**DEFENSE NUCLEAR FACILITIES SAFETY BOARD**
Washington, DC 20004-2901

December 1, 2021

The Honorable Jennifer M. Granholm
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Granholm:

The National Nuclear Security Administration (NNSA) is installing new capabilities at the Nevada National Security Site's (NNSS) U1a Complex to support the Stockpile Stewardship Program. NNSA will develop the safety analyses associated with these projects following the requirements and guidance in Department of Energy (DOE) Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*. NNSA's initiative to implement DOE Standard 3009-2014 for these projects and other NNSS facilities should lead to improved protection of workers and the public. Nevertheless, the Board found that NNSA is incorrectly using a provision in DOE Standard 3009-2014 that allows existing facilities with no viable control strategy to move the assumed location of the co-located worker for calculations that serve as the basis for safety control selection.[1]

More specifically, consistent with the discussion in the enclosed staff report, the Board concludes the following:

- The provision in DOE Standard 3009-2014 does not apply to the projects at the U1a Complex because it only applies to existing facilities and not to projects designated as major modifications;

- Even if NNSA allowed the U1a Complex to use the inapplicable provision in DOE Standard 3009-2014, it would be inappropriate to assume a distance of 3,500 meters for the calculation of co-located worker dose consequences, as there are co-located workers closer to the postulated accident location;

[1]DOE Standard 3009-2014 defines the co-located worker as a hypothetical individual assumed to be 100 meters from the facility where the accident occurs.

- A more robust shipping container for subcritical experiment assemblies would protect radioactive material from a variety of insults, including seismic-initiated events, during onsite transfers at NNSS; and

- The application of the provision in DOE Standard 3009-2014 elsewhere in DOE's defense nuclear complex could result in an underestimated risk and inappropriate control set for the protection of co-located workers at other facilities or sites.

Prior to incorrectly implementing the provision in DOE Standard 3009-2014, the NNSA contractor at NNSS estimated significant consequences to the co-located worker for seismic accident scenarios. DOE Standard 1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, requires additional analysis and enhanced seismic design for the safety controls to mitigate these consequences. If NNSA concludes that the contractor's proposed safety controls for these scenarios are adequate, then NNSA should consider approving an equivalency or exemption request to the seismic design requirements. This approach would lead NNSA to consider the risk to nearby workers and is the appropriate way to implement DOE Standard 3009-2014 rather than moving the co-located worker's assumed location.

The Board further encourages DOE to complete implementation of DOE Standard 3009-2014 across its defense nuclear complex, given its improvements compared to the previous version. However, DOE should consider revising this standard in the future to ensure that accident scenarios with the potential for high consequences to the co-located worker are appropriately analyzed and controlled.

The enclosed report describes the issues identified during the review and is provided for your information and use.

Sincerely,

Joyce L. Connery

Joyce L. Connery
Chair

Enclosure

c: Dr. David Bowman
Mr. Matt Moury
Mr. Joe Olencz

# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

## Staff Report

July 30, 2021

### Alternate Location for the Co-Located Worker at the U1a Complex

**Summary.** The National Nuclear Security Administration (NNSA) is installing new capabilities at the U1a Complex to support the Stockpile Stewardship Program. The contractor executing these projects, Mission Support and Test Services, LLC (MSTS), determined that these projects constitute major modifications to the existing facility. MSTS estimated that there could be high radiological dose consequences to the co-located worker for seismic-initiated accident scenarios in the unmitigated analysis. In Department of Energy (DOE) Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [1], the co-located worker is a hypothetical person assumed to be located "at a distance of 100 meters from a facility (building perimeter) or estimated release point." When the potential dose consequences of a seismic-initiated event to the co-located worker are high, certain requirements in DOE directives are applicable. These requirements include a higher degree of analysis and design for the seismic-related controls.

As a result of the high estimated consequences for a seismic-initiated accident scenario at the U1a Complex, MSTS developed an equivalency [2] to the DOE requirements for analysis and design of seismic-related safety controls for NNSA approval. The equivalency requested approval to use reduced seismic criteria for the analysis and seismic design of safety controls located underground at the U1a Complex. In response to the request, the NNSA Cognizant Secretarial Officer (CSO) for Safety advised MSTS to assume that the co-located worker was 3,500 meters from the release point [3], which would reduce the estimated radiological consequences such that the DOE requirements for increased protection of co-located workers for high-consequence seismic accident scenarios would no longer apply. This approach is allowed in DOE Standard 3009-2014 for existing facilities if no viable control strategy exists that could prevent or mitigate an accident scenario from exceeding DOE onsite consequence thresholds.

Members of the Defense Nuclear Facilities Safety Board's (Board) staff reviewed the applicability of the guidance cited by the NNSA CSO for Safety in DOE Standard 3009-2014 to the major modification projects at the U1a Complex. The Board's staff team found:

- The language in DOE Standard 3009-2014 applies only to existing facilities. It is inappropriate to apply this guidance to the U1a Complex projects since they each constitute a "major modification" to an existing facility.

- MSTS implemented the advice of the NNSA CSO for Safety by determining accident consequences for the co-located worker at a location that is inappropriate even under the allowance described in DOE Standard 3009-2014. There are workers closer to where the accident occurs than the location that MSTS chose for the analysis.

- MSTS could reduce the hazards of operations at the U1a Complex by completing the initiative for procuring a more robust shipping container, which would protect radiological material from a variety of insults during onsite transfers.

- Despite the specific issues with the consequence analysis for co-located workers at the U1a Complex, DOE should continue to implement DOE Standard 3009-2014 for its facilities, given its improvements compared to the previous version. However, DOE should consider revising this standard in the future to ensure that accident scenarios with high consequences to the co-located worker are appropriately analyzed and controlled.

**Background.** The U1a Complex is an underground facility at the Nevada National Security Site (NNSS) where subcritical experiments are executed. Subcritical experiment activities may comprise a series of both static and dynamic (i.e., with high explosives) experiments using both radioactive and non-radioactive materials. The U1a Complex currently has only one location where these experiments can be conducted (referred to as the Zero Room). MSTS is currently executing the Enhanced Capabilities for Subcritical Experiments (ECSE) project, which consists of multiple projects that constitute major modifications to the U1a Complex. Completion of these projects will increase the number of Zero Rooms to three.

As part of the ECSE project, MSTS will install a new single-axis multi-pulse radiography system and a Zero Room with infrastructure and support systems similar to the existing Zero Room. MSTS plans to construct the new Zero Room at the intersection of two existing drifts. MSTS is following DOE Order 420.1C, *Facility Safety* [4], for this project, which requires the safety analysis and supporting design to be developed and integrated in accordance with DOE Standard 1189-2016, *Integration of Safety into the Design Process* [5]. MSTS is developing the DOE Standard 1189-2016 safety basis deliverables, such as the preliminary documented safety analysis (PDSA), using the methodology, criteria, and guidance in DOE Standard 3009-2014.

For the ECSE safety basis documents, MSTS initially planned to only evaluate new hazards and accidents within the project scope, which would exclude hazards already analyzed in the existing U1a Complex safety basis [6, 7]. As a result, MSTS did not analyze a seismic-initiated explosion (e.g., an inadvertent insult to high explosives) in the new Zero Room in the ECSE conceptual safety design report and draft PDSA because the potential dose consequences were bounded by the above ground explosion analysis in the existing safety basis.

As part of a separate effort to update the U1a Complex safety basis to meet the requirements in DOE Standard 3009-2014, MSTS recalculated the potential dose consequences to the co-located worker from a seismic-initiated explosion using the default atmospheric dispersion factor (i.e., $\chi/Q'$) for ground-level releases specified in DOE Standard 3009-2014. In contrast, the existing U1a Complex safety basis uses a custom onsite $\chi/Q'$ value to estimate the potential dose consequences to the co-located worker. MSTS found that using the value specified in DOE Standard 3009-2014 for the unmitigated analysis resulted in estimated dose consequences exceeding 100 rem total effective dose (TED) to the co-located worker at 100 meters. MSTS recognized that this new analysis would impact the ECSE project.

For natural phenomena hazards (including the seismic hazard), DOE Order 420.1C requires major modifications to be developed in accordance with the applicable requirements and criteria contained in DOE Standard 1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities* [8]. DOE Standard 1020-2016 requires credited seismic controls to be designed to seismic design category (SDC)-3 criteria when the unmitigated dose consequences exceed 100 rem TED to the co-located worker. DOE Standard 1020-2016 requires a site-specific probabilistic seismic hazard analysis (PSHA) and subsequent facility condition assessment to be performed for facilities with SDC-3 controls. In July 2020, MSTS developed a request for an equivalency for the seismic requirements in DOE Order 420.1C for the U1a Complex. In the equivalency request, MSTS provided a basis to design the credited seismic controls to SDC-2 criteria rather than SDC-3 criteria, thereby avoiding the need for site-specific analyses (e.g., PSHA). In September 2020, NNSA's Nevada Field Office (NFO) provided the equivalency request to the NNSA CSO for Safety for approval [9].

Instead of approving the equivalency, the NNSA CSO for Safety advised NFO to use the guidance in section 3.3.2 of DOE Standard 3009-2014, which states:

> *For existing facilities, a situation could occur where no viable control strategy exists that could either prevent or mitigate one or more of the hazard/accident scenarios from exceeding the above onsite radiological or chemical consequence thresholds. In such a case, the DSA may determine co-located worker consequences at receptor distances further than 100 meters, if it* [is] *consistent with the actual location of adjacent facilities.*

Based on the NNSA CSO for Safety's advice, MSTS plans to analyze the dose consequences from a seismic-initiated explosion to the co-located worker at the Area 6 construction facilities—approximately 3,500 meters from the U1a Complex—in the upcoming ECSE PDSA.

The Board's staff assessed the applicability of the guidance in DOE Standard 3009-2014 to move the assumed location of the co-located worker in the safety analyses for the U1a Complex's major modification projects. The staff team conducted a teleconference review on February 24, 2021, with personnel from MSTS, NFO, and NNSA headquarters.

**Discussion.** The results of the Board's staff team's review are summarized below:

*Inappropriate Use of DOE Standard 3009-2014 Guidance at NNSS*—The Board's staff team concluded that the language in DOE Standard 3009-2014 to move the assumed location of the co-located worker is not applicable to the ECSE project at the U1a Complex. The guidance in DOE Standard 3009-2014 is applicable for "existing facilities." However, MSTS determined that the ECSE project is a major modification[1] to an existing facility. The language in DOE Standard 3009-2014 delineates the difference between major modifications and existing facilities. Specifically, the standard has different guidance and requirements for an existing facility when compared to a major modification to an existing facility. Also, DOE Order 420.1C

[1]DOE Standard 1189-2016 defines a major modification as a modification that "substantially change[s] the existing safety basis for the facility."

has requirements that are applicable to major modification projects and not existing facilities. The staff team concludes that it is inappropriate to use an exception for existing facilities (e.g., the guidance in DOE Standard 3009-2014 to move the assumed location of the co-located worker) for a major modification project. Even if the ECSE project were an existing facility, MSTS did not perform an analysis on the viability of control strategies to prevent or mitigate the seismic-initiated accident scenarios.

Since the provision for determining co-located worker consequences farther from the facility does not apply to the ESCE project, DOE Standard 3009-2014 requires MSTS to analyze the co-located worker at 100 meters for all hazard and accident scenarios associated with the major modification project at the U1a Complex. MSTS has already determined that the unmitigated dose consequences from a seismic-initiated explosion exceed 100 rem TED to the co-located worker at 100 meters. Therefore, DOE Standard 1020-2016 requires the credited seismic controls to be designed to SDC-3 criteria. As discussed above, DOE Standard 1020-2016 requires a PSHA and subsequent facility condition assessment to be performed for facilities with SDC-3 controls. The staff team recognizes that MSTS plans to credit several controls for a seismic-initiated explosion scenario in the new Zero Room (e.g., Zero Room structure and overhead anchoring) and design them to meet SDC-2 criteria.[2] MSTS has no plans to evaluate these controls to determine whether they meet SDC-3 criteria, and instead submitted an equivalency request per DOE Order 420.1C. Overall, the Board's staff team concludes that NNSA should consider approving the equivalency request or have MSTS follow the seismic design requirements in DOE Standard 1020-2016.

*Incorrect Interpretation of DOE Standard 3009-2014 Guidance*—The NNSA CSO for Safety's memorandum states, "The Nevada National Security Site is unique in its significant distances between facilities, testing areas, and the public; NNSA should take advantage of these unique features in the furtherance of its mission." This statement encourages using the guidance in DOE Standard 3009-2014 to move the assumed location of the co-located worker for future analyses at NNSS. If this guidance is used in future safety analyses, the staff team is concerned that misapplication of the guidance could result in an underestimated risk and inappropriate control set for the protection of the co-located workers at this site and other sites and facilities.

For example, even if the guidance in DOE Standard 3009-2014 were applicable to the major modification projects at the U1a Complex, the staff team concludes that moving the assumed location of the co-located worker to the Area 6 construction facilities is inappropriate. This location is approximately 3,500 meters from the U1a Complex and fails to take into account workers located in the administrative trailers or parking lot at the U1a Complex, which are

[2]DOE Standard 1020-2016 requires SDC-2 controls to be designed to the criteria of IBC-2015, *International Building Code* [10]. However, MSTS notes that the IBC-2015 seismic design criteria are applicable for the design of new controls at the surface and that the seismic ground motions are reduced at the underground elevation of the U1a Complex. As a result, MSTS developed a report that provides a technical justification for reducing the seismic hazard underground by 50 percent at the U1a Complex [11]. In the report, MSTS identifies relevant external studies and several site-specific reports and data that support a reduction in the underground seismic ground motions. MSTS plans to apply the reduction to the seismic design criteria from IBC-2015 when designing the seismic-related controls that will be located underground at the U1a Complex. The Board's staff team has not yet reviewed this report in detail.

approximately 400 meters from the U1h hoist (location where the subcritical experiment package is lowered into the facility). In addition, MSTS plans to replace the administrative trailers by constructing two new support buildings at the U1a Complex to support the expected increase in personnel due to the expansion of the programmatic mission at the facility [12]. Figure 1 below highlights the distance between the U1a Complex and the Area 6 construction facilities.


**Figure 1.** *Aerial view of the U1a Complex and Area 6 construction facilities*

NNSA personnel informed the staff team that the individuals in the administrative trailers or at the parking lot can be considered facility workers because they are trained to respond to the different emergency scenarios at the U1a Complex. However, DOE Standard 3009-2014 defines a co-located worker as a worker assumed to be located "at a distance of 100 meters from a facility (building perimeter) or estimated release point." Therefore, the population of co-located workers includes individuals in the U1a Complex who are 100 meters away from the building perimeter where the release occurs. Also, DOE Standard 3009-2014 does not exclude an individual from consideration as a co-located worker based on their training to respond to emergency events.

*Robust Shipping Container*—In 2018, MSTS identified a planned improvement listed in the U1a Complex safety basis to evaluate alternate shipping containers for the subcritical experiment package. The planned improvement is intended to develop a container that will provide electrical, thermal, and better mechanical protection when the subcritical experiment package is in transit to a Zero Room at the U1a Complex. A robust shipping container would provide additional protection from seismic-initiated accidents discussed above. The staff team concludes that MSTS should complete this initiative so that it can be used for subcritical experiments at the U1a Complex. This would also address a concern communicated by the

Board in a letter dated December 19, 2018, on the lack of engineering controls when transporting the subcritical experiment package at the U1a Complex [13].

*Suggested Changes to DOE Standard 3009-2014*—Many DOE defense nuclear facilities have not updated their safety basis documents to meet the guidance and requirements in DOE Standard 3009-2014. Fully implementing DOE Standard 3009-2014 across DOE's defense nuclear complex is an important safety objective, given the standard's improvements compared to the previous version. However, the staff team found that NNSA inappropriately used and misinterpreted the provision in DOE Standard 3009-2014 for moving the assumed location of the co-located worker for the U1a Complex. The staff team also finds that this provision would still be potentially problematic, even if it were interpreted and applied as written.

DOE Standard 3009-2014 requires safety analysts to estimate the unmitigated consequences of accident scenarios. If those consequences exceed certain thresholds, the standard requires the analyst to identify safety controls to prevent the accident or mitigate consequences to below the thresholds. Safety class controls are required if the unmitigated dose consequences to the offsite public exceed the evaluation guideline (i.e., 25 rem TED). Safety significant controls are required if the unmitigated dose consequences to the co-located worker exceed 100 rem TED. For existing facilities, the standard addresses situations where "no viable control strategy exists" to mitigate the consequences below these thresholds.

For existing facilities with high mitigated consequences (i.e., after crediting safety controls) to the co-located worker, DOE Standard 3009-2014 states that the analyst "shall provide a technical basis for the acceptance of the mitigated analysis results, including the reasons why other controls were not credited to reduce consequences below 100 rem" in the safety basis. However, the standard allows the analyst to first attempt to reduce the dose consequences below 100 rem TED by assuming the co-located worker is further than 100 meters away, "if it [is] consistent with the actual location of adjacent facilities." If the dose consequences can be reduced below 100 rem TED in this way, then the requirement for discussing other controls is no longer applicable.

The staff team concludes that this process is inappropriate because it allows the analyst to avoid identifying safety significant controls when they would normally be required, without having any additional discussion of other controls that were considered. It is important to include such a discussion, as DOE might choose to direct its contractor to identify further safety controls or make other improvements. Therefore, when DOE reviews and approves the safety basis, the discussion of this situation may be incomplete.

DOE could more effectively evaluate the acceptability of proposed safety measures to protect co-located workers if hazard and accident analyses were always performed with the co-located worker assumed to be at a distance of 100 meters from the building perimeter (or estimated release point) where an accident occurs.[3] If the mitigated dose consequences to the co-

[3]There are instances where it is conservative and appropriate to assume the co-located worker is farther than 100 meters from where the accident occurs. For example, DOE Handbook 1224-2018, *Hazard and Accident Analysis Handbook* [14], states, "The CW [co-located worker] may be located at a farther distance if an elevated or buoyant radioactive plume causes a higher exposure beyond the 100 m distance."

located worker exceed 100 rem TED, then the analyst should include a discussion of what other controls were considered but were deemed unviable, and why the risk is acceptable in the safety basis. As part of discussing the risk, it may be appropriate for an analyst to evaluate the radiological dose consequences for the co-located worker at distances greater than 100 meters if the nearest receptor is expected to be further away. DOE could use this information to better understand the risk associated with the accident scenario and whether that risk is acceptable.

**Conclusion.** The allowance in DOE Standard 3009-2014 to move the assumed location of the co-located worker for "existing facilities" is not applicable to the ECSE project at the U1a Complex since it is a major modification to an existing facility. Therefore, the ECSE safety analysis should determine potential consequences to the co-located worker at a distance of 100 meters for all hazard and accident scenarios. MSTS has already determined that the unmitigated dose consequences from a seismic-initiated explosion exceed the onsite thresholds for the co-located worker at 100 meters. Therefore, DOE Standard 1020-2016 requires the credited seismic controls for this event to be designed to SDC-3 criteria, which requires a site-specific PSHA and facility condition assessment. MSTS plans to design the new seismic-related controls to meet SDC-2 criteria. MSTS has no plans to evaluate these controls to determine whether they meet SDC-3 criteria and instead submitted an equivalency request to NNSA for approval. The staff team concludes that the appropriate path forward would be for NNSA to evaluate the MSTS equivalency request and either approve it or have MSTS follow the seismic design requirements in DOE Standard 1020-2016.

The staff team also concluded that MSTS could reduce the hazards of operations at the U1a Complex by completing the initiative to procure a robust shipping container for the subcritical experiment package. This control would protect the radiological material from a variety of insults, including seismic-initiated events, when the package is in transit to a Zero Room.

Lastly, despite the specific issues with the consequence analysis for co-located workers at the U1a Complex, MSTS's ongoing effort to upgrade the safety basis documents for the Device Assembly Facility and U1a Complex by implementing DOE Standard 3009-2014 should improve the safety bases and lead to improved protection of workers and the public. Completing implementation of this standard across the DOE defense nuclear complex is an important safety objective, given its improvements compared to the previous version. However, DOE should consider revising this standard to ensure that accident scenarios with the potential for high mitigated consequences to the co-located worker are appropriately analyzed and controlled.

## References


[1] Department of Energy, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, DOE Standard 3009-2014, November 2014.

[2] Mission Support and Test Services, LLC, *Request for Equivalency for DOE O 420.1C, "Facility Safety," Natural Phenomena Hazards Requirements at the Nevada National Security Site U1a Complex*, SB-RPT-2020-U1A-001, Revision 0, July 2020.

[3] Memorandum from Theodore A. Wyka, National Nuclear Security Administration (NNSA) Cognizant Secretarial Officer for Safety, to David R. Bowman, NNSA Nevada Field Office Manager, *Use of an Alternative Location for the Co-located Worker for Safety Analysis and for Determination of Natural Phenomena Hazards Design Criteria*, December 2020.

[4] Department of Energy, *Facility Safety*, DOE Order 420.1C, Change 2, July 2018.

[5] Department of Energy, *Integration of Safety into the Design Process*, DOE Standard 1189-2016, December 2016.

[6] Mission Support and Test Services, LLC, *U1a Complex Subcritical Experiments Documented Safety Analysis*, U1a-SCE-DSA-001, Revision 3, Change Notice 1, January 2020.

[7] Mission Support and Test Services, LLC, *U1a Complex Subcritical Experiments Technical Safety Requirements*, U1a-SCE-TSR-001, Revision 3, Change Notice 1, January 2020.

[8] Department of Energy, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, DOE Standard 1020-2016, December 2016.

[9] Memorandum from David R. Bowman, NNSA Nevada Field Office Manager, to Theodore A. Wyka, NNSA Cognizant Secretarial Officer for Safety, *Approval of Permanent Equivalency at the U1a Complex for U.S. Department of Energy Order 420.1C, Change 2, Natural Phenomena Hazards Design Criteria*, RLA-20085, September 2020.

[10] International Code Council, *International Building Code*, IBC-2015, October 2015.

[11] Mission Support and Test Services, LLC, *Technical Justification for Reduced Seismic Hazard Underground at the Nevada National Security Site U1a Complex*, U1a-RPT-2021-001, Revision 0, March 2021.

[12] Mission Support and Test Services, LLC, *U1a Complex Asset Management Plan*, PLN-U1a-AMP, Revision 1, 2021.

[13] Defense Nuclear Facilities Safety Board, *U1a Complex Safety Basis Review*, December 2018.

[14] Department of Energy, *Hazard and Accident Analysis Handbook*, DOE Handbook 1224-2018, Interim Use, August 2018.