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

I. Title of USI Evaluation:

USI Evaluation of Core Vessel Insert Leak Rate

II. Description of Proposed Activity (or discovered condition) (use attachments if necessary):

This USI Evaluation assesses the impacts of the measured leak rate of the recently installed Beam Line 9 Core Vessel Insert (CVI) which is significantly higher than the engineering design specification. This evaluation shows that although the leak rate is well above the engineered design specification, the seal does not significantly impact the overall Core Vessel leak rate or its ability to perform its credited safety confinement function.

Background

The Core Vessel serves the credited safety function of confining mercury and mercury vapor following an accident that breaches the target vessel allowing mercury and cooling water to spill into the Core Vessel. The Core Vessel has a number of connections that introduce leakage including the 18 neutron beam windows (Core Vessel Inserts with integral beam windows and Core Vessel metal seals), the target and proton beam window inflatable metal bellows seals, the Core Vessel lid (double elastomeric o-ring seal) and the Core Vessel drain line. Each connection leaks at some rate. Leakage from the various connections to the Core Vessel is manifested in the form of air in-leakage into the vessel during nominal SNS operations where the vessel is run in a helium atmosphere at ~ 650 Torr. Individual seal leakage contributions to the overall core vessel leak rate are not a safety concern provided the overall core vessel leak rate is acceptable.

In the event of an accident resulting in spilled mercury, contaminated atmosphere is confined within the Core Vessel. Any out leakage from the Core Vessel would go into the Service Bay and into the monolith bulk shield liner. Leakage into the Service Bay is not a concern as it is specifically designed to confine target liquid/vapor leakage. Any vapor leakage into the monolith bulk shield liner 1) could migrate to the Shutter Drive Equipment Room (SDER) and 2) shielding components could be contaminated thus complicating future handling. Potential Core Vessel seal leak paths into the bulk shield liner include all of the Core Vessel Inserts, the core vessel lid, and the proton beam window. The monolith bulk shield liner and SDER are normally swept by the PCE system and entry into the SDER is prohibited during beam to target on operations.

Figure 1 below shows the CVI, PBW, Target, and Core Vessel Lid interfaces. Figures 2 and 3 show schematic depictions of the Core Vessel within the monolith.

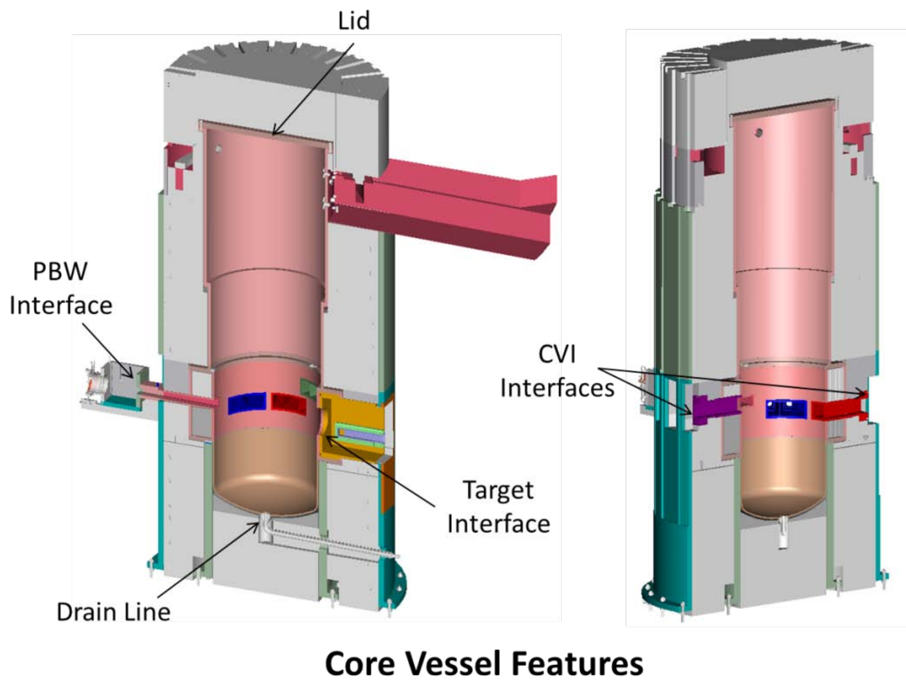
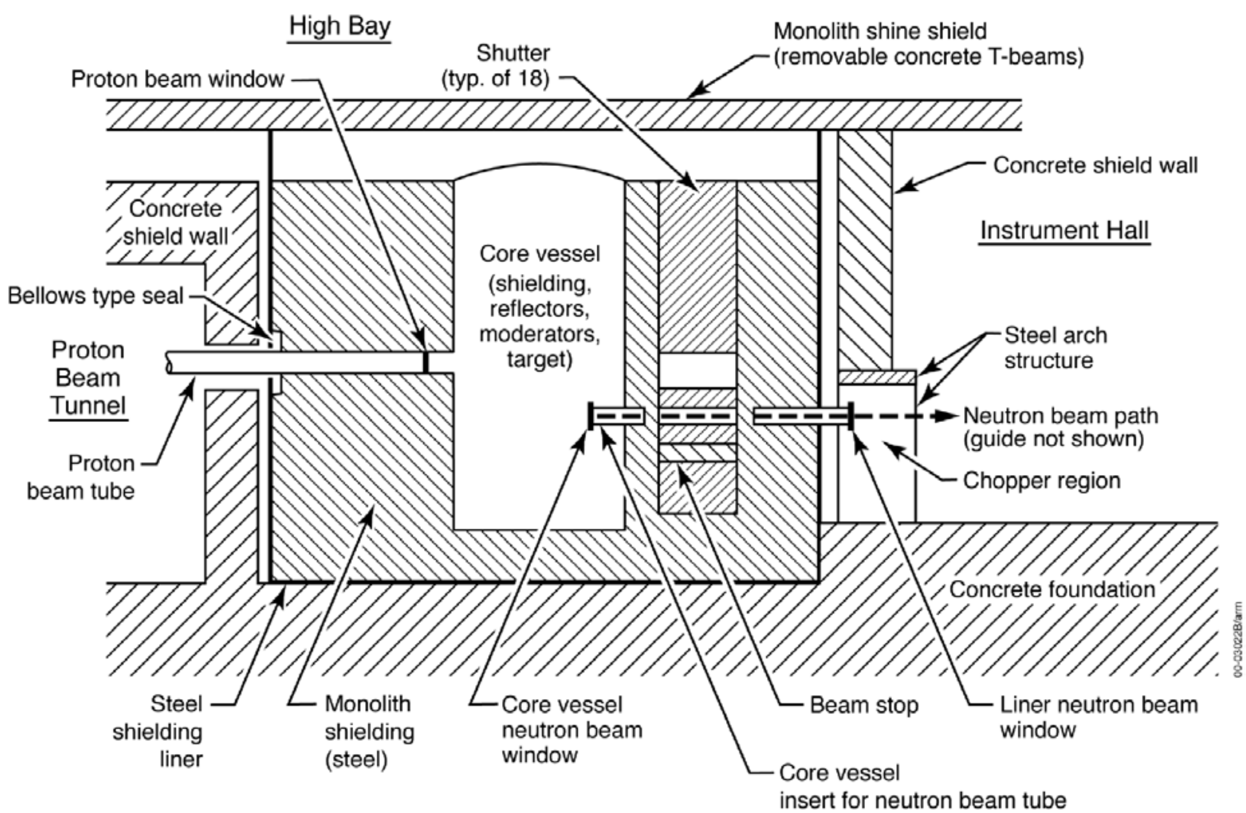


Figure 1. Core Vessel Features



Note: The schematic cross-section above was selected to show the proton beam tube and a typical neutron beam path. The angle between the proton beam tube and the neutron beam path shown above is about 120°.

Figure 2. Schematic depiction of Core Vessel within monolith.

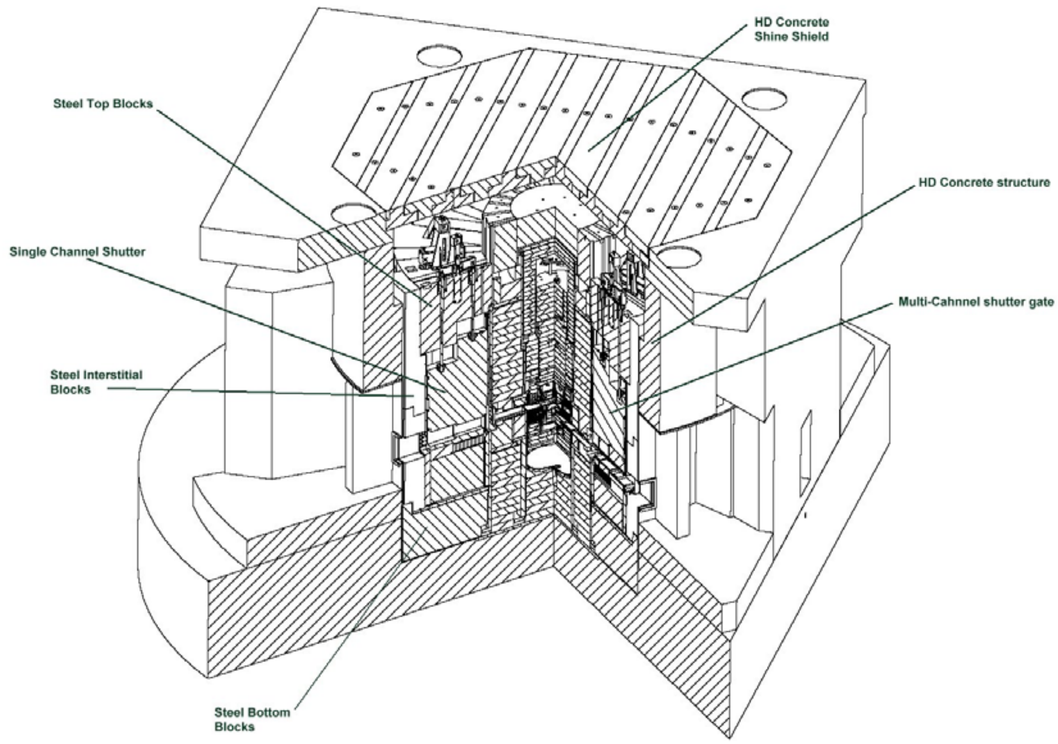


Figure 3. Depiction of Core Vessel within monolith

Core Vessel Leak Rate

The original Core Vessel vacuum system design document[1] defined and calculated many parameters associated with the SNS Core Vessel pressure environment. These parameters included total gas load to be overcome by the vacuum system, pump down times, etc. The total design leak rate of the Core Vessel was calculated in this document to be .051 Torr-L/s.

Many Core Vessel leak rate (rate of rise) measurements have been performed over the years to enable trending of the overall Core Vessel leak rate following component replacements, etc. The results of these measurements range from 9 mTorr/hr to 20 mTorr/hr with an average rate of rise of 12.5 mTorr/hr. Given the 12.5 mTorr/hr rate of rise and assuming a Core Vessel volume of 5125 Liters, the following average measured leak rate can be found:

$$12.5\frac{mtorr}{hr}\cdot\frac{hr}{3600sec}\cdot\frac{torr}{1000mtorr}\cdot 5125liters = \ 0.0178\frac{Torr-L}{s}$$

The average measured leak rate is about 35% of the 0.051 Torr-L/s baseline design leak rate.

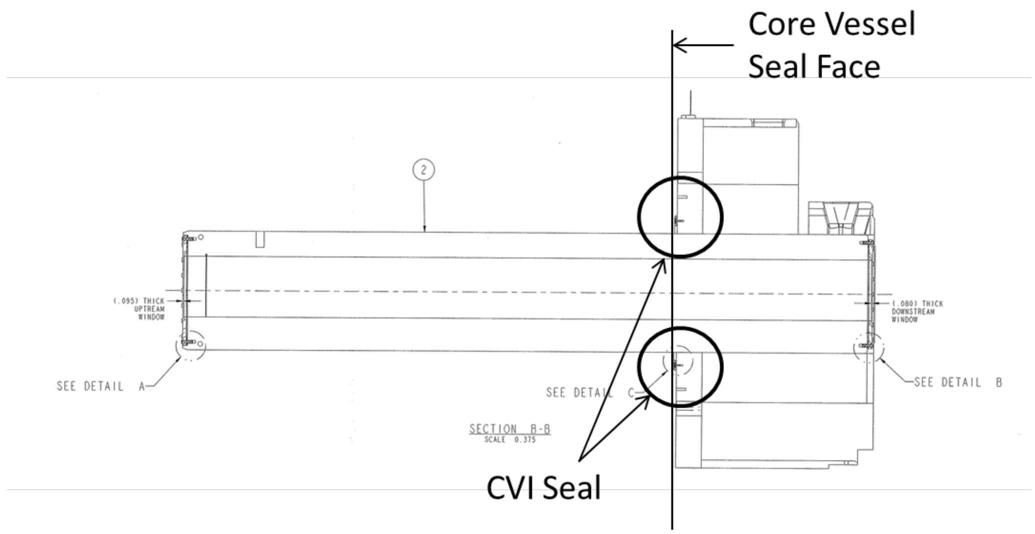
CVI Seal Leak Rate

Rate of rise leak testing of the double metal o-ring seal on the BL 9 CVI following recent installation has revealed a rate of rise of approximately 3.9 Torr/hr (measurement performed 6-26/27-2013)[2]. This leak

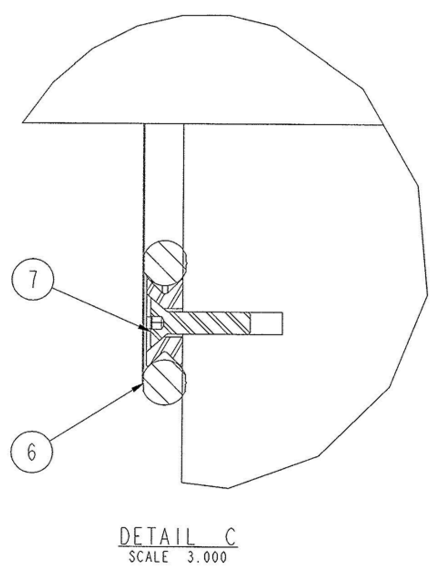
[1] Core Vessel Vacuum System, SNS106060000-DA0022-R00, December 10, 2001
[2] BL 9 Core Vessel Insert Leak Rate Discussion, email attachment from Mike Dayton to David Freeman, July 10, 2013 at 3:15 pm.

rate is ~ 2 orders of magnitude greater than the engineer design leak rate[3] for CVI seals of 50 mTorr/three hour (~.017 Torr/hr).

The following figures depict the CVI configuration and seal detail.



BL 9 CVI Seal Configuration



CVI Seal Detail

3 Process Specification Installation of Core Vessel Inserts (As-Built) Experimental Facilities Instrument Systems, WBS 107030600, Section 3.4.1, Item 29, 107030600-TS0002-R04, SNS October 2004.

Given the BL 9 seal leak detection volume (the interstitial volume of the CVI metal seal and the tubing utilized to enable leak detection) of .552 liters (reference Table 1 of SNS 107030600-II0002-R04), the leak rate can be calculated:

$$L = \frac{(3.9\,Torr)(.552\,liters)}{3600\,sec} = 5.98x10^{-4}\,\frac{Torr - L}{s}$$

The CVI leak rate for BL 9 seal is only about 1% of the Core Vessel engineer design specification of 0.51 torr-liter/sec.

The Core Vessel leak rate following BL 9 CVI installation was measured to be 9 mTorr/hr which corresponds to the lowest of the previously measured values that ranged from 9 to 20 mTorr/hr. Therefore, the BL 9 CVI seal leak rate does not significantly impact the overall Core Vessel leak rate.

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.

The Core Vessel (including Core Vessel insert, neutron beam window, etc.) is addressed in the following sections of the FSAD-NF:

3.3.2, Core Vessel and Internals
3.3.13.3, Core Vessel Inserts
4.3.4, Hg Offgas treatment/Core Vessel
4.3.8, Core Vessel General Scenarios
5.2.3, Target Service Bay/Core Vessel Fire Barrier – Isolation Function
5.2.4, Target Service Bay/Core Vessel Fire Barrier – Two-Hour Equivalent Fire Barrier
5.2.8, Core Vessel (w/ rupture disk) and Neutron Beam Windows

Details of the very low leak rate levels associated with seals are not addressed and do not need to be addressed in the FSAD-NF. No changes to the FSAD are warranted based on this analysis.

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

The Core Vessel is addressed in the ASE Appendix 1 *Passive Credited Engineered Controls* in the following sections:

Appendix 1, Section 3 Service Bay/Core Vessel Fire Barrier
Appendix 1, Section 4, Core Vessel with Rupture Disk and Neutron Beam Windows

Details regarding the very low leak rates associated with vessel seals are not addressed and do not need to be addressed in the ASE. No changes to the ASE are warranted based on this analysis.

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:

The Core Vessel is a Credited Engineered Control (CEC) credited with mitigating accidents that involve releases of radioactive mercury/cooling water into the Core Vessel. The probability of occurrence of accidents that credit the Core Vessel confinement safety function are unchanged, regardless of Core Vessel leak rates.

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

   The unmitigated consequences of accidents that credit the Core Vessel confinement function are unchanged by Core Vessel or CVI leak rates. Mitigated accident consequences would be a function of the overall Core Vessel leak rate which has been shown to not be significantly impacted by the CVI 9 leak rate. Individual seal leakage contributions to the overall core vessel leak rate are not a safety concern provided the overall core vessel leak rate is acceptable. The Core Vessel leak rate following BL 9 CVI installation was measured to be 9 mTorr/hr which corresponds to the lowest of the previously measured values that ranged of 9 to 20 mTorr/hr and is well within the overall Core Vessel leak rate design specification. Therefore, the BL 9 CVI seal leak rate does not significantly impact the overall Core Vessel leak rate.

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:

   The probability of occurrence of a malfunction of the Core Vessel confinement function is unchanged by the minor increase in observed CVI leak rate. The Core Vessel insert is secured to the Core Vessel by four large studs with a preload of ~32,000 lbs per stud ensuring no significant movement.

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:

   The consequences of a malfunction of the Core Vessel confinement function are unchanged.

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 new type of accident is created by operating with the elevated Core Vessel insert leak rate

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:

The possibility of a new or different type of malfunction of equipment is not increased by operating with a the Core Vessel insert leak rate. The overall Core Vessel leak rate remains well below design specification and falls with normal measurements over history of SNS.

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.

____ ____________

David Freeman, Qualified Preparer Date

____ ____________

Mike Harrington, Qualified Reviewer Date

____ ____________

Mike Dayton, Remote Handling Engineer Date

____ ____________

Danny Williams, System Engineer for Core Vessel Confinement Function Date

____ ____________

Mike Baumgartner, Mechanical Systems and Operations Group Leader Date

Approvals:

____ ______________

Signature of SNS Operations Manager or Designee Date

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.

David Freeman, Qualified Preparer	July 16, 2013 Date
Mike Harrington, Qualified Reviewer	7-18-2013 Date
Mike Dayton, Remote Handling Engineer	7-18-2013 Date
Danny Williams, System Engineer for Core Vessel Confinement Function	7-18-2013 Date
Mike Baumgartner, Mechanical Systems and Operations Group Leader	7/18/13 Date

Approvals:

for Kevin Jones Signature of SNS Operations Manager or Designee	7/18/13 Date