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

I. Title of USI Evaluation

USI Evaluation the design and construction of the RTBT stub

II. Description of Proposed Activity:

The Spallation Neutron Source is undergoing upgrades to support an increase in the proton beam power called the Proton Power Upgrade (PPU) project. One purpose for these upgrades is to provide sufficient proton beam power to serve a Second Target Station (STS), which has already achieved CD-1 as a major construction project at ORNL. Another aspect of the PPU project that supports the STS is the construction of the Ring-to-Target-Beam-Transport (RTBT) stub. The RTBT stub will add the physical tunnel structure required to minimize the impact of STS construction while First Target Station (FTS) continues to operate. This is advantageous because it uses the long FTS outage already required for the major portion of PPU equipment installation to eliminate the need for a future FTS outage.

This USIE examines the RTBT stub shielding design and potential effects of the RTBT stub construction work on safe operation of the SNS. The addition of new accelerator tunnel introduces the need for changes to the Personnel Protection System (PPS). Radiological evaluations during design and following construction are required to ensure the design goals for shielding the accelerator tunnels are met. Mature, existing processes will be implemented to control accelerator operation while existing shielding is removed and ensure that activated materials are identified and controlled if disturbed by construction.

During the interim period when the RTBT stub has been constructed but the STS tunnels have not, the RTBT stub shielding performance must be consistent with the existing portions of the tunnel to ensure that the potential for personnel exposure outside of the accelerator tunnel is controlled. This need is first addressed by performing neutronic evaluations of the shielding design consistent with the existing tunnel shielding to validate that the design is sufficient. During construction, the physical characteristics of the shielding materials, such as density and thickness, will be monitored to ensure that the constructed tunnel section will meet the design requirements. Finally, the shielding effectiveness will be verified by performing thorough radiological surveys of the recently constructed stub and associated disturbed sections of the earthen berm.

II.A Description of RTBT Stub and Shielding Design

The RTBT stub, shown in Figures 1 to 4 below, will be an extension to the existing RTBT accelerator tunnel. The temporary stacked shielding shown in the figures serves as a barrier partitioning the stub tunnel into two areas. The upstream area will be part of the access controlled RTBT segment, and the downstream area will be treated as an occupiable area during accelerator operations. Access to this new tunnel area will be from the existing RTBT tunnel via the personnel access door shown in Figure 4. The approximate location of the two planned penetrations from the RTBT tunnel into the RTBT stub is shown in Figure 3. The area downstream of the wall will be accessible through an exterior door at the tunnel end. This area will not be access controlled by the PPS as part of the tunnel complex. Neutronic evaluation of the stacked shielding is addressed in Section II.C.

The RTBT stub will be buried in earth to provide additional shielding in a manner analogous to the earthen berm covering the existing SNS accelerator tunnel system. Neutronic analysis shows that the design thickness of the concrete RTBT stub tunnel ceiling (~70 cm) combined with the designed soil depth (~500 cm) is sufficient to meet the shielding design goals as discussed in Section II.C.

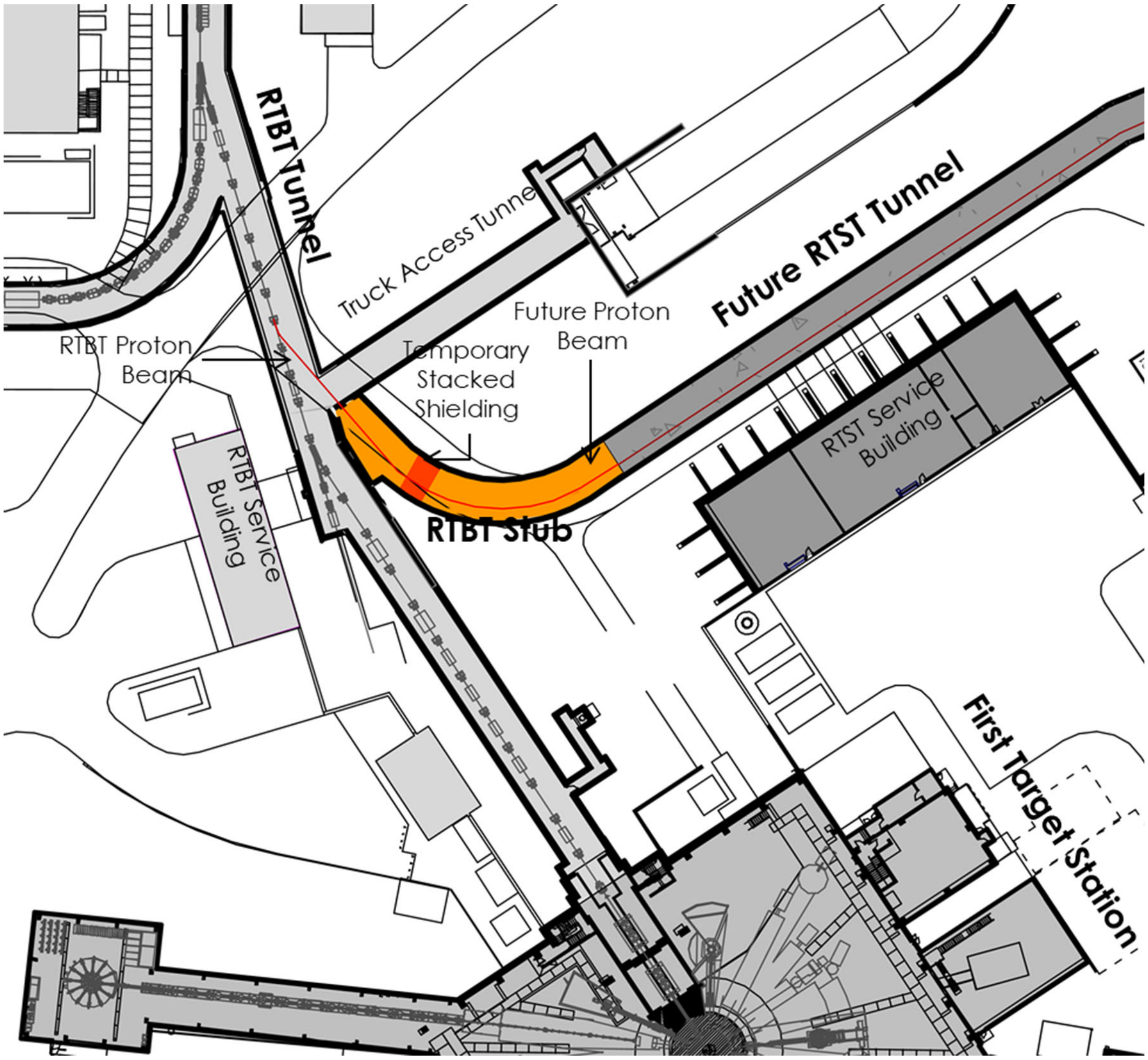

Figure 1. Overhead view of the RTBT stub location relative to existing and future structures.

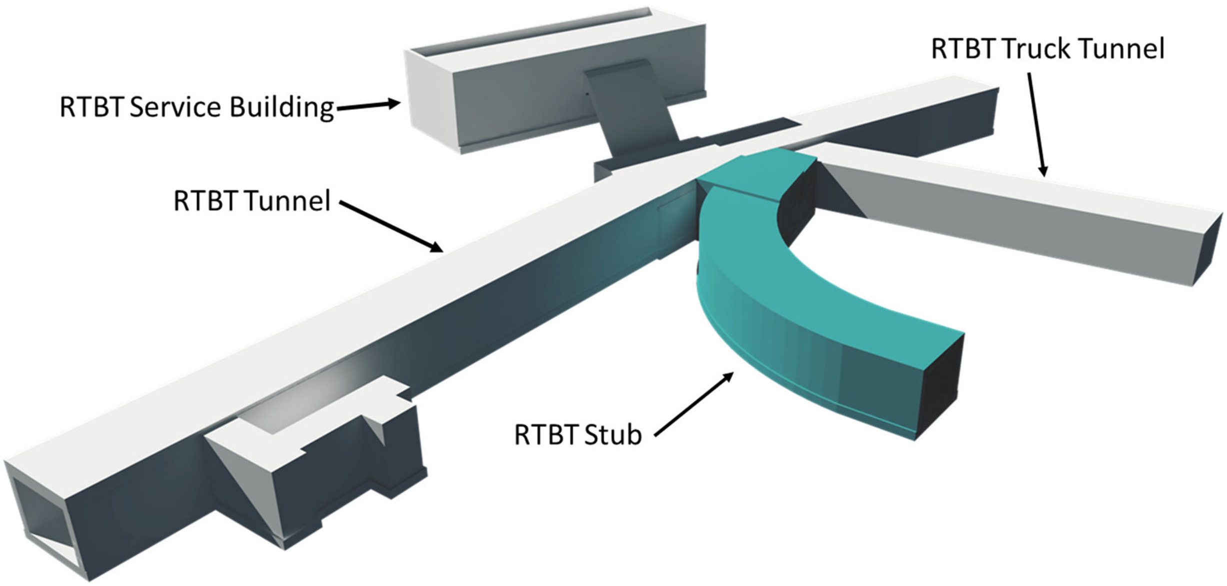

Figure 2. 3D rendering of RTBT stub with existing structures.

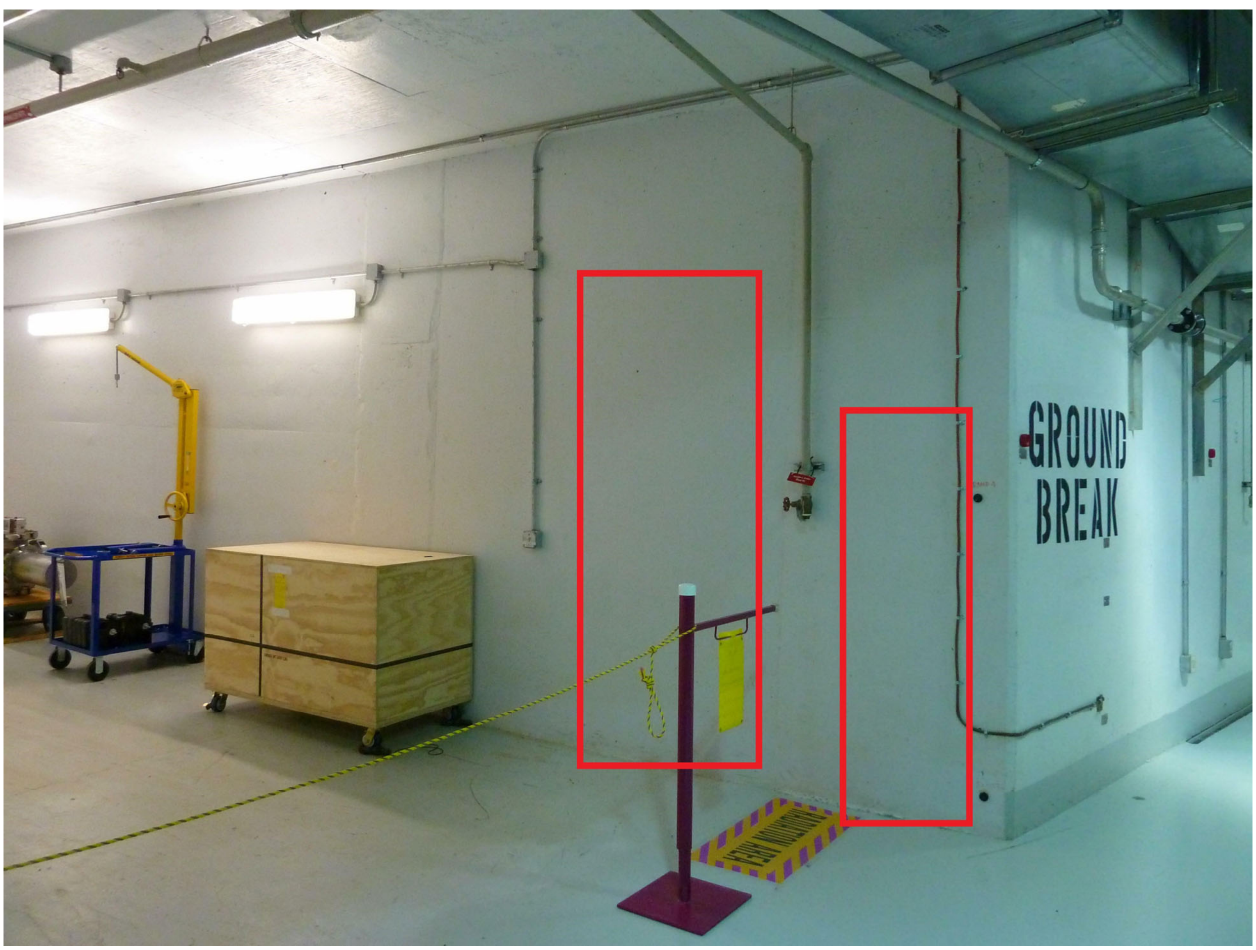

Figure 3. Approximate location of designed tunnel wall penetrations from RTBT to RTBT stub.

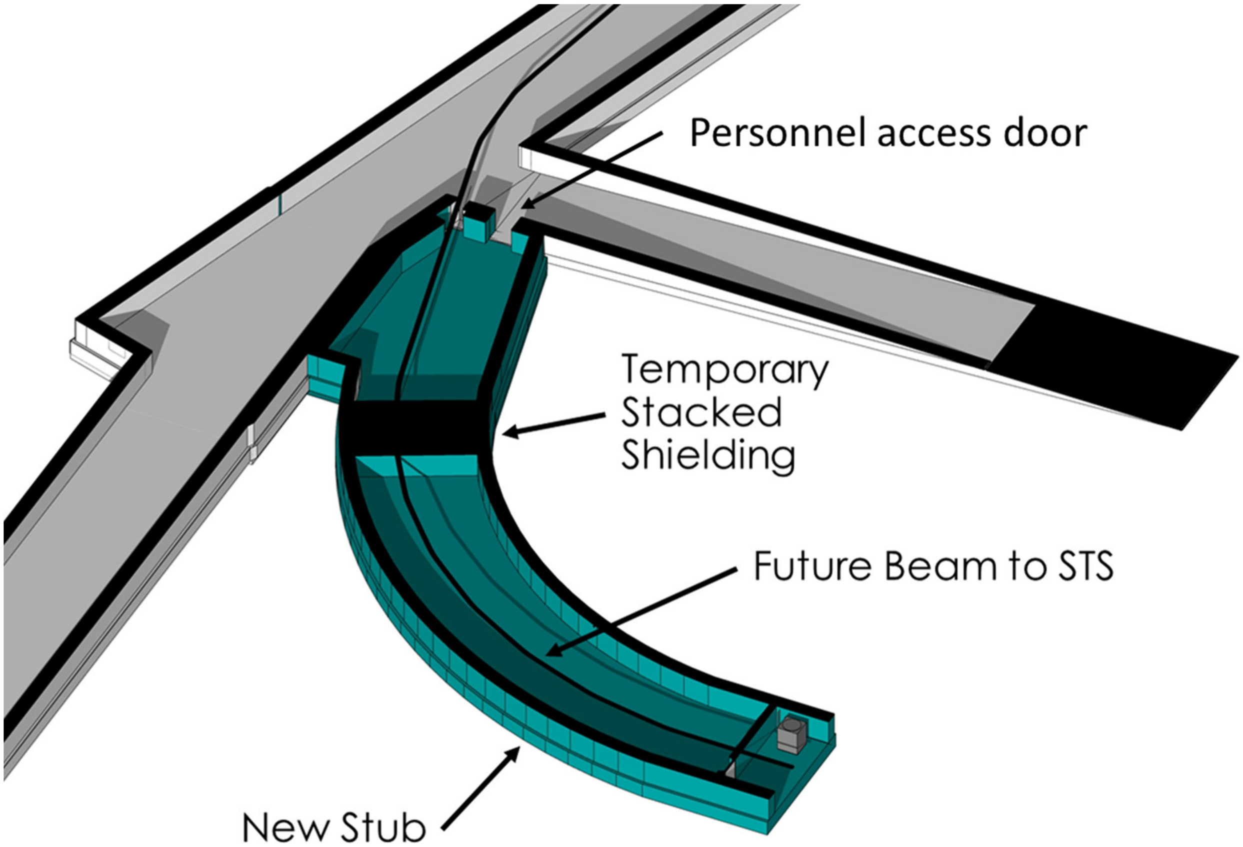

Figure 4. Cross-section of RTBT stub to illustrate internal geometry.

II.B Description of PPS Changes

With the addition of new tunnel areas, PPS modifications will be required to ensure appropriate PPS controls are in place. This will include a new interlocked area radiation monitor on the downstream side of the RTBT stub temporary stacked shielding wall, and a new Beam Shutdown Station (BSS) will be provided on the upstream side of the temporary stacked shielding to support search and life safety functions (see Figure 5). A significant portion of the hardware to support these new devices is expected to be installed prior to the construction of the RTBT stub as part of an upgrade of the RTBT segment to certified safety hardware, which will be evaluated separately. The existing cable for the interlocked radiation monitor at the RTBT Truck Entrance will also need to be rerouted to eliminate interference with the RTBT stub construction.

The temporary stacked shielding will prevent access to tunnel segments through the RTBT stub, so no additional access control functions will be required. The tunnel side of the stacked shielding will be accessible only from the RTBT tunnel and will be handled as a new part of the RTBT tunnel segment. The potential consequences to personnel accessing the RTBT tunnel side of the RTBT stub are bounded by the consequences of an access violation into the RTBT segment because there will be no beam components in the RTBT stub until after completion of the full tunnel into the STS.

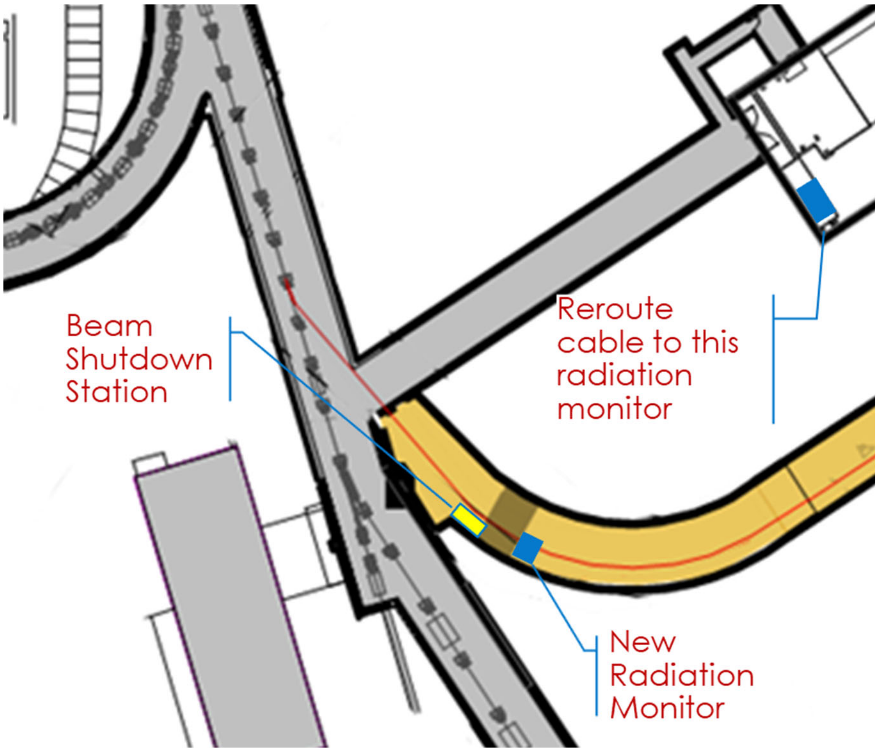

Figure 5. PPS changes supporting RTBT stub construction

II.C Description of Tunnel Shielding Neutronic Evaluations

The hazard analysis provided in the FSAD-PF relies upon shielding design. The design goal for shielding at SNS is to reduce the dose below 0.25 mrem/hr during routine operations in accessible areas with no occupancy restrictions for workers [1]. Neutronic analysis has been performed for the new RTBT tunnel configuration using the design geometry and beam loss assumptions consistent with the existing shielding design analysis [2]. This includes evaluation of three areas upstream of where the beam would split to go to the STS and downstream along each path. Evaluated beam loss conditions are normal operations (losses of 1 W/m) and point loss of the full power post-PPU beam (2.8 MW) in the RTBT DH13 magnet.

During the interim period between PPU and STS construction, a shield plug will be used to protect personnel from streaming radiation that might occur inside the RTBT stub. A neutronic evaluation was performed to size this shield plug to meet shielding design goals [3]. This shield plug was sized for a 2 MW beam since it will be removed as part of STS construction, and beam operations to the FTS are limited to 2 MW. Neutronic evaluations indicate that the potential accident dose rates outside of the RTBT stub are consistent with existing accident analysis (generally less than 20 R/hr) and thus will be sufficiently mitigated by use of interlocked area radiation monitors consistent with the existing tunnels. The maximum dose rate estimated on the earthen berm (18.5 feet of combined concrete and soil) of the RTBT stub is 5 R/hr [2]. The analysis of the RTBT temporary stacked shielding shows that 540 cm of shielding will reduce the worst-case spill scenario to 11 R/hr.

II.D Construction Activities

Installation of the RTBT stub tunnel will require major construction and direct connection to the existing accelerator tunnel structure. This includes large scale excavation of the RTBT berm and surrounding soil to allow construction of the stub tunnel. Portions of the existing RTBT tunnel wall will be removed (see

Figure 3) to accommodate the STS beam pipe penetration and a personnel door to provide access to the upstream portion of the stub. These activities introduce several risks. Measures are needed to ensure that the design configuration of existing shielding is either not disturbed or restored to no less than the minimum thickness and density. Radiological monitoring is also necessary to ensure that any activated materials, primarily soil and concrete, are either undisturbed or controlled. Finally, personnel hazards common to construction activities (standard construction hazards) must be managed.

II.D.1 Radiological Monitoring During Construction Activities

Operation of the proton accelerator has the potential to generate high neutron fluence in localized areas that can lead to activation of shielding materials. To facilitate planning, radiological sampling has been performed to evaluate the profile of accessible shielding materials [4]. The sampling indicated no detectable amount of activation in either soil or concrete, so it is not expected that removed concrete or soil will need to be controlled due to activation. However, radiological monitoring will still be performed throughout the deconstruction activities associated with the RTBT stub construction, such as cutting of existing RTBT tunnel concrete. If activation is detected, the affected materials will be handled per SBMS requirements consistent with the level of activation that is discovered to ensure safety of workers and the environment.

II.D.2 Shielding Configuration Control and Beam Containment

Temporary or permanent reconfiguration of radiation shielding is common during operational outages of the SNS so that normally inaccessible components can be accessed for activities such as inspection, maintenance, repair, and replacement. A robust administrative process has been developed for accelerator beam containment and to maintain configuration control of radiation shielding through OPM Section 2.H-7 *Radiation Shielding and Barriers* [7] and supplemented by OPM Section 2.H-13 *Hold for Radiation Safety (RS Hold)* [8]. This process will be implemented to control beam operations during the construction of the RTBT stub. Once construction is complete, the new shielding configuration, including the temporary stacked shield stub wall, will be incorporated into these processes.

The existing shielding of the RTBT tunnel has been demonstrated to be effective over the operational history of the SNS. Once construction activities are complete, shielding issues identified by operational surveys could require expensive and invasive remediation, so verifying the shielding configuration frequently throughout the construction process, such as confirming concrete form dimensions prior to pouring and evaluating concrete density for each batch, provides the most efficient way to meet shielding requirements.

The Quality Assurance (QA) function of the PPU project has been engaged to implement controls to ensure the key deliverables are obtained. This will be accomplished through the use of an Acceptance Criteria Listing (ACL) that specifies the required delivered condition and will be used to document satisfaction of each of these critical requirements. The requirements to be satisfied include concrete density, tunnel wall and roof thickness, soil density, and soil thickness verification within the RTBT and RTBT stub shielding zone. For each characteristic, the installed material must meet the specification in the associated approved drawing. Testing and inspection requirements have been incorporated into lower-level specifications to check and monitor these parameters before, during, and after key construction activities. QA requirements are incorporated in the Project Manual from CannonDesign [9].

QA will evaluate all non-conforming (NC) conditions identified throughout the construction process. This evaluation brings together key stakeholders in the design and operation and considers the potential impacts of the NC. Based upon stakeholder input, QA will determine the appropriate response to each NC with possible outcomes such as “accept as-is” and “rework”. In the case of a shielding NC, neutronics

SMEs, the RSO and Radiation Safety Committee would be engaged as appropriate for the severity of NC to determine an appropriate response. A shielding NC may or may not be evaluated using the USI process as deemed appropriate based upon the potential impacts.

The final means of verifying shielding effectiveness is by radiological survey of affected shielding during beam operations. Procedures are in place to direct the performance of these surveys. One procedure is designed to evaluate shielding in new or modified beam areas [5]. Another procedure also directs surveys to evaluate shielding effectiveness when new operating parameters are introduced [6]. The procedures include taking surveys while beam power is ramped then extrapolating the results to full beam power. This way, the defined limits are not exceeded during testing. These procedures will be used together to develop a survey plan to verify shielding performance during initial beam operations following installation.

II.D.3 Standard Construction Hazards

The PPU project is fully integrated into ORNL processes including institutional programs for the management of safety. The PPU approach has been to implement ORNL programs, promulgated via SBMS, rather than develop separate programs. This has proven highly efficient, as ORNL is a mature institution with well-developed systems to manage the various hazards commonly encountered during construction projects at a large research institution, and many of the PPU project staff are already familiar with the ORNL processes.

The SBMS process for managing the construction hazards associated with the RTBT stub falls within the Worker Safety and Health management system [10] which flows down requirements into the "Purchasing Goods and Services" subject area [11]. This requires the construction subcontract to include a Job Hazard Analysis (JHA) which invokes the worker safety and health measures needed to address the evaluated hazards. These measures are incorporated into the construction contract using pre-defined clauses to ensure they are a binding requirement for the subcontractor. Safety and health requirements, including those listed above, are wholly contained in the ORNL/Chestnut Ridge Facilities ES&H Plan [12]. This process has proven effective at SNS for ensuring proper worker safety and health practices by construction subcontractors.

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. If so specify the applicable FSAD and relevant sections.

Yes, a description of the new tunnel structure will need to be added in FSAD-PF Section 3.2.4.1.3, *Building 8200 – Accelerator Tunnels*, Section 3.2.4.1.3.4 *Building 8200 – RTBT Tunnel*. The FSAD-PF discusses the PPS in Section 3.2.3 *Accelerator Safety System* and Section 5.2.1 *Personnel Protection System*, but the changes described here are beyond the level of detail addressed in the FSAD-PF content. Estimated dose rates under accident conditions should be incorporated as appropriate in the accident analysis of Section 4.

IV. Does the proposed activity or discovered condition affect any of the requirements of the ASE. If so, list the affected sections.

No, the PPS is addressed in Section 3.2 of the ASE, but the ASE does not address the system components at the level of detail described here.

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 RTBT stub will not introduce any new access to existing tunnel segments, and additional PPS equipment will be installed to support search of the new area introduced by the RTBT stub in a manner consistent with the existing accelerator tunnel segments. Operation of the beam will be controlled during construction activities consistent with existing OPM procedures. None of these changes affect the probability of an existing accident. Therefore, construction of the RTBT stub and subsequent operation do not significantly increase the probability of any accident evaluated in the FSADs.

2. Could the change significantly increase the consequences of an accident previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:
   No, construction of the RTBT stub does not introduce any changes to operational parameters, such as beam power, that would affect the severity of an accident. As discussed in Section II.B, the shielding design ensures that there is not a significant change to the radiation levels outside the beam enclosure during normal operations or accident conditions. Therefore, construction of the RTBT stub and subsequent operation do not significantly increase the consequences of any accident evaluated in the FSADs.

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 PPS changes discussed are consistent with the existing PPS design and best practices of safety system design and will be further evaluated upon completion of final design. High reliability components from reputable vendors will be used, including safety-rated components when appropriate. The design of the RTBT stub does not introduce any conditions or situations that could increase the probability of failure of the PPS. Therefore, the construction of the RTBT stub and subsequent operation do not significantly increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the FSADs.

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, it is assumed that a malfunction of equipment important to safety provides no mitigation for associated accidents. Therefore, full unmitigated accident consequences are assumed for a CEC malfunction. Since construction of the RTBT stub and subsequent operation do not have an impact on the unmitigated consequences of associated accidents, the proposed change does not significantly increase the consequences of a malfunction of equipment important to safety.

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 design and construction of the RTBT stub is consistent with existing tunnel segments. No new hazards or accident scenarios are introduced. All credible accident scenarios associated with the RTBT stub are adequately addressed by existing accident analysis, and the associated additions to the PPS will ensure that all credible accidents are appropriately mitigated. Therefore, the construction of the RTBT stub and subsequent operation do not create the possibility of a different type of accident than any previously evaluated in the FSADs.

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 expected changes to the PPS are consistent with the existing design of the PPS and do not introduce the possibility for new failure modes. No other equipment important to safety is affected by this change. The design of the RTBT stub does not introduce any new conditions or situations that could introduce new failure modes in the PPS. Therefore, the construction of the RTBT stub and subsequent operation do not increase the possibility of a different type of malfunction of equipment important to safety.

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.

JACOB PLATFOOT (Affiliate) Digitally signed by JACOB PLATFOOT (Affiliate) Date: 2021.08.30 13:03:28 -04'00'

Jacob Platfoot, Qualified Preparer — Date

Mark Connell Digitally signed by Mark Connell Date: 2021.08.30 13:09:02 -04'00'

Mark Connell, Level 2 Manager for Conventional Facilities — Date

Evans, Nicholas J. Digitally signed by Evans, Nicholas J. Date: 2021.08.30 14:03:33 -04'00'

Nick Evans, Level 2 Manager for Ring Systems — Date

Digitally signed by Freeman, David W. Date: 2021.08.30 14:28:20 -04'00'

David Freeman, Qualified Reviewer — Date

Mark Champion Digitally signed by Mark Champion Date: 2021.09.07 10:21:55 -04'00'

Mark Champion, PPU Project Manager — Date

Approvals:

Fulvia Pilat Digitally signed by Fulvia Pilat Date: 2021.09.07 16:53:19 -04'00'

Signature of SNS Operations Manager or Designee — Date

References

1. *Spallation Neutron Source Final Safety Assessment Document for Proton Facilities*, 102030103-ES0018-R02, December 2010.
2. *Soil Thickness above RTBT/RTST for Proton Power Upgrade Condition*, 106100200-DA0110-R00, October 2019.
3. *Shielding Plug for RTBT Stub*, 106100200-DA0113-R00, October 2019.
4. ORNL Radiological Survey, SNS-522350, performed 23 October, 2019.
5. *Fault Study Preparation Guidelines and Fault Study Procedure for Primary and Secondary Beam Areas*, SNS OPM 2.H-16, Revision 1, August 2019.
6. *Requirements for Radiological Survey for New Operating Parameters*, OPM 2.H-7.5, Revision 2.1, January 2021.
7. *Radiation Shielding and Barriers*, OPM 2.H-7, https://ns-staff.ornl.gov/operations/SNS-OPM_Folder_Tree/index.html.
8. *Hold for Radiation Safety (RS Hold)*, OPM 2.H-13, https://ns-staff.ornl.gov/operations/SNS-OPM_Folder_Tree/index.html.
9. *PPU-RTBT Stub Preliminary and Final Design – Project Manual*, CannonDesign, PPUP-600-TS0005-R00, July 11, 2019.
10. *Worker Safety and Health Program*, Oak Ridge National Laboratory Standards Based Management System, https://sbms.ornl.gov/sbms/sbmsearch/progdesc/wsh/pd.cfm, Revised July 7, 2021.
11. *Purchasing Good and Services* Subject Area, Oak Ridge National Laboratory Standards Based Management System, https://sbms.ornl.gov/sbms/SBMSearch/SubjArea/Procurement/ProPurch.cfm, Revised June 26, 2020.
12. *Oak Ridge National Laboratory/Chestnut Ridge Facilities Project Environmental, Safety, and Health Plan*, 102030000-ES0007-R08, September 2020.