SNS-OPM-ATT 2.B-10.a.
Unreviewed Safety Issue (USI) Evaluation Form

I Title of USI Evaluation:

Isolate Power Supply Commons in Klystron Gallery PPS Racks and isolate Linac/HEBT Gate Control Power

II Description of Proposed Activity (or discovered condition):

This proposed modification is part of the continuing corrective actions to eliminate potential common failure modes from the accelerator PPS systems. It is tracked under ACTS Issue 16952.1 *"Separate the PPS power supply commons."*

The proposed modifications addressed in this USID include:
1) Isolate Klystron Gallery PPS cabinet power supply commons from earth ground. Specifically for this USID, the Klystron PPS CAB03 PLC 'C' power supply wiring.
2) Replacing semiconductor diodes with relays used to isolate the Linac and HEBT power controlling the magnetic lock on the Linac/HEBT PPS gate.

The associated Permanent Change Request is documented through SNS-RAD-ICS-CR-0011 and Design Change Notice SNS-RAD-ICS-CN-0039.

> *Note: It is intended to implement this modification at the same time as magnet power supply electrical interlocks are removed from the PPS (See USID 102030102-ES0083). However, this modification and removal of magnet power supply interlocks are considered two separate activities and are not interdependent.*

II.A Summary of Changes to Hardware and Equipment

1) Remove wires that connect PPS Chipmunk (PLC 'C') DC power returns (commons) to earth ground.
2) Re-terminate the PLC 'C' power supply commons to a dedicated common terminal strip in lieu of using a Device Net connector as a common termination point.
3) Re-wire the Linac/HEBT tunnel gate junction boxes to use relays instead of diodes to electrically isolate the two sources of control power for the gate magnetic lock.

II.B Background

The proposed modifications described in this USI are part of the long-term corrective action plan tracked as ACTS Issue 16952.1. This modification eliminates potential common failure modes by completely isolating the PPS Chipmunk PLC 'C' power from the cabinet earth ground. The power for the PPS PLC A and PLC B chains are already isolated from earth ground and each other. The proposed changes evaluated in this USI better meets the intent of FSAD-PF 3.2.3.4.1 *PLC Hardware:*

> *"Each redundant PLC in a one-out-of-two configuration is maintained as a separate system to minimize common mode failures."*

Isolation of the 24VDC power for each PPS rack was identified and approved as the appropriate corrective action to eliminate a potential common failure mechanism. A December 2013 design review of proposed interim and long-term modifications identified

> *"The long term modifications, isolating all PLC power supplies from earth ground, maintaining segment and chain power supply isolation and using isolated outputs is a correct solution to the original design shortcomings."*[4]

4 SNS-RAD-ICS-TR-0002 *"Spallation Neutron Source Personnel Protection System Modification Review Committee Report"*

An independently lead SNS Hazard and Operability Study (HAZOP) team tasked with looking for other potential common failure modes also recommended:

> *"The long term corrective action to separate PPS power supply commons remains the best way to eliminate the failure mode leading to the July 2013 event. This will be a multi-year effort."*[5]

The initial phase, isolation of CCR PPS cabinet power supplies, was reviewed and completed in July 2015 under USID 102030102-0080. Modification of accelerator PPS cabinets to isolate DC power commons will continue through 2018.

II.B.1 Modification of Klystron Gallery CAB03 Power Supply Commons

The DC power commons are already isolated in Klystron gallery cabinets KL:CAB01, 02, and 04. The power for PLC Division A and Division B are isolated in cabinet KL:CAB03. The KL:CAB03 Chipmunk power (PLC 'C') is not isolated from earth ground at this time. Further, a Device Net[6] connector was used in lieu of a dedicated common terminal strip in the implementation of the cabinet wiring. Using a connector terminal as a terminal strip is not accepted good practice. This modification will isolate PLC 'C' DC returns from cabinet ground and to re-terminate the PLC 'C' power supply commons using a dedicated terminal strip.

II.B.2 Modification of Linac/HEBT Gate Maglock Control

The Linac/HEBT tunnel gate serves as the primary barrier between the two PPS segments. The gate position is independently monitored by the Linac and HEBT PPS systems using separate position switches. However, there is only one magnetic lock for the gate that can be energized by either the Linac or the HEBT PPS segment. Steering diodes are used to 'OR' the maglock power from the two PPS segments. The power supply returns for the Linac and HEBT are also connected together with steering diodes at this junction box. While steering diodes can prevent significant currents from affecting adjacent segment power, they do not truly isolate the two adjacent PPS segments. In order to completely isolate the Linac PPS power from the HEBT PPS power, the diodes will be removed and a relay will be added to the HEBT gate maglock control signals. The DC power and return for the HEBT will then be fully isolated from the Linac.

II.C Detailed Description of Changes:

The following section provides more detail on the proposed modifications described in section II.A and II.B

1. *Remove wires that connect PPS Chipmunk (PLC 'C') DC power returns (commons) to earth ground.*
    a. Removing the wire connecting PLC C power supply commons to earth ground ensures each of the redundant legs of the PPS operate independently.

    The DC returns are isolated through engineering re-design of the DC power distribution within the KL:CAB03. Figure 3 shows the existing wiring configuration with power supply commons tied to earth ground as well as the modified power wiring. The revised power supply wiring is fully documented through approved revision controlled drawings.

2. *Re-terminate the PLC 'C' power supply commons to a dedicated terminal strip in lieu of using a Device Net connector as a common termination point.*

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5 Mahoney, K., et. al. *"Hazard and Operability Study: SNS Personnel Protection Systems."* May 7, 2014

6 Device Net is a Rockwell Automation industrial communication network system used to connect PLC devices.

Install a bussed terminal strip. Connect each power supply, the redundancy module, and field commons to this terminal strip. Figure 3 shows the existing wiring configuration with power supply commons tied to a Device Net connector as well as the modified power wiring using a dedicated terminal strip. The revised power supply wiring is fully documented through approved revision controlled drawings listed in PCR SNS-RAD-ICS-CR-0011.

Verification of Items 1&2:
The isolation between each of the PPS PLC power supplies from each other and from earth ground is verified through:

- review of the proposed wiring design
- independent inspection of the equipment
- electrical measurements on the installed equipment

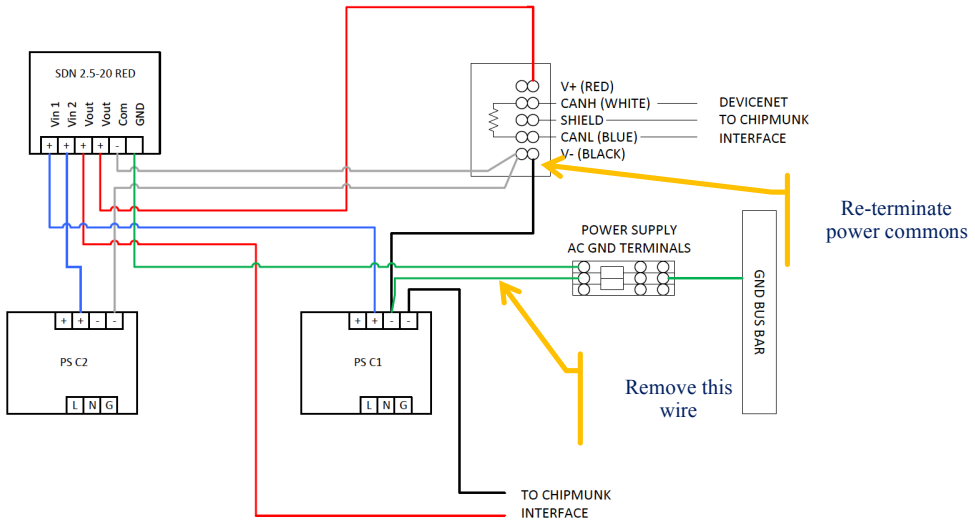
3. *Re-wire the Linac/HEBT tunnel gate junction boxes using relay logic rather than diodes to electrically isolate the gate magnetic lock control power supply returns from each other.*
The steering diodes will be removed from the gate interface boxes.
Two relays will be installed to isolate the HEBT maglock control power from the Linac maglock control power. The relays will be located in the PPS junction box immediately above the gate. The gate control contacts are arranged as a logical 'OR' where either the Linac or the HEBT PPS can lock the gate. Figure 4 shows the existing gate maglock controls with steering diodes. Figure 5 shows the modified gate maglock controls with relays used for isolation between the Linac and HEBT PPS systems.

Note: In the process of updating the gate wiring diagram, details such as wiring terminals were added to the revised drawings as shown in Figure 5.

Verification of Item 3:
Isolation and proper operation of the Linac and HEBT gate functions will be verified through:

- review of the proposed wiring design
- independent inspection of the equipment
- electrical measurements on the equipment
- local and remote testing of each gate function to include
    - independent operation of gate position switches
    - independent operation of gate magnetic lock
    - independent operation of emergency exit (ESTOP) pushbuttons
    - proper operation of Linac/HEBT stack lights

EXISTING



PROPOSED

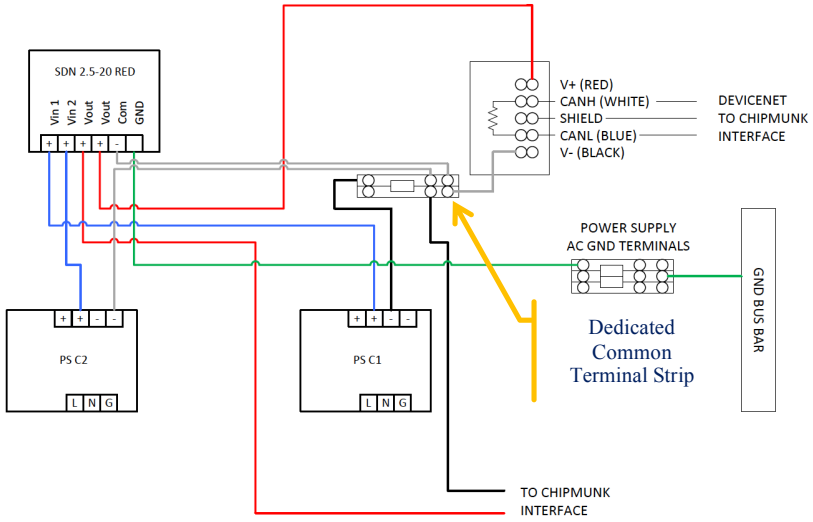


Figure 3 Existing and Proposed wiring of PLC 'C' Power in KL:CAB03

EXISTING

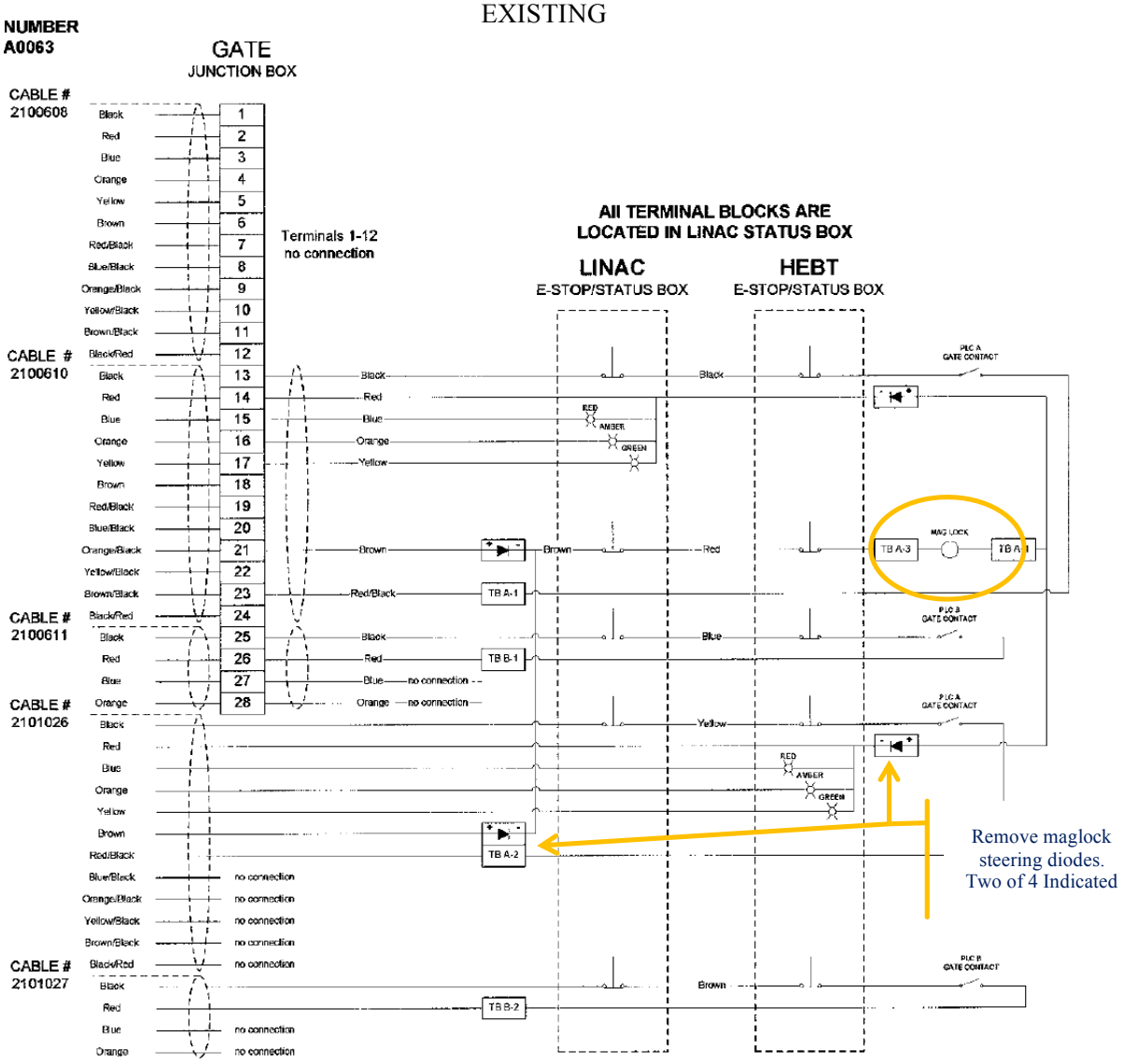


Figure 4 Existing gate maglock control using steering diodes

PROPOSED

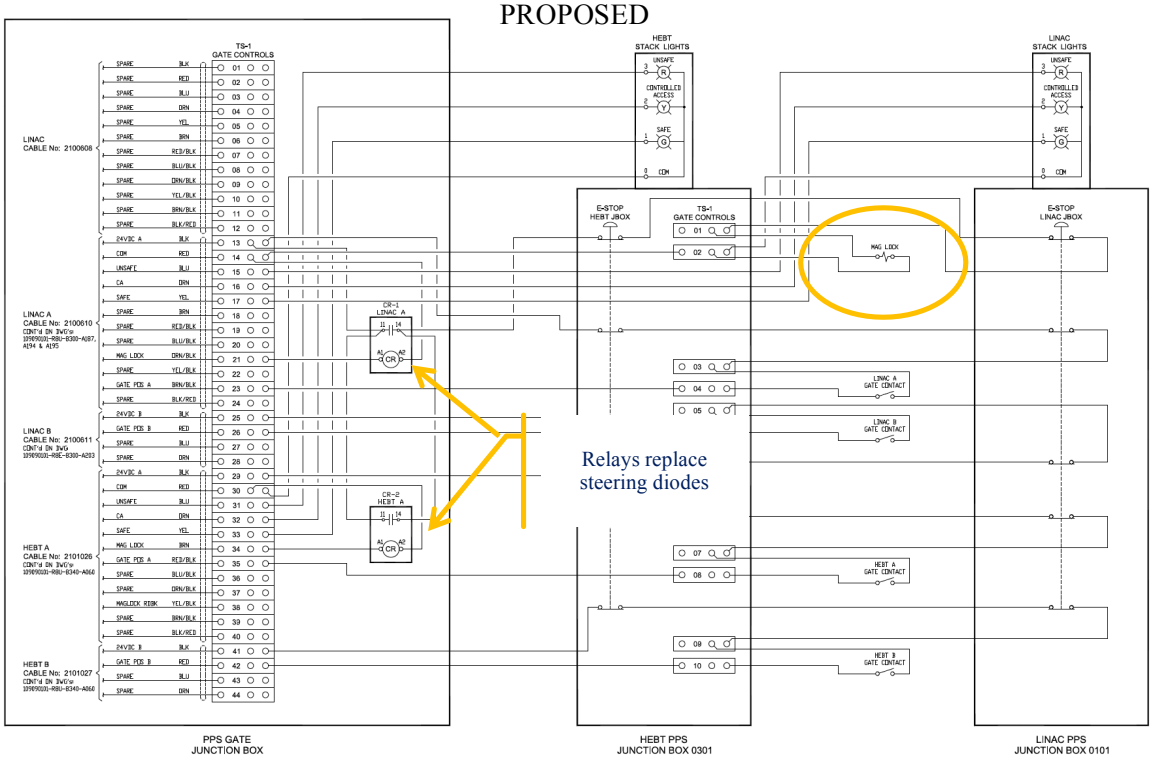


Figure 5 Modified gate maglock control using relays for isolation

II.D QA, Verification, and Validation

Given the externally reviewed and approved solution to eliminate potential common mode ground errors is to isolate the DC power, there are a set of processes in place to ensure the solution and other modifications are implemented faithfully and correctly. In addition to design and change management processes for CECs defined in the SNS Operations Procedure Manual (OPM), the SNS Protection Systems Team utilizes lifecycle processes defined in ISO/IEC/IEEE 15288 *"Systems and software engineering —System life cycle processes"* to assure the final product meets the intended performance requirements.

II.D.1 Design Process:

The design process first entailed a 100% verification of the existing documentation, construction and wiring of the klystron gallery cabinets and the Linac/HEBT gate wiring. The verified information was then used as the design basis for the subsequent engineering modifications for the revised wiring.
The drawings for klystron gallery CAB03 were modified to remove the PLC C power connections to chassis ground. The new drawings also show exactly where power supply common wires are connected.
The design of the PPS junction boxes at the Linac/HEBT tunnel gate were modified to fully isolate Linac and HEBT wiring. In addition to wiring diagrams, junction box assembly drawings were created to show the existing and modified layout. Drawings are listed in PCR SNS-RAD-ICS-CR-0011.

II.D.2 Implementation Process:

II.D.2.1 Hardware Fabrication
The only hardware fabrication is to install modified Linac (JB101) and HEBT (JB301) gate junction boxes at the Linac/HEBT gate in the accelerator tunnel. The modified junction boxes eliminate the steering diodes. Adding the relays to the PPS gate junction box will be done in-situ. Figure 6 shows the gate junction box with modifications highlighted.

II.D.2.2 Software Modification
There are no software modifications as part of this change.

II.D.2.3 Integration Process
Final integration testing will occur with the in-situ system after installation. The final integration tests include testing the Linac/HEBT gate controls before commissioning and full certification of the Linac and HEBT PPS segments.

II.D.2.4 Operations Documentation and Training
There are no changes to Operations Documentation and Training associated with this modification.

II.D.3 Testing and Verification Process:

II.D.3.1 Laboratory Testing (Linac/HEBT Gate Only)
A model of the modified Linac/HEBT gate junction boxes will be tested in the Lab. This will allow verification of correct wiring and methods before installation in the tunnel.

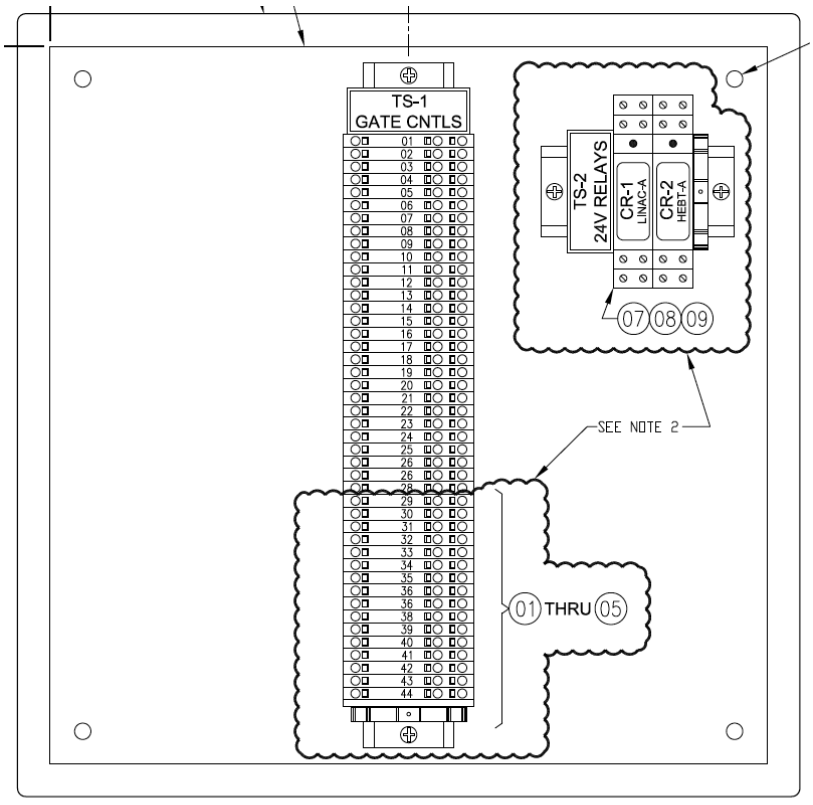
II.D.3.2 Installation Testing
The Klystron cabinet PLC 'C' modifications will be verified against the modified power distribution drawings.
The installed Linac/HEBT gate junction boxes will be fully tested along with monitored and controlled devices on the gate. Tests include:

- Gate position switch operation
- Gate magnetic lock operation
- Gate emergency exit switch (ESTOP) operation
- Linac/HEBT stack lights
- Electrical isolation of the above items

II.D.3.3 Commissioning and Certification
The Linac and HEBT PPS systems will undergo commissioning and certification testing as part of the verification process.

Note: at this time Commissioning and Certification of this modification are integrated into the overall commissioning and certification testing performed with the removal of magnet power supply interlocks (See USID 102030102-ES-0083). The commissioning plan includes specific steps to test the modifications made as part of this change and may be performed independently if required.

Conclusion of Section II
The material presented in section II supports the determination of a negative USI as documented through the negative answers to the guiding questions in parts III and IV. The changes associated with the isolation of klystron gallery PPS power supplies and the Linac/HEBT gate controls do not negatively affect the PPS functions described in the FSADs and ASE. Nor are there new failure modes or potential accidents introduced through this change. Rather, the change described in this document improves the overall safety reliability of the installed accelerator PPS systems.



PPS GATE JUNCTION BOX
COVER REMOVED (BACK PANEL)

Figure 6 Linac/HEBT Gate junction box assembly highlighting modifications

III Does the proposed activity or discovered condition affect information presented in the FSAD-NF or FSAD-PF, e.g. regarding equipment, administrative controls, or safety analyses.

No. The proposed modifications to the PPS klystron gallery cabinets do not affect information presented in the FSADs. The PPS system is described in the FSAD-PF Section 3.2.3 and requirements for the PPS CECs are presented in FSAD-PF Section 5.2.1. The proposed modifications do not affect the safety functionality of the PPS as described in the FSADs other than to remove potential vulnerabilities to a common mode failure.
The proposed changes improve the compliance and performance of the PPS within the FSAD requirements. Specifically, the proposed modification better implements the requirements described in the FSADs.

IV Does the proposed activity or discovered condition affect any of the requirements of the ASE.

No, the requirements and operational conditions given in the SNS ASE Section 3.2 *Personnel Protection System (PPS)* remain unaffected. The level of detail regarding the proposed modifications (e.g. power supply wiring) is not addressed in the ASE. The proposed modifications do not affect the safety functionality of the PPS other than to remove potential vulnerabilities to a common mode failure.

V USI Evaluation Criteria:

1. Could the change significantly increase the probability of occurrence of an accident previously evaluated in the FSADs? Yes __ No _X_

Justification: No. The PPS is a Credited Engineered Control credited with protecting workers from potentially injurious prompt radiation produced by accelerator operations. The probability of occurrence of an accident associated with accelerator produced prompt radiation is not affected by the proposed modifications associated with the new PPS Racks. The proposed modifications do not affect the safety functionality of the PPS other than to remove identified vulnerabilities to a common mode failure.

2. Could the change significantly increase the consequences of an accident previously evaluated in the FSADs? Yes__ No _X_

Justification: No. The PPS is a Credited Engineered Control credited with protecting workers from potentially injurious prompt radiation produced by accelerator operations. The consequences of accidents addressed in the FSADs (i.e. excessive prompt radiation exposure) are not affected by the proposed modifications associated this change. The proposed modifications do not affect the safety functionality of the PPS other than to remove potential vulnerabilities to a common mode failure.

3. Could the change significantly increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the FSADs?

   Yes__ No _X_

   Justification: No. The purpose of the proposed modification is to eliminate the potential vulnerability to a common mode failure such that the probability of an unsafe failure of the PPS is reduced.

4. Could the change significantly increase the consequences of a malfunction of equipment important to safety previously evaluated in the FSADs?

   Yes__ No _X_

   Justification: No. The PPS is a Credited Engineered Control (CEC) credited with protecting workers from potentially injurious prompt radiation produced by accelerator operations. The potential safety consequences of a failure of the PPS system (i.e. excessive prompt radiation exposure) are grave and are unchanged by system modifications. The proposed modifications do not affect the safety functionality of the PPS other than to remove potential vulnerabilities to a common mode failure.

5. Could the change create the possibility of a different type of accident than any previously evaluated in the FSADs that would have potentially significant safety consequences?

   Yes__ No _X_

   Justification: No. The proposed modifications do not increase the possibility of a different type of accident than those evaluated in the authorization basis that would have potentially significant safety consequences. The type of significant potential accidents associated with the PPS system continues to be excessive personnel exposure to accelerator produced prompt radiation; no new types of accidents are created. The proposed modifications do not affect the safety functionality of the PPS other than to remove potential vulnerabilities to a common mode failure.

6. Could the change increase the possibility of a different type of malfunction of equipment important to safety than any previously evaluated in the FSADs?

   Yes__ No _X_

   Justification: No, the proposed modifications will not increase the possibility of a different type of malfunction of equipment important to safety as evaluated in the FSADs. The proposed modifications will reduce the probability of occurrence of a malfunction of the PPS associated with a common mode failure.

VI. USI Determination: A USI is determined to exist if the answer to any of the 6 questions above (Section V) is "Yes." If the answer to all 6 questions is "No", then no USI exists.

a. Does the proposed activity (or discovered condition) constitute a USI?

__ Yes – DOE approval required prior to implementing

X No – Proposed activity may be implemented with appropriate internal review.

Kelly Mahoney, Protection Systems Team Leader, Qualified Preparer — 7-January-2016 Date

Aaron Coleman, Protection System Engineer, Reviewer — 1/8/2016 Date

David Freeman, SNS Safety Specialist, Qualified Reviewer — 1/7/2016 Date

Glen Johns, Accelerator Operations Group Leader, Reviewer — 1-7-16 Date

Hans Vogel, NScD Directorate Operations Manager, Reviewer — 1/14/16 Date

Approvals:

Kevin Jones, SNS Operations Manager or Designee — January 14, 2016 Date