICS INTERFACE

The APPS will provide secure read-only communications to the EPICS to transfer data from the APPS to EPICS. EPICS will not be able to alter APPS programming or data in any way.

WBS 1.9.9.1 will provide an IOC and software that will interface with APPS logic controllers. Controls shall provide networking services to interconnect the IOC to the Integrated Controls System (ICS) network.

The APPS will originate all data from the main control room. The data available to EPICS will include the status of all inputs and outputs from the APPS, as well as logic states pertaining to the status of each accelerator segment (i.e., restricted access, sweep mode, power permit, and beam permit).

Radiation detectors will be installed throughout the facility to verify that gamma and neutron radiation fields in tunnels and surrounding areas do not exceed requirements. Readings of radiation levels will be transmitted to EPICS.

3.2 MAIN CONTROL ROOM

The operator interfaces and programmable logic controllers (PLCs) will be located in the main control room. The following equipment will be installed:

- Operator consoles
- Test/diagnostic console
- PLC racks

The operator consoles will be installed in the auxiliary operator area in a location selected by Controls. There will be six operator consoles. These consoles will be used by the control room operators to interface with the APPS.

The consoles will conform to the Controls definition for standard operator consoles.[1]

Test/diagnostic consoles will be installed in an auxiliary area in the main control room in a location selected by Controls. These consoles will be used by APPS technicians to maintain and test the APPS.

There will be three test/diagnostic consoles. The consoles will conform to the Global Control definition for standard operator consoles.[1]

The PLC processors and control room I/O racks will be installed in the equipment area of the main control room. These racks do not require separation from other nonsafety equipment.

There will be five PLC racks. The racks will conform to the Global Control definition for standard 19-in. control racks.

3.3 EQUIPMENT PROTECTION SYSTEM

The APPS will provide the Equipment Protection System (EPS) with status information on the accelerator segments. Contact inputs will be provided that indicate whether beam operation is permitted in a segment. Two inputs (one from each redundant channel) will be provided. The contacts will meet the following requirements:

- SPST contact will be rated at 24 VDC, 0.5 A non-inductive.
- Contact will be closed when beam is permitted.
- Contacts will originate in the front-end building.

4. FRONT END

The APPS will interface with the front-end equipment to cut off beam and for beam containment. The APPS will control beam production by interrupting power to the extraction high-voltage power supply and the RF to the RF quadrupole (RFQ). These functions will be performed in conjunction with the Target Protection System.

4.1 HIGH-VOLTAGE POWER SUPPLY

The APPS will stop beam production by interruption of 208 VAC power to the –65-kV extraction power supply and by directly interfacing with the power supply remote control interface. An electrical contactor will be installed in series with the 208 VAC electrical feed to the power supply. When beam production is not allowed, AC power will be interrupted by the APPS.

The APPS will also interface with the –65-kV power supply remote control interface. The APPS will provide a contact output to the interface. When the contact is open, the power supply shall turn off. The contact will be rated for 120 VAC, $\leq$1 A non-inductive.

The –65-kV power supply remote control interface shall supply a feedback output to the APPS to indicate when the power supply is on. The output shall meet the following requirements:

- SPST contact shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contacts shall be open when the power supply is on.

[1]In terms of footprint, power requirements, and heat output.

To facilitate configuration control, the power supply shall be installed in a separate equipment rack from other equipment. Conduit for input power to the power supply and output voltage wiring to the hot deck shall be run separately from other conductors.

4.2 RFQ KLYSTRON POWER SUPPLY

The APPS will redundantly stop beam production by shutting off the RF to the RFQ. An interface is required to allow the APPS to inhibit operation of the RF klystron.

The APPS will shut of RF production by two methods. The first method will involve control of the start relay in the step-start rack for the high voltage converter/ modulator (modulator). The second method will involve an input to the personnel safety system (PSS) interlock for the RF transmitter.

High Voltage Converter/ Modulator

The APPS will provide a control relay to interface with the 2400 VAC power contactor in the step-start relay rack. This relay shall be in series with the contactor control signal from the modulator control panel. The APPS relay contact shall be the last control contact (no other control contacts between the APPS contact and the power contactor coil). The contactor shall be configured to remove power from the modulator when the control signal is de-energized. The APPS contact will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the power supply.

The contactor shall have auxiliary contacts to provide a feedback signal to the APPS. The auxiliary contacts shall meet the following requirements:

- SPDT contacts shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact shall be open when the power supply is on.

The APPS shall provide a feedback signal to the HV converter/ modulator equipment control rack assembly. This signal will indicate when the APPS is inhibiting power to the modulator. The feedback signal will meet the following requirements:

- SPST contact will be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact will be open when the modulator operation is not allowed.

RF Transmitter

The APPS will provide an input into the PSS control circuit for the RF transmitter. The RF transmitter shall shut down when commanded by the APPS. The APPS input will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the transmitter.

The RF transmitter shall provide a feedback signal to the APPS. The feedback signal shall consist of a contact output that meets the following requirements:

- SPDT contact shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contacts shall be open when the RF transmitter is on.

4.3 END OF MEBT BEAM STOP

The end of medium-energy beam transport system (MEBT) beam stop (beam stop) will be used for beam containment. When the front end is operational and personnel are located inside the beam-line tunnel, the beam stop will be used (along with the drift-tube LINAC RF) to ensure that beam is not transported to occupied areas.

The beam stop shall be designed to "fail-safe." The beam stop shall fail closed when motive power is removed from the beam stop actuator. The APPS will provide a mechanism to directly inhibit opening the beam stop (i.e., if an air actuator is used, the APPS will provide a solenoid valve to vent the actuator and close the beam stop).

Position switches are required to allow the APPS to monitor the beam stop position. Position switches shall be mounted on the beam stop to indicate when the stop is in the fully open and fully closed positions. Redundant limit switches are required. The limit switch outputs shall meet the following requirements:

- The SPST contact shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contacts shall be closed when the condition is true (contact will be closed from the closed limit switch when the beam stop is closed).

5. LINAC

The APPS will control energy sources in the LINAC for beam containment and to prevent exposure to radiation and exposed energized conductors.

5.1 BEAM CONTAINMENT

The RF supply to the first and second drift tube LINAC (DTL) tank will be controlled to allow front end tuning while personnel are located in the LINAC tunnel. Because of the design of the RF system, RF power to the DTLs cannot be automatically shut off while retaining the RF supply to the RFQ. A manual operation will be required to disconnect the high voltage leads from the modulator to the DTL klystron. A trapped key interlock system shall be used to ensure that the proper sequence is followed to disable the RF to the DTL klystrons while retaining high voltage to the RFQ klystron. A trapped key system shall be provided to enforce the following operating procedure to transition from normal operation to front end tuning mode:

- Shut off power to HV converter/ modulator
- Remove HV leads to DTL klystrons
- Turn on power to HV converter/ modulator
- Switch APPS from normal to front end tuning mode.

5.2 CONTROL OF KLYSTRONS

Malfunctioning klystrons can create unacceptable radiation levels inside the beam lines in the LINAC. The klystrons will be automatically controlled to prevent operation when personnel can access the LINAC beam line.

The APPS will shut of RF production by two methods. The first method will involve control of the start relay in the step-start rack for the high voltage converter/ modulator (modulator). The second method will involve an input to the personnel safety system (PSS) interlock for the RF transmitter.

High Voltage Converter/ Modulator

The APPS will provide a control relay to interface with the 2400 VAC power contactor in the step-start relay rack. This relay shall be in series with the contactor control signal from the modulator control panel. The APPS relay contact shall be the last control contact (no other control contacts between the APPS contact and the power contactor coil). The contactor shall be configured to remove power from the modulator when the control signal is de-energized. The APPS contact will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the power supply.

The contactor shall have auxiliary contacts to provide a feedback signal to the APPS. The auxiliary contacts shall meet the following requirements:

- SPDT contacts shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact shall be open when the power supply is on.

The APPS shall provide a feedback signal to the HV converter/ modulator equipment control rack assembly. This signal will indicate when the APPS is inhibiting power to the modulator. The feedback signal will meet the following requirements:

- SPST contact will be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact will be open when the modulator operation is not allowed.

RF Transmitter

The APPS will provide an input into the PSS control circuit for the RF transmitter. The RF transmitter shall shut down when commanded by the APPS. The APPS input will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the transmitter.

The RF transmitter shall provide a feedback signal to the APPS. The feedback signal shall consist of a contact output that meets the following requirements:

- SPDT contact shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contacts shall be open when the RF transmitter is on.

5.3 MAGNET POWER SUPPLIES

The LINAC magnets will have exposed, energized electrical conductors. To protect workers, the magnet power supplies will be automatically controlled to prevent operation when personnel can access the LINAC beam lines.

The APPS will provide a control relay to interface with the power contactor that controls the AC power for the each magnet power supply. This relay shall be in series with the contactor control signal from the power supply control system. The APPS relay contact shall be the last control contact (no other control contacts between the APPS contact and the power contactor coil). The contactor shall be configured to remove power from the modulator when the control signal is de-energized. The APPS contact will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the power supply.

The contactor shall have auxiliary contacts to provide a feedback signal to the APPS. The auxiliary contacts shall meet the following requirements:

- SPDT contacts shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact shall be open when the power supply is on.

6. HEBT, RING, AND RTBT

The APPS will interface with the HEBT dipole magnet power supplies for beam containment and with the other magnet power supplies to prevent hazards associated with exposed energized conductors. The APPS will provide beam containment by interrupting power to the HEBT dipole magnet power supplies. The APPS will mitigate hazards associated with exposed energize conductors by interrupting power to the magnet power supplies.

6.1 HEBT DIPOLE MAGNET POWER SUPPLIES

The APPS will provide beam containment by the interruption of 480 VAC power to the dipole magnet power supplies and by directly interfacing with the power supply remote control interface. Power contactors will be installed in series with the 480 VAC electrical feed to the power supply. When beam containment is required, AC power will be interrupted by the APPS. The APPS will also interface with the power supply remote control interface.

The APPS will provide a contact output to the interface. When the contact is open, the power supply shall turn off. The contact will be rated for 120 VAC, $\leq$1 A non-inductive.

The power supply remote control interface shall supply a feedback output to the APPS to indicate when the power supply is on. The output shall meet the following requirements:

- The SPST contact shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contacts shall be closed when the power supply is on.

6.2 MAGNET POWER SUPPLIES

The HEBT, Ring & RTBT magnets will have exposed, energized electrical conductors. To protect workers, the magnet power supplies will be automatically controlled to prevent operation when personnel can access the beam lines.

The APPS will provide a control relay to interface with the power contactor that controls the AC power for the each magnet power supply. This relay shall be in series with the contactor control signal from the power supply control system. The APPS relay contact shall be the last control contact (no other control contacts between the APPS contact and the power contactor coil). The contactor shall be configured to remove power from the modulator when the control signal is de-energized. The APPS contact will meet the following requirements:

- SPST contact will be rated at 110 VAC, 10 A
- Contact will be open to turn off the power supply.

The contactor shall have auxiliary contacts to provide a feedback signal to the APPS. The auxiliary contacts shall meet the following requirements:

- SPDT contacts shall be rated at 24 VDC, 0.5 A non-inductive (minimum requirements).
- Contact shall be open when the power supply is on.

7. TARGET

The Target Protection System (TPS) will provide the beam containment function that prevents transport of the beam from the RTBT to the target. The TPS will apply controls to the RTBT dipole magnet located at the extraction dump. These controls will ensure that the dipole magnet cannot be energized and thus beam cannot be transported to the target.

The APPS will interface with the TPS to determine the status of this beam containment function. The TPS shall provide redundant inputs to the APPS to indicate the status of the beam containment function. The inputs shall meet the following requirements:

- SPST contact rated at 24 VDC, 0.5 A non-inductive
- Contacts shall be open when beam can be transported to the target
- Contacts shall be closed when power is lost to the beam containment controls
- Contacts shall originate in the target building

The TPS shall provide redundant inputs to the APPS when beam to target is permitted.[2]. The TPS shall provide one input to each APPS channel. Each input shall conform to the following requirements:

- The SPST contact shall be rated at 24 VDC, 0.5 A non-inductive
- Contacts shall be open when beam to target is not permitted or when power is lost to the beam containment controls
- Contacts shall originate in the target building

[2]The specific purpose for this interlock is to ensure that beam operation does not produce unsafe levels of prompt radiation in occupied areas.