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

I. Title of USI Evaluation

USI Evaluation for increasing allowable target gas injection flow to 10 SLPM contingent on continued stable behavior.

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

This USIE evaluates the conclusions of the GI3 Safety Assessment Supplement (SAS) [1] and succeeding internal note [2] and USIE [3] in light of 2 years of experience with target gas injection at flow rates below 2 SLPM to determine the safety implications of continuing increases in gas injection via inlet orifice bubblers (IOBs) up to a nominal injection rate of 10 SLPM. The SAS originally evaluated a nominal flow rate of 1 SLPM with off-normal flowrates up to ~3 SLPM. The succeeding documents focused on changes to the IOBs, allowing up to 2 SLPM of nominal injection without any changes to the off-normal scenarios. However, further increases require changes to the gas supply system that will impact a larger portion of the existing safety analysis, including off-normal scenarios.

The proposed changes being evaluated are:

- Replacement of the pressure control valve (PCV-3241) and flow meter (FE-3235) in Gas Panel 9 with new hardware capable of delivering and measuring flow rates up to 10 SLPM at 100 psig.
- Update of interlock and alarm setpoints supporting target gas injection to be consistent with increased system capacity.
- Allowance to utilize the testing procedure [4] to continue increasing gas injection rate in a deliberate, step-wise manner per the requirements described here and identify unexpected mercury loop behaviors that might require further evaluation through the USI process.

Since the SAS was issued in 2017, experience operating with target gas injection has alleviated many of its concerns, which were largely founded in uncertainty stemming from a lack of operational experience. In all observed cases, target gas injection has shown itself to have predictable and mild impacts on mercury loop operation. Three major concerns were identified in the SAS: accumulation of large amounts of gas, shedding gas pockets, or drifting of TPS instruments. Experience thus far indicates that none of these is a serious concern for safe operation of the mercury process loop. Each of these will be addressed in more detail below.

The procedure [4] implemented to test and validate loop behavior for incremental increases in gas injection flow has been exercised and improved, enforcing a deliberate development process and building a body of evidence and data vital to evaluating future increases. This procedure was designed to specifically evaluate the major concerns identified in the SAS and broadly evaluate other impacts on target systems. Continued increase in target gas injection flow is contingent upon the continued use of this process to investigate loop behavior at incremental steps and evaluate whether mercury loop behavior has changed such that the safety evaluation needs to be revisited.

The SNS Operations Envelope (OE) [8] enforces limitations on target gas injection in Section 5.28. The Normal Operating Value represents the highest value of target gas injection that is allowable during normal mercury loop operation based upon completion of testing in accordance with [4] and the authorization of the SNS Operations Manager. The OE Limit is based upon the parameters that have been evaluated for the safety of workers, the public and environment through the USI process and provides the maximum level of target gas injection that may be tested without first performing additional safety analysis. This limit is also approved by the SNS Operations Manager through the approval of a USI Evaluation. Completion of this USI Evaluation will allow the OE Limit to be increased to 10 SLPM.

Additionally, unforeseen events [5] resulted in the prompt injection of a large, high pressure helium bubble into the mercury process loop. The most severe consequences anticipated to result from gas injection involved the release and rapid expansion of a trapped helium bubble that forced mercury out of the Service Bay via the MOTS loop seal. Estimates of the size of the helium bubble that was actually injected into the loop indicate that the observed event bounds any credible event resulting from target gas injection. The mercury loop transient following helium bubble injection had two outcomes that are ultimately positive for increased target gas injection. First, vulnerability of the helium supply lines to high mercury level in the mercury pump tank was identified and addressed. Second, the controls credited in the SAS to protect the MOTS loop seal were demonstrated to be effective, completely preventing any mercury from reaching the MOTS GLS. This provides strong evidence that the control set now in place is an effective mitigation strategy for any unexpected mercury loop behavior that may result from increased target gas injection.

II.A Summary of Observations and Conclusions from Gas Injection Experience to Date

Target gas injection has now been used in the operation of six targets across more than two years. A comprehensive evaluation of experience gained throughout this period is provided in Reference [6]. Throughout this period gas injection has been demonstrated to significantly reduce cavitation damage and reduce strain of the mercury target. Limited amounts of gas accumulation have been observed, well below the values assumed in the SAS [1]. No transient increase in mercury pump tank level associated with the release of larger gas pockets has been observed when the pump is stopped. Other than an initial rise in pump tank level that mostly occurs during the first hour of gas injection operation, no further gas accumulation is observed. Finally, there has been no observed effect on TPS instruments. Thus, it is anticipated that gas injection rate could be increased without adverse impacts on safe operation of the mercury process loop.

II.A.1 Accumulation of Gas in the Mercury Process Loop

Each time gas injection rate has been increased, the process loop response has been characterized prior to beam operations in accordance with Reference [4]. One part of this process is to evaluate the total rise in pump tank level resulting from gas injection, presumably due to accumulation of gas in the loop. The results of this process are summarized in Table 1 and Figure 1 below. At low injection rates, the total displacement has been small and predictable. The largest displacement seen, T24, translates into a pump tank level rise of 1.2% with substantial headspace remaining in the tank.

Table 1. Volume of Mercury Displaced for Each Target (Ref. [6]).

Date	Target	Design	Gas Injection Rate	DP	Q_{Hg}	Volume Displaced
10/25/2017	T18	Jet-Flow	0.45 SLPM	35.3 psid	250 GPM	1.7 L
12/20/2017	T18	Jet-Flow	0.25 SLPM	22.3 psid	203 GPM	3.8 L
05/14/2018	T19	Jet-Flow	0.40-0.57 SLPM	34.8 psid	255 GPM	2.2 L
08/20/2018	T20	Jet-Flow	0.50 SLPM	34.4 psid	258 GPM	1.7 L
01/11/2019	T21	Original	0.86 SLPM	30.0 psid	293 GPM	2.7 L
06/20/2019	T22	Blue	1.0 SLPM	30.1 psid	290 GPM	3.2 L
10/29/2019	T24	Jet-Flow	1.7 SLPM	34.3 psid	259 GPM	5.6 L

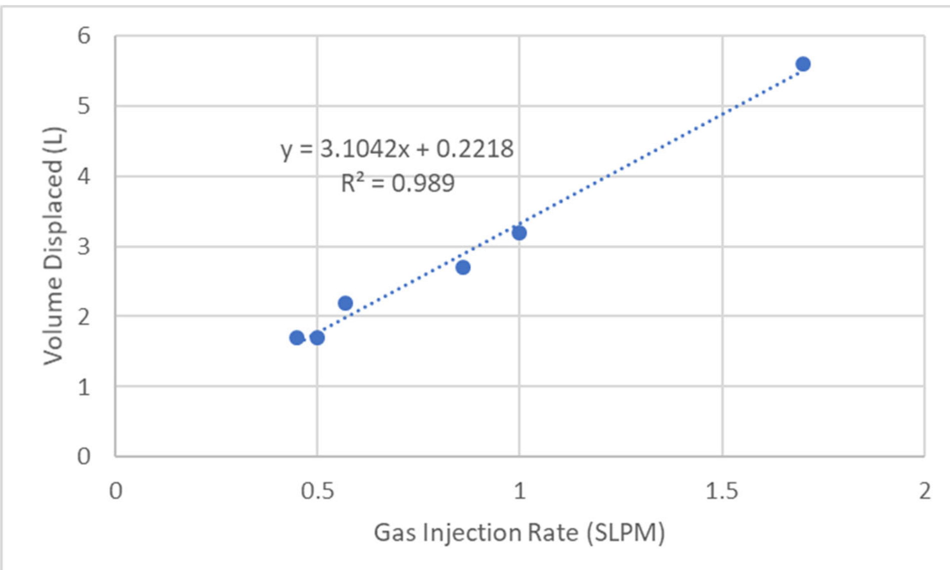

Figure 1. Plot of Gas Injection Rate v. Volume Displacement (Ref. [6])

Although the observed data points are roughly linear, it is expected that accumulation will flatten as gas injection rate is increased further since locations where the gas accumulates will eventually saturate. Extrapolation of the available data conservatively estimates 31 L of displacement at 10 SLPM, which is well within the capacity of the pump tank (~80 L at 86% level). Effort has been invested in attempting to bound the potential accumulation of gas in the mercury process loop by systematically evaluating the physical constraints in the various locations throughout the loop. The results of this effort are documented in Reference [7], which conservatively estimates the maximum displacement of 67.9 L. Sufficient headspace is available for this amount of accumulation in the mercury pump tank for initial levels below about 88%.

In any credible case, the accumulation of gas in the loop is expected to mostly occur over a period on the order of an hour. A procedure [4] is in place to ensure that loop behavior is carefully monitored during initial operations with an increased flow rate. The procedure specifies limits in pump tank level rise with responses and hold points if these limits are exceeded. Unpredicted behavior due to increased gas flow would be identified during this process, and operator action can easily ensure that loop operations remain within normal bounds by controlling or stopping the gas injection rate. Although no effects have ever been observed that manifest over a period of days or longer, a prudent approach to higher injection rates would include an extended period of operation at a moderately increased gas flow rate before further increases as described in Section II.A.4 below.

II.A.2 Gas Pocket Shedding

As discussed in Section 4 of [6], no evidence of "shedding" behavior has been observed in the SNS mercury loop. "Shedding" is a behavior in which pockets of gas accumulate in the loop and release suddenly resulting in a transient rise and then prompt drop in mercury pump tank level. Preliminary gas injection testing at the Target Test Facility (TTF) showed this as a possibility under conditions of high gas flow of large bubbles with a low pump speed (280 RPM). However, the normal operating value for pump speed in the Operations Envelope [8] is 350±5% RPM, and "shedding" behavior has not been observed at this higher pump speed. Additionally, certain features of the TTF loop are non-prototypic of the SNS loop and could have significantly contributed to the observed shedding behavior. If operation at a lower pump speed is desired, the new operational parameters would have to be updated in the OE which requires testing using Reference [4] to ensure no unusual loop response is observed, such as "shedding". Although this behavior is not expected to occur, confirmation of this expectation is central to performance of Reference [4], which enforces continued vigilance.

II.A.3 Impacts on TPS Instruments

Another focus of Reference [4] is verification that gas injection has no adverse effects on the operability of the credited Target Protection System (TPS) differential pressure sensors. These sensors are used to ensure that the mercury target module has sufficient mercury flow to prevent boiling of target mercury which could lead to a target failure with significant consequences. A pump curve is generated prior to any gas injection to characterize loop behavior with the installed target. This is repeated several times after gas injection operation to ensure that the characteristic curve has not significantly shifted, which could indicate a change in detector performance. The redundant sensors are also compared against one another. This process will ensure that any new impacts on TPS sensors are quickly identified. If impacts are seen, draining and refilling the mercury process loop is expected to restore the sensors to normal operation.

II.A.4 Gas Injection Testing Procedure

As part of Gas Injection Initial Implementation (GI3), a testing procedure [4] was developed to formalize the process used to evaluate the impacts of gas injection on mercury loop operation and solicit agreement from stakeholders to implement gas injection long term. This procedure has continued to provide a useful process to evaluate the impacts of increased gas injection rates and obtain agreement from stakeholders that it is appropriate to modify the Normal Operating Value for gas injection parameters listed in Section 5.28 of the Operations Envelope [8].

During the first two years of gas injection operation, the USI process has been implemented to evaluate progressive steps of development and ensure that each evolution can be safely implemented with the existing set of credited controls. However, the experimental nature of this process relies on the performance of the testing procedure to evaluate impacts and limits the value of performing separate evaluations for each stepwise increase in injection rate. Since all experience to date has shown gas injection impacts to be mild and predictable, this USIE authorizes continued increases up to the highest intended flow of 10 SLPM with two contingencies.

First, if mercury loop behavior diverges significantly after a stepwise increase in gas injection rate, then the USI process should be initiated to determine the level of evaluation and approval needed to proceed. Accelerator Safety is one of the stakeholders that reviews and approves the results of the testing procedure, which ensures a crosscheck of the conclusions prior to proceeding into routine operations.

Second, gas injection rate increases will be performed in deliberate steps of no more than 1 SLPM. This helps ensure that the magnitude of unexpected phenomenon should be limited during testing. Each time a new set of gas injection parameters is approved, two weeks of operation will be allowed to observe longer term loop response and verify that no other unexpected behaviors will manifest before testing another change in gas injection parameters.

II.B Lessons Learned from Mercury Loop Fill Transient Events

In March 2019, an unidentified mercury leak from the mercury process loop resulted in depletion of the mercury reserve in the storage tank and eventual injection of a large helium bubble into the mercury process loop, as described in References [9] and [5]. This challenge to the mercury process loop systems served to illuminate vulnerabilities in the system not previously addressed and to demonstrate the effectiveness of the controls in place. This section will focus only on the lessons that are applicable to the proposed changes being evaluated here.

II.B.1 Vulnerability of Gas Supply Lines

One significant outcome of the event was the transport of a small amount of mercury spallation products out of the mercury process loop and into helium supply lines connected to the top of the mercury pump tank. The severity of this outcome was increased due to details of the pump tank helium supply line routing, discussed in detail in Reference [5]. Although this vulnerability was realized during a mercury loop filling operation, it was recognized that these supply lines were similarly vulnerable to mercury intrusion during the postulated gas accumulation accident resulting from target gas injection.

The vulnerabilities specific to target gas injection were fully addressed prior to returning to operation, as described in Reference [5], using credited controls implemented through a revision to the supplemental ASE [10], which included the existing controls for GI3 and a new Service Gallery Radiation Alarm System. No further action is necessary to address these vulnerabilities at this time.

II.B.2 Observation of Bounding Event

Of greater import for this evaluation was the observed response of the mercury process loop to a large, high pressure helium bubble starting low in the loop and venting. The mercury loop fill transient event was in many regards a more severe version of the helium accumulation gas release accident scenario (TS3-29) considered in the SAS [1]. The bubble injected into the loop during the fill transient was at a similar pressure to the accumulated helium bubble evaluated for GI3 in Reference [11] and a much larger volume, given that the peak injection rate is estimated to have been more than 690,000 SLPM [12]. The pump tank was completely filled with mercury and pressurized, bursting the pump tank rupture disc and venting mercury and helium. This progression of the fill transient events was consistent with predictions for the GI3 accumulated gas release scenario postulated for target gas injection. As a comparison between the two events, the volume of gas at standard conditions conservatively calculated to have accumulated in the GI3 event is 638 L [11]. The estimated volume of gas at standard conditions injected from the storage tank was 1340 L [13]. Thus, the quantity of gas injected during the fill transient was more than double the highly conservative estimate of potential gas accumulation in the mercury loop due to target gas injection.

The credited pump tank rupture disc and loop seal with orifice completely prevented liquid mercury from passing into the MOTS GLS. This validates the efficacy of these credited controls for any credible mercury loop transient event associated with target gas injection.

Although mercury was able to reach an undesired area via the helium supply lines, the installed check valves were effective at halting the progress of bulk mercury. This led to the implementation of gas jumpers inside the Service Bay that combine two check valves with an orifice and sintered metal filter to limit or prevent potential mercury intrusion into portions of the helium supply lines outside the Service Bay. As discussed above, the gas supply lines were fully addressed as part of the recovery effort, so no additional analysis of these lines is provided here.

The suite of credited and process controls implemented mitigates the consequences of this event to be well below an acceptable level. Since this event bounds any event postulated to result from target gas injection, this provides assurance that the controls in place are sufficient to handle off-normal or unexpected behaviors as target gas injection rate is increased.

II.C Description of Technical Changes Planned to Support 10 SLPM

The hardware modifications associated with this change are limited. Two components in Gas Panel 9 will be replaced with similar components of a higher capacity [14] (see Figure 2). PCV-3241 will be replaced with a valve capable of flowing 10 SLPM with a supply pressure of 180 psig. Based upon vendor supplied parameters, the maximum flow through PCV-3241 (fully open with 180 psig supply pressure) is 24 SLPM [15], compared with 2.1 SLPM for the current valve. FE-3235 will be replaced with a flowmeter ranged to read 0 to 10 SLPM. The USIE to allow 2 SLPM of gas injection flow [3] evaluated the impact of increasing the IOB orifices and the gas supply orifice on the target and the scope included orifices sufficient to flow 10 SLPM. The increased capacity of the Gas Panel 9 components on off-normal scenarios will be addressed in Section II.D.

Alarms and interlocks associated with target gas injection are also being modified consistent with the hardware changes. The replacement flow meter will continue to provide flow alarm signals. The high flow alarm will be adjusted based upon operating target's flow capability and the gas injection flow that is permitted by the OE [8]. The high-high flow alarm and interlock P29 are expected to be set with margin below the maximum range of the flow meter and the OE limit. These are intended primarily to respond to hardware failures that result in excessive flow. A thorough description of the controls and interlocks implemented to support target gas injection is provided in Reference [16].

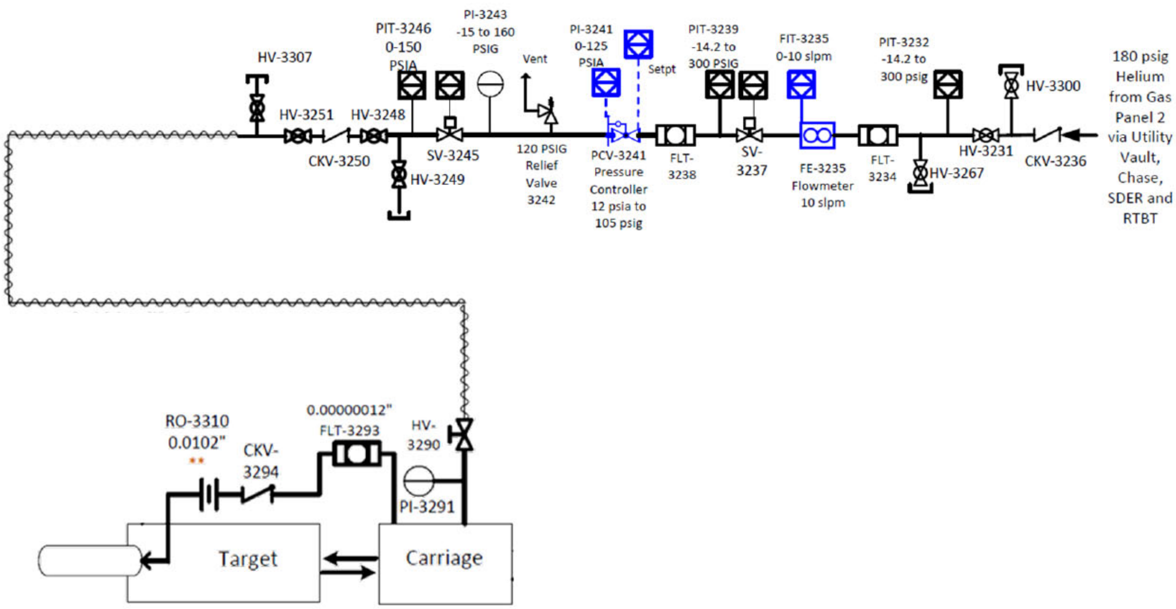

Figure 2. Schematic diagram of Gas Panel 9 and Target Components.

II.D Safety Evaluation

In preparation for GI3, a thorough hazard evaluation was performed to identify scenarios that could credibly have a significant safety impact on workers, the public, or the environment which was documented in the SAS [1]. Some of these evaluations will be revisited here to evaluate the effects of the proposed changes described above and reconsider unrealistically conservative assumptions in the light of understanding gained through two years of experience with target gas injection. Impacts of the proposed changes on the hazard evaluation in Sections 4.2.1 and 4.2.2 of the SAS are addressed in the sections below. The hazard evaluation in Sections 4.2.3 and 4.3 of the SAS were reviewed, and it was determined that the proposed changes do not have any potential to affect these scenarios.

II.D.1 Helium Supply System Scenarios

Section 4.2.1 of the SAS [1] provides hazard evaluation for the GI3 helium supply system for target gas injection. Most of the scenarios discussed in that section are unaffected by this change because they are concerned with the potential for the helium supply piping to provide a pathway for mercury or spallation gases to escape the confinement of the mercury process loop or Service Bay. There are no changes being made to the hardware configuration in the Service Bay, so there is no impact on these scenarios. The only helium supply scenario affected involves postulated abnormal helium flow as discussed below.

Section 4.2.1.1 of the SAS [1] evaluates the potential impact of abnormal helium flow. Since the proposed changes affect the magnitude of abnormal flow, this scenario merits revisiting. The SAS evaluates a variety of component failures and associated abnormal gas flows that could result. These scenarios were generally limited by engineered features of the system, such as the orifice size of the pressure control valve, system relief valves or other orifices in the system, up to and including the IOBs. Given the increased capacity now being engineered into the system by the proposed change to the pressure control valve, the potential high flows under similar circumstances are increased proportionately with the increase in capacity. Since the initial estimations were based on a system intended to deliver 1 SLPM, increasing the design system capacity to 10 SLPM approximately increased the estimated failure flows by a factor of 10. Calculations supporting these estimates are provided in Reference [15].

The bounding failure flow estimated is 28.3 SLPM, unrealistically assuming concurrent failures in the pressure regulators at the helium supply tube trailer, failure of the pressure control valve, failure of the Gas Panel 9 relief valve (PRV-3242) and neglecting flow resistance of the IOBs [15]. Although this scenario assumes more equipment failures than would be considered credible, it conveniently serves to bound any credible combination of concurrent failures including a broken IOB supply tube inside the target as discussed in Section 4.2.2.5 (TS3-34) of the SAS [1]. This flow rate is substantially higher than any credible off-normal gas injection flow rate, but it would result in only a 1% volume fraction of gas in the mercury [17]. Testing indicates that the mercury process loop flow would remain in a bubbly regime with a minimal impact on heat transfer or fluid flow dynamics. The effect of high gas flow on the loop is expected to be similar to observed effects described in Section II.A with larger magnitude.

These loop impacts would be expected to cause significant operational interruptions, but no significant safety consequences are expected. Alarms and interlocks associated with high helium supply flow would be expected to quickly stop target gas injection [16]. Alarms and interlocks would also terminate gas injection should the mercury pump tank level increase beyond setpoints. The time scale of the loop response is also long enough to allow operator response to the event. However, timeliness of automatic or operator response is not necessary to prevent significant safety consequences.

Should the high helium flow interlock and associated alarms/operator actions fail to terminate gas injection flow and abnormal flow were to persist, increased accumulation would be expected to occur across a timescale of about an hour. The pump tank rise would be fastest initially and then slow down as the loop becomes saturated with accumulated gas, eventually reaching a steady state. Should the helium accumulation raise the mercury level in the pump tank beyond high level setpoints, alarms would be actuated, and an automatic interlock would terminate gas injection. Accumulation of gas is expected to saturate at a level below the top of the pump tank, and even if the pump tank were to be filled, increasing system pressure as mercury entered the loop seal would limit the effects of further accumulation if automatic interlocks and alarms/operator intervention were to fail. The possibility that this accumulation raises pump tank level enough to transport mercury outside the Service Bay is not credible.

It is possible that the high helium flow would be sufficient to cause “shedding” behavior with associated unstable pump tank level transients. Gas “shedding” behavior would be expected to transport at most small droplets, which would be confined by the MOTS GLS or components in the gas supply jumper. It is not anticipated that there would be any mechanism to transport bulk mercury out of the loop via shedding.

Passive design features associated with the MOTS loop seal have been demonstrated to be effective in maintaining mercury within the loop during transient level conditions as discussed in Section II.B, and similar features have now been implemented on all gas supplies to the mercury loop designed to limit or prevent potential mercury intrusion into portions of the helium supply lines outside the Service Bay. The magnitude of this event would be significantly less severe than the event that occurred during the mercury loop fill transient. Since there is no potential for significant safety consequences from this event, the conclusions of the SAS are unchanged. The proposed changes evaluated here can be implemented without a significant increase in the probability or consequence of helium supply system accidents evaluated in the SAS.

II.D.2 Mercury Process Loop Scenarios

Section 4.2.2 of the SAS [1] provides hazard evaluation of the effects of GI3 on operation of the mercury process loop. Most of the scenarios discussed in that section are unaffected by this change because the proposed changes do not affect the hardware configuration in the Service Bay. The only mercury process scenario affected is excessive accumulation of injected gas in the mercury process loop, discussed below.

Section 4.2.2.2 of the SAS describes the postulated scenario (TS3-29) that led to designation of the mercury pump tank rupture disk and discharge path and the mercury pump tank exhaust line loop seal and orifice as credited engineered controls. The detailed analysis evaluating this scenario is documented in Reference [11]. The calculation first examines an unmitigated event in which highly conservative assumptions are used to support analysis in the face of uncertainty. This analysis reaches the conclusion that there is a potential for mercury to be transported out of the Service Bay via the MOTS and a credited control is needed to prevent the accident. A mitigated analysis is then performed that demonstrates the efficacy of the selected credited controls at preventing any transport of mercury out of the Service Bay.

A key assumption of the unmitigated analysis is the accumulation of all injected gas in the mercury loop. This unrealistically conservative assumption was based on the inability to justify a lower number, since there was no experience base for gas injection at SNS. By choosing the worst possible value, a bounding analysis could be ensured. However, after two years of experience, it is clear that only a small fraction of injected gas accumulates and gas accumulation in the loop reaches an equilibrium state within a relatively short period of time, as discussed in Section II.A.1. As such, the long-term accumulation of all injected gas postulated is clearly outside the realm of physical possibility. Additionally, analytical work has been done to conservatively estimate the maximum accumulation that is physically possible in the mercury loop, and the estimated maximum accumulation is not expected to overfill the pump tank [7]. Therefore, the unmitigated case is no longer considered credible. However, there is still uncertainty regarding the behavior of the loop as gas injection rate is increased, so prudence dictates that the existing credited controls should be retained to provide protection for unexpected cases, at least until the desired rate of gas injection has been attained and sufficient experience accrued to provide assurance of safe operations. Additionally, the mercury loop fill transient (TS3-36) [5] would still require crediting these controls even if the event associated with gas injection were totally removed from the safety analysis.

The mitigated analysis is independent of gas injection rate since the mercury pump tank rupture disk will open at a fixed level of mercury in the pump tank, and thus after a fixed volume of accumulation.

Because of the conservatism of the original evaluation, it is still a bounding case for the evaluation of the potential consequences of target gas injection. No change to the controls is needed, but an updated discussion of the potential impacts of target gas injection on mercury loop operation should be included when the FSAD-NF is revised to incorporate target gas injection. As further experience with high injection flow rates is accrued, it may be appropriate to reduce the postulated consequences or probability of TS3-29. The process and technical changes being evaluated here can be implemented without a significant increase in the probability or consequence of mercury process loop accidents evaluated in the SAS.

II.E Conclusion

This evaluation considered the potential safety impacts of proposed changes in Gas Panel 9 with associated alarm and interlock changes that would enable the target gas injection system (excluding the IOBs) to inject up to 10 SLPM at a pressure of 100 psig. Provisions implemented in the testing procedure for increasing the OE limit for target gas injection flow ensure a deliberate, incremental approach is applied as injection flow is increased. An observed change in mercury process loop response to increased target gas injection flow will be identified by the testing procedure and evaluated using the USI process. The effects of increased target gas injection flow on the safety analysis supporting target gas injection were evaluated, and the existing analysis was determined to bound credible accident scenarios based upon operational experience with target gas injection. No changes to the existing set of credited controls is needed. This evaluation applies only to gas injection using IOBs; swirl bubbler injection or other developments in the method of gas injection are expected to require evaluation using the USI process.

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.

This change affects information contained in supplemental documents to the FSAD-NF, namely the Safety Assessment Supplement [1] and associated documents [2, 3] as discussed in Section II.D above. The content of this USI Evaluation should be incorporated into the FSAD-NF in conjunction with incorporation of target gas injection information as a whole.

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

No, the proposed change does not affect the requirements of the ASE or the supplemental ASE [10].

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 potential hardware failures and mercury loop behaviors that could lead to an accident scenario are unaffected. The new hardware selected has the same high reliability design and manufacturing pedigree as the previous hardware. If any unexpected behavior is observed during performance of the testing procedure for changing gas injection parameters, it will be evaluated using the USI process prior to operations with that target gas injection rate. As determined in Section II.D, the probability of occurrence of an accident previously evaluated is not significantly increased.

2. Could the change significantly increase the consequences of an accident previously evaluated in the FSADs?
   Yes __ No _X_
   Justification:
   No, as discussed in Section II.D, the consequences of previously evaluated accidents remain bounding for any credible accident associated with target gas injection. Therefore, the consequences of accidents previously evaluated is not significantly increased.

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 proposed modification has no potential to affect a credited control. The proposed changes are limited in scope and the essential function of all components is unchanged, only capacities and setpoints are being modified. Thus, the probability of occurrence of a malfunction of equipment important to safety is not significantly increased.

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:

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 this proposed change does not have an impact on the unmitigated consequences of its associated accidents, it 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 proposed changes are of limited scope and have no impact on the essential function of components with the modifications limited to capacities and setpoints. No new accident scenarios are created by the proposed changes. As discussed in Section II.A, there is no reason to expect that the mercury loop response will be significantly different at higher gas flow rates, but if unexpected responses are observed, processes described in Section II.A.4 are in place to ensure that the new situation is reviewed through the USI process prior to routine operation. Increased attention and existing controls combined with the relatively long response time of the mercury loop ensures that gas injection can be terminated prior to adverse consequences during the course of the testing procedure [4]. Thus, there is not a possibility of a different type of accident than any previously evaluated with significant safety consequences.

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 change does not have the possibility to affect a credited control, and the limited scope of the change ensures that no new failure modes are being introduced. There is no possibility for 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: 2020.03.27 09:42:03 -04'00'

Jacob Platfoot, Qualified Preparer — Date

Charlotte Barbier
2020.03.27 10:54:02 -04'00'

Charlotte Barbier, Engineering Analyst — Date

Digitally signed by Greg Stephens
Date: 2020.03.27 11:01:15 -04'00'

Greg Stephens, Technical Component Utilities Engineer — Date

Freeman, David W. Digitally signed by Freeman, David W.
Date: 2020.03.27 12:34:07 -04'00'

David Freeman, Qualified Reviewer — Date

Approvals:

Pilat, Fulvia C. Digitally signed by Pilat, Fulvia C.
Date: 2020.03.27 15:11:28 -04'00'

Signature of SNS Operations Manager or Designee — Date

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