DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

September 7, 2018

The Honorable James Richard Perry
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Perry:

The Defense Nuclear Facilities Safety Board conducted a review of the H-Canyon Facility Justification for Continued Operation (JCO) approved by the Department of Energy on November 29, 2017. The JCO was established due to the indeterminate ability of the H-Canyon Exhaust Tunnel to perform its safety class function during and after a design basis earthquake. A prominent feature of the JCO is the reliance on operator actions to stop an ongoing radiological material transfer within five minutes of an earthquake to protect the public and co-located worker. The Board has identified several issues with the implementation of this compensatory measure. As detailed in the attached enclosure, the calculated unmitigated dose consequence after a design basis earthquake is categorized as high for the co-located worker. The enclosure is provided for your information and use.

Yours truly,

Bruce Hamilton
Acting Chairman

Enclosure

c: Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

June 29, 2018

MEMORANDUM FOR: Christopher J. Roscetti, Technical Director

COPIES: Board Members

FROM: Z. McCabe, M. Randby

SUBJECT: H-Canyon Justification for Continued Operation

Members of the Defense Nuclear Facilities Safety Board's (Board) staff conducted an on-site review of the current control set at Savannah River Site's (SRS) H-Canyon in March 2018. This report documents safety issues with H-Canyon's current control set. Savannah River Nuclear Solutions (SRNS) implemented a justification for continued operation (JCO) in February 2018 because of the indeterminate ability of the H-Canyon Exhaust (HCAEX) Tunnel to perform its safety class safety function during and after a design basis earthquake (DBE). SRNS personnel are pursuing additional non-linear structural analyses to characterize the structural integrity of the HCAEX Tunnel in its degraded state and to determine if the HCAEX Tunnel can perform its safety function during and after a DBE [1, 2]. The JCO implemented new compensatory measures, elevated the functional classification of existing controls, and allowed for H-Canyon to receive and process certain spent nuclear fuel.

The staff team's review focused on the compensatory measures identified in the JCO, the revised accident analysis and dose consequence calculations, and implementation of the compensatory measures including the Transfer Protocol compensatory measure. The JCO consists of 11 compensatory measures. The staff team focused its review on the compensatory measures that involve personnel action after a seismic event. The staff team identified two safety issues with the JCO compensatory measures at H-Canyon that reduce the effectiveness of the control set: incomplete implementation and demonstration of the Transfer Protocol compensatory measure, and the reliability of the Seismically Qualified Vessel Air Purge Response compensatory measure. Additionally, the staff team identified several opportunities for improvement including restraint of wheeled obstructions in the gang valve corridors, investigation of the means to de-energize power lines near the portable air compressor, and protection of material-at-risk (MAR) assumptions in the JCO. The staff team performed an out-brief to the Department of Energy's (DOE) Savannah River Office (DOE-SR) and SRNS personnel on May 15, 2018, highlighting the aforementioned issues.

Background. As a result of the December 16, 2015, Board letter to the Assistant Secretary for Environmental Management, *H-Canyon Seismic Performance and Condition*, SRNS examined concrete core samples from the H-Canyon personnel tunnel [3]. Preliminary evaluations of the concrete core samples revealed that the concrete may be degraded beyond what was assumed in the HCAEX Tunnel structural analysis. As a result, SRNS declared a

potential inadequacy in the safety analysis and a positive unreviewed safety question in June 2017 due to the indeterminate ability of the HCAEX Tunnel to perform its safety class safety function during and after a DBE [1]. Per DOE Guide 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*, SRNS drafted U-JCO-H-00003, *H-Canyon Justification for Continued Operations for Issues Associated with the HCAEX Tunnel*, which DOE-SR reviewed and approved on November 29, 2017 [4, 5, 6]. SRNS implemented the JCO in February 2018 [7]. The JCO implements new MAR assumptions (not protected in the JCO), implements administrative compensatory measures that serve safety class functions, and upgrades several existing controls that serve safety significant functions in the DSA to compensatory measures that serve safety class functions. The approval and implementation of this JCO allowed H-Canyon to receive and process certain spent nuclear fuel, which commenced in March 2018.

In the meantime, SRNS is performing a non-linear structural analysis, expected to be completed in the middle of fiscal year 2019, to determine if the HCAEX Tunnel can perform its safety function during and after a DBE. Instead of providing a specific exit date, the JCO states that it can be exited if the non-linear structural analysis verifies the ability of the HCAEX Tunnel to perform its credited safety function in its degraded state, or if the documented safety analysis (DSA) incorporates the JCO [5]. The JCO's duration is dependent both on the execution of engineering work and the assumption that the non-linear structural analysis will verify that the HCAEX Tunnel can perform its safety function during and after a DBE.

Incomplete Implementation and Demonstration of Transfer Protocol Compensatory Measure. The JCO includes a new administrative compensatory measure that serves a safety class function, the Transfer Protocol. The Transfer Protocol is intended to limit the total releasable material due to failed process transfer piping during a seismic event to 1,000 plutonium-239 equivalent curies (PEC). SRNS personnel determined that the release of 1,000 PEC equates to a calculated dose consequence of less than 88 rem total equivalent dose (TED) to the co-located worker at 100 meters and less than 1 rem TED to the maximally-exposed offsite individual (MOI) [8]. The Transfer Protocol is the only mitigative compensatory measure that the JCO implemented. Mitigation actions are performed by a standby gang valve operator (GVO)[1] stationed in the vicinity of the gang valve corridor and tasked with manually stopping a transfer[2] within five minutes after a seismic event.[3] Should this control fail during a HCAEX Tunnel collapse during a seismic event, the 100 rem TED threshold to the co-located worker could be significantly exceeded and the MOI evaluation guideline of 25 rem TED could be challenged given the current H-Canyon facility MAR limits [5]. Opportunities for improvement related to MAR limits are discussed later in this report.

[1] Throughout this report, the term "GVOs" refers to operations personnel at H-Canyon that have a variety of responsibilities, including sometimes being assigned standby duties for the Transfer Protocol compensatory measure. The term "standby GVO" refers to the specific GVO assigned to the standby duties for the Transfer Protocol compensatory measure.

[2] Not all transfers require a standby GVO. Certain high MAR transfers always require a standby GVO. Lower MAR transfers may require a standby GVO if the transfer occurs concurrently with another transfer. The Transfer Protocol procedure, *Seismic Event Standby*, determines whether a standby GVO is needed for any given transfer [9].

[3] For one specific transfer, the standby GVO must only be stationed within the H-Canyon facility instead of in the vicinity of the gang valve corridor and has 75 minutes instead of five minutes to stop the transfer [9].

SRNS personnel have not provided clear expectations to GVOs performing standby duties nor have they provided GVOs and other H-Canyon personnel with the opportunity to demonstrate the Transfer Protocol's effectiveness through emergency preparedness demonstrations. The staff team concludes clear, written expectations provided to the standby GVO prior to each transfer, as well as sufficient demonstration of the Transfer Protocol through drills and what-if-type scenario-based interviews, would largely resolve these issues.

Multiple Methods for Stopping a Transfer Not Communicated—SRNS personnel stated that there are three possible methods for a standby GVO to stop any ongoing transfer: (1) throttle the specific steam valve, (2) throttle the overhead steam header to the valve bank, and (3) pull the pin and manipulate the cam bar to place the gang valve into airblow. As of June 2018, there is no explicit procedure for a standby GVO that details any of these three methods. However, the control room procedure, 221-H-121, *Seismic Event Standby*, which is used to determine if a standby GVO is required, does provide the following guidance: "[t]he GVO will immediately throttle steam valve(s) as necessary to stop the transfer," and "[t]he Standby Operator is responsible to manually stop the transfer if a seismic event is experienced in H-Canyon or as directed by the H-Canyon Control Room" [9].

Through discussions with SRNS and the staff team's observations, the staff team concludes that SRNS has not effectively communicated to the GVOs its expectation that standby GVOs will use all three of these methods to stop a transfer if needed. For instance, if the first two options failed to stop the transfer, SRNS personnel stated that the standby GVO could pull the pin and manipulate the cam bar to place the gang valve into airblow. SRNS personnel did explain that it was unclear if the standby GVO would manipulate the cam bar if he or she did not have communications with the control room because of the safety concerns (i.e., a pinch point hazard if the control room remotely operated the cam bar while the GVO is in the vicinity). Additionally, a staff team member observed an evolution that included a standby GVO, during which the staff team member concluded that the GVO had not considered the overhead steam header as a means to stop the transfer.

The staff team recognizes that the GVOs are trained and routinely open and close the steam valves and the overhead steam header to the valve bank during normal operations. Additionally, control room personnel may direct a GVO to remove the cam bar pin and manipulate it manually during normal operations. However, the staff team, at the time of its review, concluded that SRNS has not effectively communicated the expectation of stopping the transfer after a seismic event through any of the three ways described previously if the other options are unavailable or control room communications fail.

Expectation of Extraordinary Measures Not Communicated—In an emergency situation, extraordinary practices can be appropriate and necessary provided the responder can safely and feasibly perform the actions. A standby GVO may be required to take these types of actions after a failure of the H-Canyon ventilation system as a result of a seismic event. At multiple locations along the length of the hot and warm gang valve corridors (approximately 10 feet wide and 650 feet long) there are several large wheeled tool boxes, equipment boxes, and other large items that are not restrained and do not have brakes [10]. A seismic event could result in these items shifting and moving in a way that could obstruct a standby GVO's travel path, damage the gang valve bank, or otherwise interfere with accessing gang valves. Opportunities for improvement related to restraining wheeled items are discussed later in this report.

SRNS personnel said that if the standby GVO's pathway was blocked, the standby GVO could crawl over the boxes or exit and re-enter the gang valve corridor via one of the side doors. However, the staff team concluded SRNS has not communicated its expectations that the standby GVO will take these types of extraordinary measures to ensure a transfer has stopped after a seismic event. For instance, exiting and re-entering would not be standard protocol as it would involve the standby GVO exiting the gang valve corridor (a contamination area) through an emergency exit into a clean area, and then going back into the gang valve corridor through another emergency exit past the obstruction.

The staff team concludes SRNS should inform the standby GVO of this expectation to ensure that a transfer can be stopped within five minutes of a seismic event.

Subjective Nature of Determining That a Transfer Has Stopped—When the standby GVO throttles a steam valve to stop a transfer, the gang valves do not provide explicit indication as to when a transfer is stopped. The *Seismic Event Standby* procedure does not specify how a standby GVO is expected to verify that he or she has successfully stopped an ongoing transfer and thus mitigated a radiological release. SRNS personnel stated that the standby GVO will reduce steam flow enough to stop the transfer, but will not completely close the steam valve. GVOs are trained to not fully close these valves to allow for some steam to continue to flow, which prevents the steam in the line downstream of the valve from condensing and leading to the creation of a vacuum that could result in radiological material being sucked back into the steam line in the gang valve corridors.

Some steam lines have pressure indication gauges that would inform the standby GVO of the steam pressure, and indirectly, whether the standby GVO had successfully stopped a transfer. However, not all gang valves have these gauges. For the steam lines without pressure indication gauges, SRNS personnel said the standby GVO would be able to determine the success of stopping the transfer through auditory and physical indications, which is how GVOs typically tell if they have stopped a transfer on these gang valves under normal operating conditions. The staff team concludes that the subjective criteria of determining success, especially under potentially non-ideal post-seismic conditions (e.g., alarms), could lead to a standby GVO erroneously believing that he or she had successfully stopped the transfer.

Lack of Standby GVO Demonstration of Transfer Protocol—H-Canyon personnel have not demonstrated the ability to perform the standby GVO actions other than through normal operations. As stated previously, GVOs routinely perform and are trained to perform the actions required to stop a transfer described previously; however, they have not demonstrated the ability to perform these actions under non-ideal conditions. As of June 2018, SRNS had not conducted any emergency preparedness drills, tabletop drills, or what-if interviews with GVOs to demonstrate that the Transfer Protocol is a reliable compensatory measure.

SRNS has stated that the basis for the decision to not conduct any drills is that the JCO is a temporary measure. However, the JCO does not have a definitive end date and is expected to be exited if the non-linear structural analysis of the HCAEX Tunnel determines it can perform its safety class function after a DBE. Considering the heavy reliance of the JCO on this mitigative compensatory measure to reduce the calculated dose consequences to co-located worker and the public after a DBE, the staff team concludes emergency preparedness drills and other formal demonstrations involving non-ideal conditions are necessary to demonstrate the Transfer Protocol's reliability and would better prepare operations personnel.

Reliability of the Seismically Qualified Vessel Air Purge Response Compensatory Measure. The contents of the H-Canyon vessels produce hydrogen gas through radiolysis. To keep the hydrogen concentration below the lower flammability limit (LFL), purge air is continuously supplied to the vessels during normal operations via the non-seismically qualified instrument air system. SRNS personnel assume that the non-seismically qualified instrument air system will fail after a seismic event. Therefore, the H-Canyon safety basis requires an alternative post-seismic purge to prevent vessels' headspace from reaching the LFL. If the LFL is reached and an ignition source is present, the resulting hydrogen deflagration could lead to significant radiological consequences to the co-located worker and MOI. SRNS personnel provide this required post-seismic purge using air that is supplied by connecting and operating a portable air compressor. This response is classified as a specific administrative control (SAC) that serves a safety significant function in the currently approved technical safety requirements (TSRs) [10]. The JCO elevates the SAC to a preventive compensatory measure that serves a safety class function due to the indeterminate ability of the HCAEX Tunnel to perform its safety function [5]. The staff team identified one issue and one opportunity for improvement (related to electrical cables, discussed later in this report) with the Seismically Qualified Vessel Air Purge Response that may challenge the reliability of the response. Additionally, the staff team understands that SRNS is considering establishing a safety management program that could resolve the issue.

General Service Compressor—The Seismically Qualified Vessel Air Purge Response that currently serves a safety significant function in the DSA relies on a designated general service portable air compressor to supply the required purge air. DOE Standard 3009-94 Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, instructs safety analysts to "[i]dentify SSCs [structures, systems, and components] whose failure would result in losing the ability to complete the action required by the SAC. These SSCs would also be considered safety-class or safety-significant based on the significance of the SAC safety function"[4] [11]. Failure of the portable air compressor would prevent the completion of the Seismically Qualified Vessel Air Purge Response, yet the portable air compressor is designated as general service.

SRNS personnel maintain the portable air compressor to a higher standard than typical general service SSCs by including periodic surveillance requirements in the TSRs. However, the portable air compressor has failed its startup surveillance requirement several times in recent years. (The staff team requested the surveillance requirement testing data from DOE-SR, but as of June 2018, had not yet received it.) Therefore, the staff team concludes that the portable air compressor may not be able to perform its safety function when called upon.

Additionally, SRNS personnel stated that two other identical general service portable air compressors are stationed near the southeastern corner of H-Canyon and are used for normal operations. If the designated portable air compressor failed after a seismic event, SRNS

[4] While the staff team understands that DOE Standard 3009-2014 is not in SRNS' contract, DOE Standard 3009-2014 expands on this instruction by stating: "For existing facilities, support SSCs shall be designated at the same classification (SC or SS) [safety class or safety significant] as the safety controls they support, or else compensatory measures shall be established to assure that the supported safety-SSC can perform its safety function when called upon. SSCs whose failure would result in losing the ability to complete an action required by a SAC shall be identified. These SSCs shall be designated as SC or SS based on the SAC safety function, or justification provided if not so designated."

personnel stated that they could bring one of the other portable air compressors to the north end of H-Canyon after a seismic event. The use of these other two portable air compressors as "contingency" portable air compressors is not documented in the DSA or JCO. SRNS personnel have stated that these other portable air compressors are periodically tested; however, they are not subject to the same TSR surveillance requirements as the credited portable air compressor. (The staff team also requested the testing data associated with these other portable air compressors, but had not received it as of June 2018.)

The approximately 800 foot long would-be travel path for the contingency portable air compressors is near overhead piping, pipe racks, chemical storage tanks, stairs and platforms, and traverses the HCAEX Tunnel [10]. SRNS personnel have not analyzed the objects along the travel path to ensure that the objects would not fail and obstruct the travel path or make it unsafe to transport the portable air compressors after a seismic event. Finally, SRNS personnel have not demonstrated the ability to transport one of the contingency portable air compressors to the north end of H-Canyon. The potential to use the two other portable air compressors does increase the ability of H-Canyon personnel to provide a post-seismic purge to the process vessels. However, considering using either of the other two portable air compressors is neither formally credited nor analyzed and demonstrated to be reliable, the staff team does not believe that this is sufficient to resolve the issue.

Safety Management Program for Compressors—SRNS personnel informed the staff team that SRNS is considering implementing a safety management program under the TSRs that would include three dedicated, general service portable air compressors. The only function of the three portable air compressors would be to provide purge air after a seismic event. The staff team notes that if DOE approves this practice, it would improve the reliability of the Seismically Qualified Vessel Air Purge Response; however, this approach would not be in strict compliance with DOE Standard 3009-94 Change Notice 3 unless one or more compressors are designated at the same functional classification as the Seismically Qualified Vessel Air Purge Response [11].

Opportunities for Improvement. The staff team identified three opportunities for improvement during its review.

Restraint of Wheeled Obstructions—There are several large wheeled tool boxes, equipment boxes, and other large items in the hot and warm gang valve corridors that are not restrained and do not have brakes. A seismic event could result in these items shifting and moving in a way that could obstruct a standby GVO's travel path, damage the gang valve bank, or otherwise interfere with accessing gang valves. The staff team identified an opportunity for improvement that would consist of placing wheel chocks or installing anchors to restrain wheeled boxes, thereby reducing the potential for objects to obstruct a standby GVO's path following a seismic event.

Electrical Cables—The JCO states that the portable air compressor designated for the Seismically Qualified Vessel Air Purge Response is stored in a "seismically safe location," north of H-Canyon. SRNS developed a calculation that concludes that nearby objects will not fall and impact the portable air compressor and that the portable air compressor will survive a DBE [12]. However, the analysis did not consider the possibility of electrical cables running to the utility poles near the portable air compressor detaching and falling near or on the portable air compressor. If a live electrical cable fell on or near the portable air compressor, it could prevent

emergency responders from reaching the portable air compressor until the cable could be de-energized.

SRNS personnel stated that if a live cable fell near the portable air compressor after a seismic event they would contact the power support group to de-energize the cable. Due to the time it would take to generate a flammable atmosphere in a vessel headspace, the H-Canyon TSRs do not require the post-seismic purge until approximately 22 hours after a loss of normal purge [13]. Therefore, H-Canyon would not be required to immediately react to a downed live cable. However, the staff team concludes that SRNS can improve its safety posture regarding this hazard by determining in advance how the cables can be de-energized and if any downstream components depend on the same power to provide an important function in an emergency.

Protection of MAR Assumptions—The JCO accident analysis assumes that the amount of MAR H-Canyon can receive and process is reduced compared to previous limits. This reduction results in a significant decrease in the calculated dose consequences to the MOI and co-located worker. However, these MAR assumptions lack formal protection in the JCO. Instead, SRNS personnel rely on charge plan calculations, which detail the properties of incoming batches, to protect the MAR assumptions. While the charge plans explicitly state MAR limits that are not to be exceeded, these limits are not clearly identified as protecting accident analysis calculations. Therefore, an unreviewed safety question process would not be triggered if SRNS personnel were to change the charge plan limits.

SRNS personnel stated that a formal compensatory measure is not needed because the JCO is temporary. The staff team concludes that a MAR limit compensatory measure in the JCO, along with an obvious reference to the compensatory measure in the charge plan MAR limit section, would ensure that SRNS would properly review any changes prior to execution of the changes.

DOE-SR and SRNS Response. The staff team communicated its observations and conclusions to DOE-SR and SRNS on May 15, 2018 via an out-brief. In response to the issues the staff team raised, SRNS personnel, with approval from DOE-SR, have developed an internal commitment tracking system item to reinforce management expectations for the standby GVOs, which includes three pending actions. The first action will include standby GVO training to reinforce the expectations for performance of the compensatory measure, including extraordinary measures if necessary. The second action is to develop and initiate exercises and drills for standby GVOs. Finally, the third action is to evaluate the 221-H-121 procedure to ensure that GVOs understand management expectations during the execution of the Transfer Protocol. These actions are scheduled to be completed in July 2018 [14].

Conclusion. SRNS implemented a JCO in February 2018 because the ability of the HCAEX Tunnel to perform its safety class safety function is indeterminate. The JCO includes new administrative compensatory measures, elevates the functional classification of existing controls, and allows for H-Canyon to receive and process certain spent nuclear fuel. One of the new administrative compensatory measures, the Transfer Protocol, is credited to mitigate the radiological dose consequence for the co-located worker and MOI as a result of a seismic-induced failure of the HCAEX Tunnel and process piping. The Board's staff reviewed the new control set and identified several issues. SRNS has not properly implemented the Transfer Protocol compensatory measure, and has not demonstrated it to be reliable. Additionally, SRNS

has not designated the portable air compressor supporting the Seismically Qualified Vessel Air Purge Response as a safety class SSC, despite the fact that it serves a safety class function. The staff team concludes these safety issues should be resolved to ensure the continued safe operation of H-Canyon while the HCAEX Tunnel's ability to perform its safety class function is indeterminate.

References

[1] Savannah River Nuclear Solutions, *Unreviewed Safety Question Evaluation: PISA PI-2017-0012, H-Canyon Exhaust Tunnel 2017 Concrete Core Testing Identified Increased Degraded Concrete Depth not analyzed in T-CLC-H-1108, T-CLC-H-1109, T-CLC-H-1110, and T-CLC-H-1111*, TRP-HCA-2017-00315, June 29, 2017.

[2] Carey, S. to J. Carter, *CAEX Nonlinear Probabilistic Fragility Analysis Status Update*, SRNS-E3520-2018-00006-SM, March 21, 2018.

[3] Letter, Joyce L. Connery, Chairman, to Monica C. Regalbuto, Assistant Secretary for Environmental Management, December 16, 2015.

[4] Department of Energy, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*, DOE G 424.1-1B Chg 2, June 12, 2013.

[5] Savannah River Nuclear Solutions, LLC, *H-Canyon Justification for Continued Operations*, U-JCO-H-00003, Revision 0, Aiken, SC, November 2017.

[6] Spears, T. to S. MacVean, *Department of Energy Approval of the H-Canyon and Outside Facilities Justification for Continued Operation (JCO), H-Canyon JCO for Issues Associated with the H-Canyon Exhaust Tunnel*, U-JCO-H-00003, Revision 0, October 2017, NMED-18-0007, November 29, 2017.

[7] Sautman, M. and Z. McCabe to S. Stokes, *Savannah River Site Resident Inspector Report for Week Ending February 23, 2018*, February 23, 2018.

[8] Norkus, J. K., *Radiological Consequences for H Canyon NPH Event to support H-Canyon Exhaust Justification for Continued Operation (U)*, S-CLC-H-01293, Revision 1, November 8, 2017.

[9] Savannah River Nuclear Solutions, LLC, *Seismic Event Standby*, 221-H-121, Revision 0, February 21, 2018.

[10] Savannah River Nuclear Solutions, LLC, *Savannah River Site H-Canyon & Outside Facilities, H-Area Documented Safety Analysis*, S-DSA-H-00001, Revision 12, Aiken, SC, August 2017.

[11] Department of Energy, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, DOE-STD-3009-94 CN3, March 2006.

[12] Soto-Toledo, Y. A., *Evaluation of Air Compressor and Hose Cabinet for DBE Loads and II/I Evaluation of Utility Poles Near To the Air Purge System*, 221-H, T-CLC-H-00988, Revision 1, May 4, 2011.

[13] Savannah River Nuclear Solutions, LLC, *Savannah River Site H-Canyon & Outside Facilities, H-Area Technical Safety Requirements*, S-TSR-H-00006, Revision 12, Aiken, SC, December 2016.

[14] Savannah River Nuclear Solutions, LLC, *Management Reinforcement of Expectations of the execution of the 221-H-121, Seismic Event Standby*, 2018-CTS-005124, May 23, 2018.