DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

The Honorable Dan Brouillette
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Brouillette:

On February 21, 2020, the Defense Nuclear Facilities Safety Board issued Recommendation 2020-1, *Nuclear Safety Requirements*. The Board recommended that the Department of Energy (DOE) revise Title 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*, to mandate the use of a single version of DOE Standard 1027 when performing nuclear facility hazard categorization. Since then, the Board has reviewed the three documents that DOE currently allows its contractors to use when performing nuclear facility hazard categorization: DOE Standard 1027-92, DOE Standard 1027-2018, and National Nuclear Security Administration Supplemental Directive 1027 (NNSA SD 1027).

During its review, the Board identified multiple safety items with these hazard categorization standards. The most significant is with the use of NNSA SD 1027, which is not technically justified, is not conservative, and is inconsistent with 10 CFR 830 and other versions of the standard. Its use may result in inappropriate facility hazard categorization, which could potentially lead to inadequate controls for protection of workers and members of the public.

Accordingly, the Board advises that DOE (1) discontinues the use of NNSA SD 1027 because its methodology is not technically justified and is superseded by DOE Standard 1027-2018, (2) updates DOE Standard 1027-2018 to address deficiencies described in the enclosure to this letter, and (3) ensures that the changes in methodology introduced in Standard 1027-2018 and NNSA SD 1027 have not caused hazard category 3 and below hazard category 3 facilities to be inappropriately categorized. The enclosure to this letter contains additional detail and is provided for your information.

Yours truly,

Thomas A. Summers
Acting Chairman

Enclosure

c: Dr. William Bookless
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

October 5, 2020

Review of DOE Nuclear Facility Hazard Categorization Standards

Summary. Title 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management* [1], states that the Department of Energy's (DOE) contractors must categorize a nuclear facility "consistent with DOE–STD–1027–92 [Change Notice 1]." DOE interprets this phrase as meaning that documents other than DOE Standard 1027-92 Change Notice 1 can be used for facility hazard categorization as long as the methodology stays the same.

As a result, DOE allows the use of multiple documents for hazard categorization:

- **DOE Standard 1027-92 Change Notice 1,** *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Repor*ts [2],

- **National Nuclear Security Administration's (NNSA) Supplemental Directive (SD) 1027 Admin Change 1**, *Guidance on Using Release Fraction and Modern Dosimetric Information Consistently with DOE STD 1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, Change Notice No. 1* [3], and

- **DOE Standard 1027-2018 Change Notice 1**, *Hazard Categorization of DOE Nuclear Facilities* [4].

The Defense Nuclear Facilities Safety Board's (Board) staff team reviewed DOE's three hazard categorization documents and identified multiple safety items. The most significant is with the use of NNSA SD 1027. NNSA SD 1027 uses a methodology that is not technically justified, is not conservative, and is inconsistent with other versions of the standard. Overall, the Board's staff team believes that DOE should discontinue the use of NNSA SD 1027 because it is superseded by DOE Standard 1027-2018 and is inconsistent with 10 CFR 830. Further, DOE Standard 1027-2018 should be updated to correct deficiencies and to clarify its guidance and requirements in order to improve its usability and to ensure appropriate and consistent facility hazard categorization.

The staff review team's safety items regarding DOE's hazard categorization documents are summarized below:

Use of NNSA SD 1027 May Lead to Facility Under-Categorization—For hazard category (HC) 2 threshold quantity (TQ) values, DOE Standard 1027-92 and DOE Standard 1027-2018 make conservative assumptions with respect to lung absorption class, while NNSA SD 1027

does not. The Board's staff team concludes that NNSA's approach is not technically justified based on the material forms present in DOE facility inventories. Further, the staff team concludes that the use of nonconservative lung absorption classes in NNSA SD 1027 constitutes a change in methodology from DOE Standard 1027-92, which makes NNSA SD 1027 inconsistent with 10 CFR 830. Use of NNSA SD 1027 may result in a less conservative facility hazard categorization compared to what would result from using DOE Standard 1027-2018. Under-categorizing a facility could result in analysts failing to identify appropriate controls to protect workers and members of the public due to the reduction in the level of analysis required for HC-3 facilities compared to what is required for HC-2 facilities.

Change in Methodology for Deriving Hazard Category 3 Threshold Quantities—DOE changed the quantitative methodology used to derive the HC-3 TQ values in DOE Standard 1027-2018 and NNSA SD 1027 compared to what was used in DOE Standard 1027-92. This change in methodology nonconservatively increased the HC-3 TQ values for many radionuclides. As a result, the newer hazard categorization documents may be considered inconsistent with 10 CFR 830.

More Clarity is Needed in DOE Hazard Categorization Documents—The Board's staff team identified that DOE's hazard categorization documents need more clarity regarding adjusting hazard categorization release fractions, evaluating new information that impacts Below HC-3 facilities, criticality exclusions, and material-at-risk exclusions. The lack of clarity could result in a defense nuclear facility being under-categorized.

Inappropriate Use of "Should" Statements—The Board's staff team identified multiple instances where DOE Standard 1027-2018 uses a "should" statement where a "shall" statement is appropriate. Analysts are allowed to treat "should" statements as guidance rather than requirements. If these statements are taken as guidance rather than requirements, it may result in analysts under-categorizing DOE's defense nuclear facilities.

Background. DOE applies a graded approach to the preparation of safety bases for its defense nuclear facilities, meaning that the level of effort used to comply with the requirements of 10 CFR 830 is commensurate with factors such as the magnitude of the hazard involved. DOE uses the hazard category of a facility to inform this graded approach and groups facilities into categories: "Hazard Category 1 has the potential for significant off-site consequences"; "Hazard Category 2 has the potential for significant on-site consequences beyond localized consequences"; "Hazard Category 3 has the potential for only local significant consequences"; and "Below Hazard Category 3 has the potential for only consequences less than those that provide a basis for categorization as a hazard category 1, 2, or 3 nuclear facility" [4].

10 CFR 830 allows contractors to prepare aspects of the documented safety analysis of a HC-3 facility in a "simplified fashion," including the hazards analysis. This simplified analysis could result in hazards that are unidentified or under-estimated, which may lead to controls not being identified for those hazards, or controls that are not classified at the appropriate safety level. Furthermore, the safety basis requirements of Subpart B of 10 CFR 830 do not apply to facilities that are Below HC-3. Inappropriate categorization as a Below HC-3 facility (instead of

HC-3 or HC-2) could thus lead to the failure to prepare a 10 CFR 830 compliant safety basis and failure to establish adequate safety controls for the facility.

DOE prepared Standard 1027 in 1992 to provide guidance on hazard categorization for preparation of safety bases for nuclear facilities. It developed radiological inventory thresholds that quantitatively define the boundaries between hazard categories. DOE invokes this standard through 10 CFR 830, which states that DOE's contractors must "[c]ategorize the facility consistent with DOE-STD-1027-92 [Change Notice 1]."

While 10 CFR 830 cites DOE Standard 1027-92 Change Notice 1, DOE's interpretation is that the phrase "consistent with" allows contractors to use other documents for hazard categorization, so long as DOE determines that the methodology in those documents is fundamentally the same as that in the cited version. NNSA issued a supplemental directive document in 2011 (NNSA SD 1027), and a revision to NNSA SD 1027 in 2014, which "recalculated the thresholds using modern dosimetric parameters and a consistent, worker-based breathing rate that are employed in contemporary DOE occupational and public protection analyses." In 2018, DOE published Standard 1027-2018 Change Notice 1, which updated the thresholds for a similar purpose, but with a key difference, as discussed below. DOE has deemed these two documents to be "consistent with" Standard 1027-92 Change Notice 1, and therefore they may be used to satisfy the requirements of 10 CFR 830.

Initial and Final Hazard Categorization—DOE's hazard categorization documents allow for a two-step process: initial hazard categorization and final hazard categorization. "Initial hazard categorization is intended to be a simple screening step that does not involve detailed computations, which will enable facility managers to quickly determine the likely facility hazard categorization. The consideration of material form, location, dispersibility and interaction with available energy sources called for in final hazard categorization is not applicable to initial hazard categorization" [4]. Initial hazard categorization[1] is based on the comparison of the facility's radiological and fissile material inventories to the TQ values listed in DOE Standard 1027-92 or DOE Standard 1027-2018 [2], [4]. These TQ values represent the boundaries between hazard categories. For example, the HC-2 TQ value represents the lower inventory boundary for HC-2 facilities and the upper inventory limit for HC-3 facilities.

The TQ values in DOE's hazard categorization documents are based on default release fractions. However, some facilities may have hazard or accident conditions that result in a greater release of material than what was assumed in the TQ derivation. Similarly, some facilities may have hazard or accident conditions that will never be as severe as what was assumed in the TQ derivation. To account for this, the hazard categorization documents allow analysts to adjust TQ values based on unique facility conditions as part of final hazard categorization. Specifically, DOE Standard 1027-2018 states, "The purpose of the final hazard categorization is to ensure that facility and accident specific factors are addressed that could either (1) change the fraction of material released in an accident or (2) change the amount of the total inventory of material subject to an accident." However, for "Below Hazard Category 3 [facilities], final hazard categorization is not performed" [4]. Accordingly, a Below Hazard

[1] NNSA SD 1027 is only used for final hazard categorization and defers to DOE Standard 1027-92 for initial hazard categorization.

Category 3 facility may be mis-categorized if it has accident conditions that exceed the default assumptions used during the derivation of the HC-3 TQ values in DOE's hazard categorization standards.

Defense Nuclear Facilities Safety Board Activity—On June 26, 2006, the Board sent a letter [5] to the DOE Acting Assistant Secretary for Environment, Safety, and Health documenting several issues with DOE Standard 1027-92. These safety items included "lack of clarity in requirements for exclusion of sealed sources from facility inventory, inconsistencies in expectations regarding implementation of Nuclear Criticality Safety (NCS) controls, and an unclear technical basis for the calculation of threshold values listed in the standard." While DOE improved the guidance in DOE Standard 1027-2018, gaps remain. The section of this report titled *More Clarity is Needed in DOE Hazard Categorization Documents* describes these gaps. The Board also issued Recommendation 2020-1, *Nuclear Safety Requirements,* on February 21, 2020, which recommended that DOE revise 10 CFR 830 to mandate the use of a single version of DOE Standard 1027 when performing facility hazard categorization [6].

Staff Review—The scope of this review included evaluating the three documents that DOE allows contractors to use to determine facility hazard categorization: DOE Standard 1027-92 Change Notice 1, DOE Standard 1027-2018 Change Notice 1, and NNSA SD 1027 Admin Change 1. Throughout 2020, the Board's staff team held multiple meetings with personnel from DOE's Office of Nuclear Safety Basis and Facility Design (AU-31) to discuss observations and concerns with the three hazard categorization documents.

Discussion. The Board's staff team identified the following safety items during its review of DOE's hazard categorization documents:

Use of NNSA SD 1027 May Lead to Facility Under-Categorization—DOE allows the use of three different documents to perform facility hazard categorization: DOE Standard 1027-92, DOE Standard 1027-2018, and NNSA SD 1027. When DOE and NNSA derived the HC-2 TQ values that are used to categorize facilities in these documents, they selected dose coefficients for each radionuclide. These dose coefficients require assumptions with respect to lung absorption class[2] that are dependent on the chemical form of a given nuclide.

DOE Standard 1027-92 and DOE Standard 1027-2018 used the lung absorption class that would result in the highest radiological dose consequences when selecting inhalation dose coefficients. NNSA SD 1027 did not use this worst case lung absorption class and instead used a default class described in International Commission on Radiological Protection (ICRP) Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients* [7]. ICRP 72 describes the default class as the "Recommended default absorption type for particulate aerosol **when no specific information is available**" [emphasis added]. This default lung absorption class is often different from the lung absorption class with the highest dose conversion factor.

[2] The health physics community uses the concept of a lung absorption class to distinguish between different chemical forms of a radionuclide that behave differently from each other inside of the human body.

The Board's staff team concludes that the methodology used in NNSA SD 1027 is not technically justified based on the material forms present in DOE facility inventories. Specifically, using ICRP 72's recommended default lung absorption classes is not appropriate for general hazard categorization because DOE has specific information about the inventories at its facilities and using the default classes can lead to non-conservative results. For example, the ICRP 72 default class for uranium is class M, but class S is more conservative for uranium. ICRP 68 [8] lists uranium class S materials as "highly insoluble compounds" that include "UO_2 and U_3O_8." DOE has inventories of uranium class S materials (UO_2) at several facilities. Accordingly, if a contractor used the default values in NNSA SD 1027, it could under-categorize its facilities[3] that have inventories of UO_2.

The Board's staff team concludes that the use of nonconservative lung absorption classes in NNSA SD 1027 constitutes a change in methodology from DOE Standard 1027-92, which makes NNSA SD 1027 inconsistent with 10 CFR 830.

Table 1 lists HC-2 TQ values (the inventory boundary between a HC-2 and HC-3 facility) as documented in DOE Standard 1027-2018 and NNSA SD 1027 for several common radionuclides. As the table shows, using NNSA SD 1027 could lead to an inappropriate and non-conservative gradation of defense nuclear facilities across the complex. For the radionuclides shown in Table 1, a HC-3 facility that uses NNSA SD 1027 is allowed to have two to three times more material than a HC-3 facility categorized using DOE Standard 1027-2018.

Table 1. *The Impact of Using DOE Standard 1027-2018 Compared to NNSA SD 1027.*

Radionuclide[4]	HC-2 Threshold (Ci): STD-1027-2018	HC-2 Threshold (Ci): NNSA SD 1027	Percent increase using NNSA SD 1027 vice STD 1027-2018
Co-60	2.58E+05	7.81E+05	203%
U-235	9.54E+02	2.62E+03	175%
Pu-238	7.37E+01	1.76E+02	139%
Pu-239	6.76E+01	1.62E+02	140%

During the review interactions, DOE personnel stated that the hazard categorization TQ values in NNSA SD 1027 are only meant for final hazard categorization and that these TQ values can be adjusted. While this may be true, the standard only discusses adjusting TQ values based on release fractions and does not address adjusting TQ values based on the lung absorption class associated with the chemical form. Accordingly, NNSA SD 1027 does not require analysts to evaluate the chemical forms in the facility's inventory to determine whether the TQ values in NNSA SD 1027 need to be adjusted.

[3] In order to use the TQ values listed in DOE Standard 1027, the potential for criticality must be precluded for facilities that contain fissile nuclides, such as U-233, U-235, and Pu-239. If criticality is not precluded, the facility is categorized as HC-2, and the topic of lung absorption class is not relevant.

[4] The number of radionuclides affected by NNSA SD 1027's change in methodology is greater than what is listed in Table 1. The table includes only a subset of radionuclides contained in DOE defense nuclear facilities. Not all radionuclides are affected by the change in methodology. In some instances, the recommended default absorption class in ICRP 72 is bounding and is therefore the same as what is used in DOE Standard 1027-2018.

Change in Methodology for Deriving Hazard Category 3 Threshold Quantities—DOE Standard 1027-92 uses an Environmental Protection Agency (EPA) document [9] as a basis to calculate TQ values for HC-3 facilities. The EPA document used a threshold dose that was one tenth of the annual occupational dose limits listed in ICRP 30, *Limits for Intakes of Radionuclides by Workers* [10]. The annual occupational dose limits for a specific radionuclide listed in ICRP 30 are based on either 5 rem whole body effective dose or 50 rem to specific organs or tissues (excluding the eye), whichever value is lower. Thus the EPA used the lower of 0.5 rem whole body effective dose, or 5 rem to a specific organ. DOE Standard 1027-92 multiplied the limiting release values listed in Appendix E of the EPA document by 20 to derive HC-3 TQ values. Accordingly, for any given radionuclide, DOE Standard 1027-92 used the lower of 10 rem whole body effective dose or 100 rem to specific organs or tissues.

DOE Standard 1027-92 inaccurately describes the quantitative methodology it used to derive its HC-3 TQ values, which may have led to inconsistencies in DOE Standard 1027-2018 and NNSA SD 1027. Specifically, the text of DOE Standard 1027-92 only describes using 10 rem whole body effective dose, and neglects to state that organ doses were also used to derive TQ values. Accounting for the organ specific dose makes a difference for certain nuclides. For example, the plutonium bone dose is more limiting than the plutonium whole body effective dose.

All three hazard categorization documents state that they use the EPA's methodology. In DOE Standard 1027-92, DOE obtained the HC-3 TQ values by simply multiplying the EPA's values by 20, and thus DOE did not necessarily need to understand the nuances of the EPA's calculations while publishing that document. In contrast, NNSA SD 1027 and DOE Standard 1027-2018 did not use the values listed in the EPA document as a starting point. Instead, NNSA SD 1027 and DOE Standard 1027-2018 derived the TQ values based on the 10 rem whole body effective dose threshold described in DOE Standard 1027-92. Therefore, the NNSA SD and DOE Standard 1027-2018 only considered the whole body effective dose limit and neglected consideration of organ doses. This resulted in a non-conservative change to the HC-3 TQ values derived in NNSA SD 1027 and DOE Standard 1027-2018 compared to DOE Standard 1027-92.

More Clarity is Needed in DOE Hazard Categorization Documents—The Board's staff team identified that all of DOE's hazard categorization documents need more clarity regarding **adjusting hazard categorization release factions**, **evaluating new information that impacts Below HC-3 facilities, criticality exclusions**, and **material-at-risk exclusions**. The lack of clarity could cause errors during defense nuclear facility hazard categorization. The Board's June 26, 2006, letter to DOE also identified a lack of clarity in DOE Standard 1027-92 [5]. While DOE has improved the guidance in DOE Standard 1027-2018, the following gaps remain:

Adjusting Hazard Categorization Release Fractions. DOE hazard categorization documents use a number of potentially non-conservative input parameters when calculating hazard category thresholds. For example, the DOE-assumed dispersion characteristics and release fractions in the TQ derivation may not bound accident conditions at specific facilities and sites. Such parameters would not be acceptable for use in safety analysis per DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [11].

DOE Standard 1027-92 discusses adjusting TQ values during final categorization for facilities initially classified as HC-2 to account for facility conditions that are different than what was assumed in the TQ derivation (i.e., the standard allows for technically justified adjustments to TQ values during final categorization that would allow a HC-2 facility to be downgraded to a HC-3 or Below HC-3 facility). However, DOE Standard 1027-92 does not have similar language suggesting or requiring TQ value adjustments for facilities initially categorized as HC-3 or Below HC-3 that have facility-specific conditions that exceed what was assumed in the TQ value derivation. This may result in facility mis-categorization when using DOE Standard 1027-92, which is the version cited by 10 CFR 830 and used by some DOE contractors.

To account for this gap in more recent versions of the standard, DOE provided additional guidance on adjusting the TQ values in DOE Standard 1027-2018 and NNSA SD 1027. For example, DOE Standard 1027-2018 states, "The methodology used to modify TQs should also be applied to situations where hazard categorization could be increased because of conditions identified in the hazard analysis." The contractor would apply the modified TQs as part of the final hazard categorization. While this is an improvement compared to DOE Standard 1027-92, there are number of concerns with the added language. Specifically, the standard (1) only provides guidance and does not require analysts to modify TQ values in situations where hazard categorization could be increased; (2) does not provide specific examples that require TQ modification to help guide analysts; (3) TQ modification only applies to final hazard categorization, and final hazard categorization is not required for facilities initially categorized as Below HC-3; and (4) as noted above, there is no analogous statement in DOE Standard 1027-92 Change Notice 1, which is the version cited by 10 CFR 830.

Evaluating New Information that Impacts Below Hazard Category 3 Facilities. New information may challenge the underlying conditions and assumptions that form the basis for the hazard categorization of a facility. In this situation, HC-2 and HC-3 facilities would follow the unreviewed safety question process outlined in 10 CFR 830. However, this process isn't applicable to Below HC-3 facilities because the safety basis requirements of 10 CFR 830 Subpart B do not apply to these types of facilities. Thus, it is unclear what process Below HC-3 facilities would follow if new information is identified that could affect its hazard categorization.

The Board's staff team is aware of recent examples at the Liquid Effluent Retention Facility at the Hanford Site [12], [13] and at TA-21-257, which is the former Radioactive Liquid Waste Facility at Los Alamos National Laboratory [14], [15], [16], where new information led to questions regarding whether these facilities were appropriately categorized as Below HC-3. In both instances, progress towards resolution of the issue was delayed due to the lack of clear guidance in DOE Standard 1027 for situations that question whether a Below HC-3 facility is appropriately categorized.

Criticality Exclusions. In addition to the TQ values based on radiological dose, Standard 1027 includes thresholds based on the potential for nuclear criticality involving fissile radionuclides (e.g. U-233, U-235, Pu-239). When the criticality-based thresholds are exceeded, DOE Standard 1027-2018 states that "the facility shall be initially categorized as HC-2, unless

criticality is precluded by segmentation or a nature of the process evaluation via simple screening." However, the standard does not provide adequate guidance for a "nature of process evaluation" or "segmentation." Specifically, the standard does not provide: a substantive definition for "nature of the process;" the criteria that should be met to develop a "simple screening;" and what types of initial conditions are appropriate and how these conditions should be protected as part of the safety basis. This lack of guidance could lead analysts to inappropriately screen out criticality hazards causing facility mis-categorization. Improved guidance in the standard that includes examples of appropriate and inappropriate criticality screening by "segmentation" and "nature of the process evaluation" could improve the usability of the standard.

Material-at-risk Exclusions. DOE Standard 1027-2018 allows for sealed sources and Type B packages to be excluded from initial hazard categorization, but states they should be analyzed during final hazard categorization as DOE facilities may present hazards not compatible with the design of sealed sources and Type B packages. The standard also states, "If the result of the initial hazard categorization concludes that the facility will be categorized as Below HC-3, final hazard categorization is not performed."

A Below HC-3 facility could have a credible accident scenario that impacts the integrity of sealed sources and Type B containers. The initial categorization could exclude these materials, and there would be no final hazard categorization that confirms whether this exclusion was technically justified. This concern is exacerbated by the fact that the level of rigor, analysis, and documentation required by a Below HC-3 facility is significantly less than what is required for HC-2 and HC-3 facilities. As a result, a detailed evaluation of hazards impacting sealed sources and Type B containers may never be performed. To address this gap, DOE Standard 1027-2018 could require sealed sources and DOT Type B containers to be included as part of the inventory during initial categorization, but allow these containers to be screened from final categorization if the containers can be shown to perform their safety function under all accident scenarios.

DOE Standard 1027-2018 allows for the exclusion of commercially available source and byproduct materials from facility hazard categorization. The standard states, "The exclusion is not extended to a commercially available product that is modified or altered from its intended use (e.g., removal of sources from a smoke detector)." However, the standard does not explicitly caution against applying this exclusion in cases where routine facility operations are intended to accumulate these types of materials.

Inappropriate Use of "Should" Statements—The Board's staff team identified multiple instances where DOE Standard 1027-2018 uses a "should" statement where a "shall" statement is appropriate.[5] Analysts are allowed to treat "should" statements as guidance rather than requirements. If these statements are taken as guidance rather than requirements, it may result in analysts under-categorizing DOE's defense nuclear facilities, which could result in facility-level controls being misclassified. These statements are documented in Appendix A.

[5] This section is focused on DOE Standard 1027-2018. However, many of the same concepts also apply to DOE Standard 1027-92 and NNSA SD 1027.

Additional Observations. In addition to the safety items documented above, the staff team noted several observations that do not significantly affect hazard categorization, but could cause inconsistencies within facility safety bases.

External Dose Pathways—DOE Standard 1027-2018, DOE Standard 1027-92, and NNSA SD 1027 all underestimate the radiological dose consequence for several gamma-ray emitting radionuclides by inappropriately applying a respirable fraction to external dose pathways (e.g., cloudshine) in the calculations of HC-2 TQs. This does not have a significant impact on hazard categorization TQ values. However, DOE could consider updating applicable TQ values to appropriately account for this phenomena to ensure that the values fully account for all radiation exposure pathways.

Threshold Quantity Values by Mass—DOE Standard 1027-2018, DOE Standard 1027-92, and NNSA SD 1027 list TQ values by mass and by activity. The Board's staff identified that the derivation of TQ values by mass is dependent on the half-life values used, and that half-life values occasionally get updated based on newer data and scientific experiments. Changes in half-life values can directly impact the derived TQ values by mass and may lead to inconsistencies in a safety basis if different documents use different half-life databases. While changes in half-life values should not significantly affect hazard categorization results, DOE Standard 1027 could acknowledge this concern and provide guidance to use TQ values based on a radionuclide's activity instead of mass.

Conclusion. The Board's staff team reviewed DOE's three hazard categorization documents and identified multiple safety items. The most significant is with the use of NNSA SD 1027. NNSA SD 1027 uses a methodology that is not technically justified, is not conservative, and is inconsistent with other versions of the standard. Its use may result in inappropriate facility hazard categorization.

Overall, the Board's staff team believes that DOE should discontinue the use of NNSA SD 1027 because it is superseded by DOE Standard 1027-2018 and is inconsistent with 10 CFR 830. Further, DOE Standard 1027-2018 should be updated to correct deficiencies and to clarify its guidance and requirements in order to improve its usability and to ensure appropriate and consistent facility hazard categorization. Ensuring appropriate facility categorization is important because under-categorizing a facility could result in analysts failing to identify appropriate controls to protect workers and members of the public due to the reduction in the level of analysis required for HC-3 and Below HC-3 compared to what is required for HC-2 facilities.

References

[1] Department of Energy, Title 10 Code of Federal Regulations, Part 830, *Nuclear Safety Management*, Subpart B, Safety Basis Requirements, 2020.

[2] Department of Energy, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Report*, DOE Standard 1027-92, Change Notice 1, September 1997.

[3] National Nuclear Security Administration, *Guidance on Using Release Fraction and Modern Dosimetric Information Consistently with DOE STD 1027-92 Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change No. 1, NNSA SD G 1027, Admin Change 1, May 2014.

[4] Department of Energy, *Hazard Categorization of DOE Nuclear Facilities*, DOE Standard 1027-2018, Change Notice 1, January 2019.

[5] Defense Nuclear Facilities Safety Board, *Issues Associated with the Implementation of DOE Standard 1027-92*, Letter to Acting Assistant Secretary for Environment, Safety, and Health, C. Russell H. Shearer, June 26, 2006.

[6] Defense Nuclear Facilities Safety Board, *Nuclear Safety Requirements*, Recommendation 2020-1, February 21, 2020.

[7] International Commission on Radiological Protection, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*, ICRP Publication 72, 1996.

[8] International Commission on Radiological Protection, *Dose Coefficients for Intakes of Radionuclides by Workers*, ICRP Publication 68, 1994.

[9] Environmental Protection Agency, *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides*, 1985.

[10] International Commission on Radiological Protection, *Limits for Intakes of Radionuclides by Workers*, ICRP Publication 30, 1979.

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

[12] Defense Nuclear Facilities Safety Board, *Resident Inspector Weekly Report: Hanford*, March 20, 2020.

[13] Defense Nuclear Facilities Safety Board, *Resident Inspector Weekly Report: Hanford*, July 19, 2019.

[14] Defense Nuclear Facilities Safety Board, *Resident Inspector Weekly Report: Los Alamos National Laboratory*, August 14, 2020.

[15] Defense Nuclear Facilities Safety Board, *Resident Inspector Weekly Report: Los Alamos National Laboratory*, July 17, 2020.

[16] Defense Nuclear Facilities Safety Board, *Resident Inspector Weekly Report: Los Alamos National Laboratory*, June 12, 2020.

Appendix A: Inappropriate Use of "Should" Statements in DOE Hazard Categorization Documents

Inappropriate use of "Should" Statements. The Defense Nuclear Facilities Safety Board's (Board) staff team identified multiple instances where Department of Energy (DOE) Standard 1027-2018 uses a "should" statement where a "shall" statement is appropriate.[1] These statements are listed below. Note that the Board's staff team bolded the word "should" for added emphasis and provided staff team analysis in the italicized Roman numeral sub-bullets.

a. "Below HC-3 [hazard category 3] facilities **should** have administrative controls in place to ensure the facility remains Below HC-3."

   i. Below HC-3 facilities have limited analysis, documentation, and controls. Ensuring that this type of facility remains appropriately categorized is an important part of a Below HC-3 facility's control strategy. Accordingly, the above statement in the standard should be elevated to a requirement, but allow technically justified exemptions in situations where it is not possible to exceed the HC-3 TQ value at a given facility.

b. "Complex analysis or phenomenology is not appropriate for initial hazard categorization. If such analysis is necessary to demonstrate segmentation of multiple structures or segmentation within a single structure, it **should** be supported by the final hazard categorization (see Section 3.2.2)."

   *i. If a facility wants to credit segmentation via a complex analysis it must be technically justified and supported in order to ensure that a facility is not mis-categorized. Accordingly, the above statement should be elevated to a requirement. This approach is also consistent with other parts of DOE Standard 1027-2018, which state, "Simple screening, with respect to criticality, in initial hazard categorization for nature of process and segmentation is allowed, see Section 3.1.6. Such arguments **will** be defended as part of final hazard categorization, as necessary" [Emphasis added].*

c. "The methodology used to modify TQs **should** also be applied to situations where hazard categorization could be increased because of conditions identified in the hazard analysis."

   i. There is no analogous statement (neither requirement nor guidance) in DOE Standard 1027-92 Change Notice 1, which is the version cited by 10 CFR 830.

   ii. This issue is described in more detail in the <u>More Clarity is Needed in DOE Hazard Categorization Documents</u> section of this report.

[1] This appendix is focused on DOE Standard 1027-2018. However, many of the same concepts also apply to other versions of the hazard categorization standard.

d. "Sealed sources are designed for multiple accident scenarios, however, DOE facilities may present hazards not compatible with design of sealed sources. In such a case, the radioactive material **should** not be excluded as part of the initial hazard categorization SOR [sum of ratios calculation] and hazard analysis necessary to demonstrate the integrity of the sealed source **should** be supported in final hazard categorization."

    i. *This issue is described in more detail in the More Clarity is Needed in DOE Hazard Categorization Documents section of this report.*

e. "[Department of Transportation] DOT Type B packages are designed for multiple accident scenarios, however, DOE facilities may present hazards not compatible with Type B package design. In such a case, the radioactive material **should** not be excluded as part of the initial hazard categorization SOR and hazard analysis necessary to demonstrate the integrity of the Type B package **should** be supported in final hazard categorization (see Section 3.2.3)."

    i. *This issue is described in more detail in the More Clarity is Needed in DOE Hazard Categorization Documents section of this report.*

    ii. *The staff notes that DOE does a better job of addressing this gap in DOE Standard 3009-2014. While DOE Standard 3009 is used for safety basis development and not hazard categorization, it provides some added context to this concern. Specifically, DOE Standard 3009-2014 states, "While DOE-STD-1027-92 excludes material in Department of Transportation Type B containers from consideration for the purposes of hazard categorization, the existence of such material **shall** be acknowledged in the DSA and the material excluded from the source term for a particular accident scenario only if the containers can be shown to perform their safety functions under accident conditions." However, Below HC-3 facilities typically do not use DOE Standard 3009-2014, and as a result this gap remains for this type of facility.*

f. "The conditions, parameters, and assumptions that form the basis for the hazard categorization of the facility **should** be maintained to ensure the hazard categorization remains valid."

    i. *If the underlying technical basis for hazard categorization changes, it may invalidate the hazard categorization of a facility. Accordingly, this statement should be elevated to a requirement.*

g. "In cases where direct shine may contribute significantly to dose, that contribution **should** be evaluated without the use of the RF [respirable fraction], and without the use of the ARF [airborne release fraction] if due to a spill release resulting in exposure to a pool."

    i. *Final hazard categorization should be based on a bounding analysis and as a result, this statement should be elevated to a requirement. This is*

consistent with other parts of DOE Standard 1027-2018. Specifically, "Hazard analysis is performed as part of final hazard categorization to determine the effects of available energy sources and radioactive material release mechanisms. The primary objectives of the hazard analysis are to… ***identify a bounding material at risk (MAR) and associated release fractions based on these factors"*** *[emphasis added].*

h. "When evaluating a postulated criticality accident for demonstrating that criticality is precluded by the nature of the process, only the conditions listed below **should** be considered..."

   i. *This language in DOE Standard 1027-2018 is unclear. Specifically, it is unclear whether this statement is establishing the permissible bounds for consideration or whether a contractor could consider "nature of the process" arguments other than those listed in the standard. In any case, more guidance and clarity is needed regarding treatment of criticality. This is described further in the More Clarity is Needed in DOE Hazard Categorization Documents section of this report.*

i. "If a change is planned at a facility or new information is discovered that affects a condition or assumption relied on to form the basis of a final hazard categorization downgrade, contractors **should** ensure that the basis for the hazard categorization remains valid in accordance with 10 CFR Part 830, Section 830.202(c)."

   i. *The above statement should be elevated to a requirement in order to ensure consistency with 10 CFR 830. This is consistent with other parts of DOE Standard 1027-2018. Specifically, the standard states, "Title 10 of the Code of Federal Regulations Part 830, Nuclear Safety Management, Subpart B, Safety Basis Requirements, establishes safety basis requirements for hazard category 1, 2, or 3 DOE nuclear facilities."*

   ii. *Additional guidance or requirements may be necessary to address situations in which new information raises questions that challenge the hazard categorization basis for Below HC-3 facilities. This issue is described further in the More Clarity is Needed in DOE Hazard Categorization Documents section of this report.*

j. "Bounding estimates, and in many cases median estimates, for radionuclide ARFs and RFs for a wide variety of MAR and release phenomena are presented in DOE-HDBK-3010. The bounding estimates **should** be used unless a different value is provided in an applicable standard or is otherwise technically justified."

   i. *DOE Standard 1027-2018 should require the use of bounding values listed in DOE Handbook 3010 unless a different value is technically justified. This is important in order to ensure consistent and appropriate gradation of facilities across DOE's nuclear weapons complex.*

There is some precedence for making the above statement a requirement. Specifically, DOE Standard 3009-2014 states, "Bounding estimates, and in many cases median estimates, for radionuclide ARFs and RFs for a wide variety of MAR and release phenomena are presented in DOE-HDBK-3010. The bounding estimates ***shall*** *be used unless a different value is provided in an applicable standard or is otherwise technically justified." While DOE Standard 3009-2014 is not used for hazard categorization, it illustrates a scenario where other DOE standards address this gap.*

AFFIRMATION OF BOARD VOTING RECORD

SUBJECT: DOE Nuclear Facility Hazard Categorization and DOE STD 1027

Doc Control#: 2021-100-0002

The Board acted on the above document on 12/23/2020. The document was Approved.

The votes were recorded as:

	APRVD	DISAPRVD	ABSTAIN	NOT PARTICIPATING	COMMENT	DATE
Thomas Summers	✔	☐	☐	☐	☐	12/23/2020
Jessie H. Roberson	✔	☐	☐	☐	☐	12/22/2020
Joyce L. Connery	✔	☐	☐	☐	☐	12/22/2020

This Record contains a summary of voting on this matter together with the individual vote sheets, views and comments of the Board Members.

Shelby Qualls

Executive Secretary to the Board

Attachments:

1. Voting Summary
2. Board Member Vote Sheets

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

NOTATIONAL VOTE RESPONSE SHEET

FROM: Thomas Summers

SUBJECT: DOE Nuclear Facility Hazard Categorization and DOE STD 1027

Doc Control#: 2021-100-0002

DATE: 12/23/2020

VOTE: Approved

COMMENTS:

None

Thomas Summers

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

NOTATIONAL VOTE RESPONSE SHEET

FROM: Jessie H. Roberson

SUBJECT: DOE Nuclear Facility Hazard Categorization and DOE STD 1027

Doc Control#: 2021-100-0002

DATE: 12/22/2020

VOTE: Approved

Member voted by email.

COMMENTS:

None

Jessie H. Roberson

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

NOTATIONAL VOTE RESPONSE SHEET

FROM: Joyce L. Connery

SUBJECT: DOE Nuclear Facility Hazard Categorization and DOE STD 1027

Doc Control#: 2021-100-0002

DATE: 12/22/2020

VOTE: Approved

COMMENTS:

None

Joyce L. Connery