May 10, 2021 ADMINISTRATIVE CHANGE 2 TO

NNSA SD 1027, "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"

Page	Paragraph	Changed	To
AT1-3	Section 2.2: Final Hazard Categorization	Clarifying language added to Section 2.2.	This supplemental directive, approved in 2011, was written to be consistent with STD-1027-1992, which is based on the ICRP 26 system, while permitting the use of dose coefficients from the ICRP 60 system. In 2018 DOE updated the hazard categorization standard based on dose coefficients from the ICRP 60 system. DOE-STD-1027-2018 and this supplemental directive provide a consistent framework but made different choices in developing the HC2 threshold tables. The ICRP recognizes that different chemical compounds of a radionuclide behave differently in the body, specifically in how inhaled radionuclides move from the lungs to the blood. DOE-STD-1027-1992 and 1027-2018 always choose the most conservative lung absorption class in developing their tables while this supplemental directive uses the ICRP "Recommended default absorption type for particulates when no specific information is available" where a recommendation exists and otherwise uses the most conservative option. This results in differences between the tables in STD-1027-2018 and this supplemental directive. There is value in both approaches and by presenting tables based on the ICRP's recommended default values the NNSA provides

			supplementary information that can be used to avoid excessive conservatism where appropriate. If the final hazard categorization analysis shows that the release fractions assumed in Table 1 of Attachment 2 or Attachment 6 are not conservative, then the Table 1 threshold values should be adjusted following the approach included in Section 2.2.1 below. In particular, the lung absorption classes must be reviewed to assure the proper class has been selected given the form of the material and the postulated accident scenarios when inhalation of material is a concern. ***NOTE: Any adjustments to the release fraction should be technically defensible and appropriately conservative and documented and cannot be accounted for in any other parameter in determining the adjusted threshold quantity.***

May 13, 2014 ADMINISTRATIVE CHANGE TO
NNSA SD G-1027, "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"***

Locations of Changes:

Page	Paragraph	Changed	To
2 / 3			Added Revision History Table
3	2	CANCELLATION. None. When implemented for a nuclear facility, the methodology provided in Attachments 1 and 2 of this guidance should be used as a consistent approach to use modern dosimetry and release fractions when performing hazard categorization consistent with the following sections from 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, September 1997* (DOE STD 1027-92): • Section 2.1, Preliminary Assessment of Facility Hazard • Section 3.1.1, Initial Radiological Hazards Screening • Section 3.1.2, Final Hazard Categorization • Attachment 1, Table A.1, Thresholds for Radionuclides	<u>CANCELLATION</u>. NA-1 SD G 1027, dated 11-28-11. When implemented for a nuclear facility, the methodology provided in Attachments 1 and 2 of this guidance should be used as a consistent approach to use modern dosimetry and release fractions when performing hazard categorization consistent with the following sections from 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, September 1997* (DOE STD 1027-92): • Section 3.1.2, Final Hazard Categorization • Attachment 1, Table A.1, Thresholds for Radionuclides
Most	Header	Attachment 1: Hazard Categorization Methodology	Attachment 1: Hazard Categorization Guidance

Page	Paragraph	Changed	To
7	1	Section 2.1, Preliminary Assessment of Facility Hazard Section 3.1.1, Initial Radiological Hazards Screening Section 3.1.2, Final Hazard Categorization Attachment 1, Table A.1, Thresholds for Radionuclides	• Section 3.1.2, Final Hazard Categorization • Attachment 1, Table A.1, Thresholds for Radionuclides
8	2.1 pgh1	Initial radiological hazards screening enables facility managers to determine quickly the likely facility categorization. This process is to provide an initial screening of the potential radiological hazards represented by a facility. It should be used for preliminary assessment of facility hazards in "plans and schedules" for proposed upgrades to Documented Safety Analyses when a Hazards Analysis has not been performed. Per DOE STD 1027-92, all nuclear facilities (i.e., radiological, Hazard Category 1, 2 and 3) must be screened to ensure they are properly categorized.	Initial radiological hazards screening enables facility managers to determine quickly the likely facility categorization. This process is to provide an initial screening of the potential radiological hazards represented by a facility. It should be used for preliminary assessment of facility hazards in "plans and schedules" for new nuclear facilities when a Hazards Analysis has not been performed, or for proposed upgrades to existing nuclear facilities. Per DOE STD 1027-92, all nuclear facilities (i.e., radiological, Hazard Category 1, 2 and 3) must be screened to ensure they are properly categorized.
8	2.1 last pgh	Note: Some of the thresholds recalculated and tabulated in this guidance are lower than those that were in the tables included in DOE STD 1027-92. A lower threshold leads to a more conservative categorization. Attachment 2, Table 2 of this guidance identifies the more conservative isotope thresholds in yellow. For isotopes where the thresholds in this guidance are more conservative than those in	Initial facility hazard categorization is per DOE-STD-1027-92.

Page	Paragraph	Changed	To
		DOE STD 1027-92, the thresholds from this guidance should be used to ensure a conservative initial categorization. Other isotopes should use the more conservative values from DOE STD 1027-92.	
9	Sec 2.2	Re-write of section: Once a Hazards Analysis (or safety analysis for less-than Hazard Category 3 nuclear facilities) has been performed, consistency with DOE STD 1027-92 requires the hazard categorization to be finalized for facilities initially categorized as Hazard Category 1, 2, or 3. A final categorization for facilities that are initially categorized as less-than Hazard Category 3 should also be performed in situations where mechanisms exist that could result in a greater radiological release than assumed when creating the tabulated thresholds. The final categorization is based on an "unmitigated release" of available hazardous material. For the purposes of hazard categorization, "unmitigated" is meant to consider material quantity, form, location, dispersibility and interaction with available energy sources, but not to consider safety features (e.g., ventilation system, fire suppression, etc.) which will prevent or mitigate a release. For less-than Hazard Category 3 nuclear facilities (i.e. radiological facilities) the safety analysis need not comply with Subpart B of 10 C.F.R. 830, but should be of	Once a Hazards Analysis (or other analysis for less-than Hazard Category 3 nuclear facilities) has been performed, consistency with DOE STD 1027-92 requires the hazard categorization to be finalized for facilities initially categorized as Hazard Category 1, 2, or 3. A final categorization for facilities that are initially categorized as less-than Hazard Category 3 should also be performed for situations where mechanisms exist that could result in a greater radiological release than assumed when creating the tabulated thresholds. For the purposes of final hazard categorization, "unmitigated" is meant to consider material quantity, form, location, dispersibility and interaction with available energy sources, but not to consider safety features (e.g., ventilation system, fire suppression, etc.) which will prevent or mitigate a release. For less-than Hazard Category 3 nuclear facilities (i.e., radiological facilities) the analysis supporting final hazard

Page	Paragraph	Changed	To
		sufficient rigor to provide confidence that the applicable thresholds in Table 1 of Attachment 2 are conservative. The Hazards Analysis (or other existing safety analyses) provides an understanding of the material which can physically be released from the facility. This inventory should be compared against the thresholds identified in Table 1 of Attachment 2. The release fractions used in generating the thresholds for Category 2 and 3 are provided in the table. These are intended to be generally conservative for a broad range of possible situations. Therefore, the inventory values of Table 1 may be used directly for determination as to whether a facility should be categorized as Hazard Category 2 or 3. However, for final categorization, if the credible release fractions or limiting exposure pathways can be shown to be significantly different than these values based on physical and chemical form and available dispersive energy sources, the thresholds should be adjusted if non-conservative (and may be adjusted if conservative) following the approach included in Section 2.2.1 below. The hazard or safety analysis should demonstrate that the assumptions made in developing the threshold values or reducing the material at risk apply in the facility being analyzed. A bases section has been provided as	categorization need not comply with Subpart B of 10 C.F.R. 830, but should be of sufficient rigor and documented to provide confidence that the final hazard categorization determination is conservative. For determining the HC-3 Threshold Quantity (TQ), the methodology is that used by Reference ‘p’ of this SD G. That methodology considers multiple exposure pathways, of which the inhalation and vegetable ingestion pathways use the release fraction variable, while the ground water ingestion and direct exposure pathways do not. The assumed release fractions are documented in Exhibit A-1 of Reference ‘p’ and are provided in Attachment 6 of this SD G for ease of reference. The limiting pathway for a specific radionuclide is then chosen as the pathway with the smallest TQ. If it is determined in the final hazard categorization analysis that the associated release fractions for a specific radionuclide are not bounded by the assumed release fractions, then the facility should re-calculate the TQs for the different exposure pathways and verify the limiting pathway and associated TQ, as further described in Section 2.2.1 below. For determining the HC-2 TQ, the methodology is per

Page	Paragraph	Changed	To
		Attachment 4 of this guidance as a reference for understanding the assumptions that were used in the derivation of the threshold quantities provided in Table 1 of Attachment 2. If the facility has a final categorization of less than Hazard Category 3, it is a radiological facility. Regardless of the thresholds in Table 1 of Attachment 2, facilities that would be categorized as Hazard Category 2 based on the consideration of criticality are required by consistency with DOE STD 1027-92 to have a final categorization of Hazard Category 2.	Attachment 1 in DOE-STD-1027-92 CN1 and the assumed release fractions are documented on Pages A-8 and A-9. If it is determined in the final hazard categorization analysis that the associated release fraction is not bounded by the assumed release fraction, then the facility should re-calculate the threshold by dividing the listed TQ by the ratio of the maximum potential release fraction to the assumed release fraction~~s~~, as further discussed in Section 2.2.1 below. If the final hazard categorization analysis shows that the release fractions assumed in Table 1 of Attachment 2 or Attachment 6 are not conservative, then the Table 1 threshold values should be adjusted following the approach included in Section 2.2.1 below. ***NOTE: Any adjustments to the release fraction should be technically defensible and appropriately conservative and documented and cannot be accounted for in any other parameter in determining the adjusted threshold quantity.*** The Hazards Analysis (or other existing safety analyses) provides an understanding of the material which can physically be released from the facility. This inventory

Page	Paragraph	Changed	To
			should be compared against the thresholds identified in Table 1 of Attachment 2. The release fractions used in generating the thresholds for Category 2 and 3 are provided in the table. These are intended to be generally conservative for a broad range of possible situations. Therefore, the inventory values of Table 1 may be used directly for determination as to whether a facility should be categorized as Hazard Category 2 or 3. The hazard or safety analysis should demonstrate that the assumptions made in developing the adjusted threshold values or reducing the material at risk apply in the facility being analyzed. A bases section has been provided as Attachment 4 of this guidance as a reference for understanding the assumptions that were used in the derivation of the threshold quantities provided in Table 1 of Attachment 2. Regardless of the thresholds in Table 1 of Attachment 2, facilities that would be categorized as Hazard Category 2 based on the consideration of criticality are required by consistency with DOE STD 1027-

Page	Paragraph	Changed	To
			92 to have a final categorization of Hazard Category 2.
9	Last pgh	For compliance with this guidance, the threshold values for Hazard Category 2 or 3 in Table 1 should be adjusted if non-conservative (and may be adjusted if conservative). This applies to final categorization of facilities initially classified as Hazard Category 3 or radiological, if the applicable ARFxRF product for the scenario being evaluated is significantly different than the values provided in Table 1. This process may result in an increase or decrease of a facility hazard category.	For compliance with this guidance, the threshold values for Hazard Category 2 or 3 in Table 1 should be adjusted if non-conservative (and may be adjusted if conservative). This applies to final categorization of facilities initially classified as Hazard Category 3 (HC-3) or less than HC-3 (i.e. radiological), if the applicable ARFxRF product for the scenario being evaluated is significantly different than the values provided in Table 1. This process may result in an increase or decrease of a facility hazard category.
10	Pgh 2	These thresholds should be adjusted when the exposure scenario would be significantly different and less conservative from that assumed in the development of the thresholds; adjustment should account for release pathways as well.	These thresholds should be adjusted when the exposure scenario would be significantly different and less conservative from that assumed in the development of the thresholds; adjustment should account for all release pathways as well.
10	Last pgh	In that case, when the conditions being evaluated are significantly different than the assumptions used to develop the thresholds in Table 1, the only potential adjustment of the threshold is to recalculate it using the methodology described in Attachment 4 of this guidance, adjusted to account for the difference in pathway or other relevant differences.	In that case, when the conditions being evaluated are significantly different than the assumptions used to develop the thresholds in Table 1, the only potential adjustment of the threshold is to recalculate it using the methodology described in **Attachment 4** of this guidance, adjusted to account for the difference in exposure pathways or other relevant differences.
11	Pgh 1	These factors and a new breathing rate consistent with the new ICRP references of 3.3 x 10-4	These factors and a new breathing rate consistent with the new ICRP references of

Page	Paragraph	Changed	To
		m3/s have been used in the determination of revised threshold quantities for both Hazard Category 2 and Hazard Category 3 facilities.	3.3333 x 10^{-4} m^3/s have been used in the determination of revised threshold quantities for both Hazard Category 2 and Hazard Category 3 facilities.
11	Last pgh		Added this sentence: NOTE: When implementing this SD G, for radionuclides not listed in Table 1 of Attachment 2, the threshold values should be calculated in accordance with Attachment 4 of this SD G.
12	Table 1 S-35	1.22E+02 2.85E-03	2.21E+01 5.18E-04
12	Table 1 Ti-44	4.97E+02 6.91E-01	3.93E+02 5.46E-01
12	Table 1 Kr-85	2.27E+07 5.80E+04 3.33E+04 8.49E+01	1.06E+07 2.70E+04 1.46E+05 3.71E+02
12	Table 1 Nb-94	4.62E+02 2.43E+03	2.49E+02 1.33E+03
12	Table 1 Mo-99	4.25E+03 8.84E-03	3.76E+03 7.84E-03
13	Table 1 Sn-126	2.43E+07 1.35E+04	1.02E+07 5.89E+03
13	Table 1 Sb-126	6.77E+02 8.1-E-03	2.64E+02 3.15E-03
13	Table 1 Xe-133	1.73E+06 9.23E+00 6.12E+03 3.26E-02	1.95E+06 1.04E+01 2.67E+04 1.43E-01
13	Table 1 Hg-203	1.79E+03 1.30E-01	5.06E+02 3.67E-02
14	Table 1 Bi-207	2.58E+04 3.90E+02 7.21E+00	3.06E+04 4.71E+02 1.04E+01
14	Table 1 Ac-227	2.09E-01 2.88E-03	1.78E-01 2.45E-03
14	Table 1 U-232	3.4E+00 1.46E-01	3.21E+00 1.49E-01
14	Table 1 end		Added: * Yellow filled boxes are updated value per the enclosed errata sheet
16	Table 2 S-35	2.9E-03	5.2E-04
16	Table 2 Ti-44	5.0E+02 6.9E-01	3.9E+02 5.5E-01
16	Table 2 Kr-85	5.8E+04 8.5E+01	2.7E+04 3.7E+02
16	Table 2 Nb-94	2.4E+03	1.3E+03
16	Table 2 Mo-99	8.8E-03	7.8E-03
17	Table 2 Sn-126	2.3E+07 1.4E+04	1.0E+07 5.9E+03
17	Table 2 Sb-126	8.1E-03	3.2E-03
17	Table 2 Xe-133	9.2E+00 3.3E-02	1.0E+01 1.4E-01
17	Table 2 Hg-203	1.3E-01	3.7E-02
18	Table 2 Bi-207	2.6E+04 7.2E+00	3.1E+04 1.0E+01

Page	Paragraph	Changed	To
18	Table 2 Ac-227	2.9E-03	2.5E-03
18	Table 2 end		Added footnote : ** Value changed as a result of SD G Update 2013 per enclosed errata sheet
19	Att 3 pgh 1	The methodology in Attachments 1 and 2 of this guidance implements an approach to consistently update the dosimetric values and release fractions used for categorizing nuclear facilities described in Sections 2.1, 3.1.1 and 3.1.2 of DOE STD 1027-92.	The methodology in Attachments 1 and 2 of this guidance implements an approach to consistently update the dosimetric values and release fractions used for categorizing nuclear facilities described in Section 3.1.2 of DOE STD 1027-92.
23	Add sec b		b. Radionuclide Reference Data: For purposes of this SD G 1027 Update, a change in the use of reference data for radionuclide information was updated. Because the International Commission on Radiological Protection (ICRP) publication 68 references ICRP-38 for radionuclide information, that same publication for radionuclide reference data will be used in this update. Further, it was also decided that should data be unavailable in ICRP-38, then the succession for reference data would then be ICRP-107. The Cloud Shine Dose Coefficients (CSDE) are obtained from Table III.1 ‘Dose coefficients for Air Submersion’ of Federal Guidance Report NO. 12 (FGR-12) dated September 1993 except as updated in ICRP-

Page	Paragraph	Changed	To
			72 Table A.4 'Effective dose rates for exposure of adults to inert gases'. The Committed Effective Dose Equivalent (CEDE) values are obtained from ICRP-72 Table A.2 'Inhalation does coefficients' and Table A.3 'Inhalation dose coefficients for soluble or reactive gases and vapors' as appropriate.
24	Pgh 2	It can be reasonably concluded from this CTA position that a breathing rate of 3.3 × 10-4 m3/s is an appropriate value to use in conjunction with dose conversion factors pertaining to both the worker (ICRP 68) and the public (ICRP 72). Accordingly, the revised Hazard Category 3 and 2 thresholds use dose coefficients from ICRP 68 and ICRP 72 respectively, in conjunction with a consistent breathing rate value of 3.3 × 10-4 m3/s.	It can be reasonably concluded from this CTA position that a breathing rate of 3.3333×10^{-4} m^3/s is an appropriate value to use in conjunction with dose conversion factors pertaining to both the worker (ICRP 68) and the public (ICRP 72). Accordingly, the revised Hazard Category 3 and 2 thresholds use dose coefficients from ICRP 68 and ICRP 72 respectively, in conjunction with a consistent breathing rate value of $3.3333 \times 10^{-4} m^3/s$.
24/25	Sec c	Section c is changed to d. Table A.1 of DOE STD 1027-92 specifies a Hazard Category 2 threshold for tritium of 30 grams. Per discussions with Tritium Focus Group Members and other personnel involved with the development of the Standard, it appears this value was chosen	Table A.1 of DOE STD 1027-92 specifies a Hazard Category 2 threshold for tritium of 30 grams. Per discussions with Tritium Focus Group Members and other personnel involved with the development of the Standard, it appears this value was chosen based on consensus,

Page	Paragraph	Changed	To
		based on consensus, taking into account operational considerations at the time. A revised threshold value was calculated to be 62.4 grams, and assumed the following: The inhalation dose coefficient selected from Table A.3 of ICRP 72 is for tritiated water for an adult (1.8E-11 Sv/Bq). Per discussions with the Chairman for the ICRP Task Group on Dose Calculations (at the time of publication of ICRP 72), this dose coefficient does not take into account skin absorption. Therefore, consistent with DOE-HDBK- 1129-2008, Tritium Handling and Safe Storage, a multiplication factor of 1.5 was used in the threshold calculation to address skin absorption. This factor can be applied to either the dose coefficient or the respiration rate – the resulting numerical value is the same. The airborne release fraction was conservatively chosen to be 0.5, which is consistent with the value specified in Appendix A (Modeling the Airborne Release and Inhalation of Radionuclides) of the EPA Technical Background Document used for the determination of Hazard Category 3 threshold values. A footnote (*) to Table A.1 of DOE STD 1027-92 stated that the DOE Tritium Focus Group provided a recommendation to increase the Hazard Category 3 threshold value from 0.1 grams to 1.6	taking into account operational considerations at the time. A revised threshold value was calculated to be 62.4 grams, and assumed the following: • The inhalation dose coefficient selected from Table A.3 of ICRP 72 is for tritiated water for an adult (1.8E-11 Sv/Bq). Per discussions with the Chairman for the ICRP Task Group on Dose Calculations (at the time of publication of ICRP 72), this dose coefficient does not take into account skin absorption. Therefore, consistent with DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*, a multiplication factor of 1.5 was used in the threshold calculation to address skin absorption. This factor can be applied to either the dose coefficient or the respiration rate – the resulting numerical value is the same. • The airborne release fraction was conservatively chosen to be 0.5, which is consistent with the value specified in Appendix A (Modeling the Airborne Release and Inhalation of Radionuclides) of the EPA Technical Background Document used for the determination of Hazard Category 3 threshold

Page	Paragraph	Changed	To
		grams. Given that the original Hazard Category 2 value was determined by consensus, and in light the Tritium Focus Group's past involvement with the Standard, NNSA requested that that they evaluate the revised Hazard Category 2 threshold value, and provide a recommendation to NNSA on an appropriate value to use. On August 25, 2010, Bill Weaver responded to NNSA on behalf of the Tritium Focus Group as follows: The position of the TFG [Tritium Focus Group] is to retain the existing DOE STD 1027 thresholds for tritium Category 2 and 3 nuclear facilities as is. The next meeting of the TFG is tentatively scheduled for the spring at SRS [Savannah River Site] and signed correspondence by all participants of that meeting can be obtained at that time, if desired. Accordingly, the radionuclide threshold values for tritium in Table 1 of this guidance default to the values in DOE STD 1027-92 (30 grams for Hazard Category 2, and 1.6 grams for Hazard Category 3).	values. A footnote (*) to Table A.1 of DOE STD 1027-92 stated that the DOE Tritium Focus Group provided a recommendation to increase the Hazard Category 3 threshold value from 0.1 grams to 1.6 grams. Given that the original Hazard Category 2 value was determined by consensus, and in light the Tritium Focus Group's past involvement with the Standard, NNSA requested that that they evaluate the revised Hazard Category 2 threshold value, and provide a recommendation to NNSA on an appropriate value to use. On August 25, 2010, Bill Weaver responded to NNSA on behalf of the Tritium Focus Group as follows: The position of the TFG [Tritium Focus Group] is to retain the existing DOE STD 1027 thresholds for tritium Category 2 and 3 nuclear facilities as is. The next meeting of the TFG is tentatively scheduled for the spring at SRS [Savannah River Site] and signed correspondence by all participants of that meeting can be obtained at that time, if desired. Accordingly, the radionuclide threshold values for tritium in

Page	Paragraph	Changed	To
			Table 1 of this guidance default to the values in DOE STD 1027-92 (30 grams for Hazard Category 2, and 1.6 grams for Hazard Category 3). UPDATE: On June 19, 2013, Bill Weaver communicated via email (B. Weaver to I. Trujillo) that the TFG has met since the publication of the SD G 1027. At that meeting, it was voted on that the TFG continues to endorse the Threshold Quantities as is currently while working on new values for recommendation for the upcoming TFG meeting in the Spring of 2014.
25	Add sec e		e. HC-2 Threshold Quantities Clarification When No Reference or DCF Data is Available for Calculation Per DOE-STD-1027-92 Attachment 1, Table A-1 sub-note 1, provides the following TQ's: • Any other beta-gamma emitter – 4.3E+05 Ci • Mixed fission products – 1.0E+03 Ci • Any other alpha emitter – 5.5E+01 Ci
27	Add sec b	Add this text to sec b. Original sec b is now sec c Original sec c is now sec d	b. Radionuclide Reference Data: For purposes of this SD G 1027 Update, a change in the use of reference data for radionuclide information was updated. Because the International Commission on Radiological

Page	Paragraph	Changed	To
			Protection (ICRP) publication 72 references ICRP-38 for radionuclide information, that same publication for radionuclide reference data will be used in this update. Further, it was also decided that should data be unavailable in ICRP-38, then the succession for reference data would then be ICRP-107.
27	Sec b	What is now section c, changed the following sentence: See Section b. in the Hazard Category 2 discussion above.	See Section c. in the Hazard Category 2 discussion above.
28	New sec d		Add this last paragraph: UPDATE: On June 19, 2013, Bill Weaver communicated via email (B. Weaver to I. Trujillo) that the TFG has met since the publication of the SD G 1027. At that meeting, it was voted on that the TFG continues to endorse the Threshold Quantities as is currently while working on new values for recommendation for the upcoming TFG meeting in the Spring of 2014.
28	New sec e		Add new section e.: e. Reference Data for Energy Level (E1) Direct Exposure Point Source The EPA Technical Background Document (reference p.), which provides the methodology as used by DOE-STD-1027 and this SD G 1027, provides an equation (Equation 6, p 4-13 of reference p) for calculating the release value for direct exposure point source. A variable in that equation is

Page	Paragraph	Changed	To
			known as E1, which is described as “the sum of the products of the gamma ray energies and the gamma ray fractions (MeV)”. To account for the various gamma ray energies and fractions when using this equation, the energy level for a given radionuclide was derived by taking the sum of the products of the gamma ray energies and the gamma ray fractions. For the initial SD G, this approach was used to derive the E1 value in the hand calculations. For this SD G Update, it was decided to use ICRP Publication 38 (ICRP-38) as the reference data for radionuclides. A benefit of using the ICRP-38 Publication is that it provides the E1 values for the radionuclides as listed. For note, ICRP-38 provides those values as both ‘LISTED’ and ‘OMITTED’. The omitted values are defined as those energies and fractions that contribute less than 0.100% of the energy level. For purposes of this SD G Update, the value used for E1 obtained from ICRP-38 considered both the listed and omitted by summing the two as provided.
28	Add sec f		Add new section f: f. Direct Exposure Cloud Submersion The EPA Technical Background Document (reference p.), which provides the methodology as used by DOE-STD-1027 and this

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			SD G 1027, provides an equation (Equation 10, p 4-17 of reference p) for calculating the release value for direct exposure cloud submersion. Argon, Krypton, and Xenon are the only noble gases whose release values are calculated based on total submersion in a cloud as discussed in reference p. A different equation for calculating direct exposure is provided for these noble gases because submersion in a cloud results in an integrated dose from all directions at varying distances from the body. The equation for this calculation considers the Derived Airborne Concentation (DAC) value for these isotopes. The DAC value is derived by considering the effective dose rates as published in ANNEXE D of ICRP-68. Assumptions considered in deriving the DAC value are 1 DAC = 0.05 Sieverts over a 2000 hour work year.
28/29	New 1st pgh section		Add new language to existing language: For this SD-G-1027 rev.1 update, a Quality Assurance (QA) plan for Re-calculating Errata Thresholds was developed and approved. The following QA Process, according to the approved plan, was followed in performing the re-calculations. 1. All thresholds will be re-calculated as hand calculations, either by calculator or by use of an

Page	Paragraph	Changed	To
			Excel spreadsheet (as an extension of a hand calculation). 2. If an Excel spreadsheet is used: a. The calculations will be conducted on DOE computers using the Excel software installed by the DOE CIO. b. Formulas for the Excel spreadsheet will be confirmed by calculator using existing threshold values. c. Software versions used will be documented. Hardware systems and versions used will be documented. d. A master controlled copy of spreadsheet calculations will be maintained by NA-SH-80. 3. Each revised threshold will be calculated independently by NNSA personnel with safety basis experience and qualified as either Senior Technical Safety Manager or Nuclear Safety Specialist. The individuals conducting the calculations will resolve any discrepancies between their calculations. 4. The revised threshold values will be distributed for peer review, at a minimum that will include review by qualified Senior Technical Safety Managers and/or Nuclear Safety Specialists in (1) NA-SH, (2) NA-00. 5. Upon resolving any discrepancies identified in

Page	Paragraph	Changed	To
			the peer review, a draft revised NA-1 SD G 1027 will be distributed for review/comment to each NNSA Site Office, NA-00, NA-10, NA-SH. A copy of the draft revised NA-1 SD G 1027 will be provided to the DFNSB staff. HC-2 and HC-3 TQ values were calculated independently by ORNL staff. NA-SH-60 NSS qualified and experienced staff performed independent calculations of HC-3 TQ values. The NA-SH-80 staff re-calculated values as documented in the errata sheet are consistent with ORNL values. Overall, all values re-calculated by NA-SH-80 staff are consistent with ORNL independent calculations. **QA Process for SD-G-1027 revision 0:**
29	New att		Add new attachment 5
29	New att		Add new attachment 6

SUPPLEMENTAL GUIDANCE

NNSA SD 1027

Approved: 11-28-11
Admin. Change 1: 05-13-14
Admin. Change 2: 05-10-21
Expires: 05-10-24

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*

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REVISION HISTORY

Revision:	Issue Date:	Revision Notes:
0	11-28-2011	Initial Issuance
1	xx-xx-2013	*NOTE: a red-line track changes version of this SD G Update is maintained and available by NA-SH-80.* *NOTE: the SD G 1027 rev. 1 was developed by NA-SH-80 with support from NA-00, NA-SH-60, and ORNL staff.* a. Incorporate as appropriate resolution of CDNS Comments to Revision 0 throughout document. b. Incorporate DNFSB Staff Comments by - Deletion of 2 bullets/text in Attachment 1 Section 1 - Clarification of text in Attachment 1 Section 2.2 - Clarification of text in Attachment 1 Section 2.2.1 regarding the use of release fractions c. Incorporate as appropriate resolution to four comments on Rev. 0 by Sandia Field Office -Comment 1 and 2: Add text to Attachment 1 Section 2.2 - Comment 3 and 4: no changes d. Add paragraph ‘b’ in Attachment 4 section Hazard Category 2 titled ‘Radionuclide Reference Data’. e. Add paragraph ‘b’ in Attachment 4 section Hazard Category 3 titled ‘Radionuclide Reference Data’. f. Clairified within the text of Attachment 4 the correct value used for BR = 3.3333 x 10^-04 m^3/s. g. Add an update in the last paragraph at the end of Attachment 4 section Hazard Category 2 on current status of Tritium Focus Group and the work to update new TQ values for Tritium h. Add an update in the last paragraph at the end of Attachment 4 section Hazard Category 3 bullet ‘e’ on current status of Tritium Focus Group and the work to update new TQ values for Tritium i. Added paragraphs ‘e’ and ‘f’ to Attachment 4 section Hazard Category 3 regarding Direct Exposure technical information. j. Updated Attachment 2, Table 1 and Table 2 revised threshold values for isotopes S-35, Ti-44, Kr-85, Nb-94, Mo-99, Sn-126, Sb-126, Xe-133, Hg-203, Bi-207, Ac-227, and U-232 (only Table 1); in accordance with Attachment 5 NA-SD-G-1027-rev.1 errata sheet. Plus added footnotes to each table as appropriate. k. Add Attachment 5 NA-1 SD-G-1027 rev.1 ERRATA SHEET. l. Provided update to the QA process within Attachment 4 last section for performing the re-calculations as part of the effort to resolve the errata. m. Add Attachment 6: EPA Tech STD Exhibit A-1 Release

		Fractions n. Added clarifying text to Attachment 2 for radionuclides not listed in Table 1 of Attachment 2. o. Added section e to attachment 4 HC-2 Section p. Deleted NOTE in section 2.1 of Attachment 1

Foreword

This supplemental guidance was inspired by a desire within NNSA to update the radionuclide threshold values tabulated in DOE STD 1027-92 CN1. NNSA personnel 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, and that are used in DOE accident analysis (e.g., DOE STD 1189). NNSA constrained the update approach by retaining the analytical methodology set forth in the DOE Standard to remain consistent with the methodology employed in the existing standard.

On October 13, 2011, the DOE General Counsel released an interpretation entitled: DEPARTMENT OF ENERGY OFFICE OF GENERAL COUNSEL INTERPRETATION REGARDING THE APPLICATION OF DOE TECHNICAL STANDARD 1027-92, HAZARD CATEGORIZATION AND ACCIDENT ANALYSIS TECHNIQUES FOR COMPLIANCE WITH DOE ORDER 5480.23, NUCLEAR SAFETY ANALYSIS REPORTS, UNDER THE PROVISIONS OF 10 C.F.R. § 830.202(b)(3). The subject of the interpretation was the use of release fractions during final categorization of facilities (initially categorized as Hazard Category 3) to reduce the category to a lower level. The interpretation stated in part: “Although the Standard does not explicitly authorize adjustment of the H.C. 3 thresholds using alternate release fractions, neither does it explicitly prohibit doing so. The Acting General Counsel concludes that the failure to fully specify the method for finalizing H.C. 3 facilities was a non-preclusive omission.”

Upon careful review of the General Counsel’s interpretation, NNSA in full coordination with the DOE Office of Health, Safety and Security, has concluded that the use of updated dosimetric information during final categorization of nuclear facilities is consistent with application of the standard as required by 10 C.F.R. 830. NNSA is promulgating this guidance to assist implementation of the interpretation for release fractions and to guide threshold adjustments based on modern dosimetry during final categorization.

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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

1. PURPOSE. This guidance provides a consistent approach and facilitates the use of updated dosimetry and release fractions in establishing the hazard category for a nuclear facility, as required in 10 C.F.R. 830, Subpart B, *Nuclear Safety Management, Safety Basis Requirements*, Section 202 (b)(3).

2. CANCELLATION. NA-1 SD G 1027, dated 11-28-11. When implemented for a nuclear facility, the methodology provided in Attachments 1 and 2 of this guidance should be used as a consistent approach to use modern dosimetry and release fractions when performing hazard categorization consistent with the following sections from 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, September 1997* (DOE STD 1027-92): Section 3.1.2, Final Hazard Categorization Attachment 1, Table A.1, Thresholds for Radionuclides

   NOTE – When using this guidance, some additional supporting text in DOE STD 1027-92 that refers to these sections is also affected, as discussed in **Attachment 3**. All other provisions of DOE STD 1027-92 affecting hazard categorization are retained in unmodified form in their entirety as applicable to the hazard categorization of nuclear facilities.

3. APPLICABILITY/SCOPE.

   a. **NNSA Personnel and facilities.** Except for the exclusion in paragraph 3d, this guidance should be applied to all NNSA personnel and to all NNSA nuclear facilities as defined in 10 C.F.R. 830 that will be operating after January 1, 2016.

   b. **Contractors.** Contractors may use this guidance if authorized by the responsible safety basis approval authority.

   c. **Exclusions.** This guidance does not apply to: Activities regulated through a license by the Nuclear Regulatory Commission (NRC) or a state under an agreement with NRC, including activities certified by NRC under section 1701 of the Atomic Energy Act.

   d. **Equivalency.** In accordance with the responsibilities and authorities assigned by Executive Order 12344, codified at 50 USC sections 2406 and 2511 and to ensure consistency through the joint Navy/DOE Naval Nuclear Propulsion Program, the Deputy Administrator for Naval Reactors (Director) will implement and oversee requirements and practices pertaining to this Directive for activities under the Director's cognizance, as deemed appropriate.

4. IMPLEMENTATION. Implementation of this guidance should be in accordance with guidance and/or direction from responsible Secretarial Officers for those facilities within their cognizance.

5. REFERENCES.

a. 10 C.F.R. 830, Subpart B, *Nuclear Safety Management, Safety Basis Requirements*.

b. DOE STD 1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice 1, September 1997.

c. LA-12846-MS, *Specific Activities and DOE-STD-1027-92 Hazard Category 2 Thresholds, LANL Fact Sheet*, November 1994.

d. LA-12981-MS, *Table of DOE-STD-1027-92 Hazard Category 3 Threshold Quantities for the ICRP-30 List of 757 Radionuclides*, *LANL Fact Sheet*, August 1995.

e. International Commission on Radiological Protection (ICRP) Publication 30, Part 1, *Limits for Intakes of Radionuclides by Workers*, 1979

f. ICRP Publication 30, Part 2, *Limits for Intakes of Radionuclides by Workers*, 1980

g. ICRP Publication 30, Part 3, *Limits for Intakes of Radionuclides by Workers*, 1981

h. ICRP Publication 30, Part 4, *Limits for Intakes of Radionuclides by Workers: an Addendum*, 1988

i. ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, 1994.

j. ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*, 1996.

k. DOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public*, 1988

l. DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, 1988

m. Federal Guidance Report No. 12, *External Exposure to Radionuclides in Air, Water, and Soil*, 1993 *n.* DOE HDBK 1129-2008, *Tritium Handling and Safe Storage,* December 2008

o. DOE STD 5506-2007, *Preparation o_fSafety Basis Documents for Transuranic (TRU) Waste Facilities,* April 2007

p. *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 o_fthe Comprehensive Environmental ReJponse, Compensation, and Liability Act: Radionuclides,* a Report to the Emergency Response Division, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, February 1989 (Repo1t prepared by ICF Incorporated and C-E Environmental, EPA Contract 68-03-3452)

q. Memorandum from W. Ostendorff, Central Technical Authority, to D. Winchell, Los Alamos Site Office Revitalization Manager, *Clar(flcation of Dose Calculation Parameters in DOE-STD-5506-2007,* October 22, 2007

r. DOE STD 3009-94, *Preparation Guide for US. Department of Energy Nonreactor Nuclear Facility Documented Sqfety Analyses*

s. Depaitment of Energy Office of General Counsel Interpretation Regarding the Application of DOE Technical Standard 1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Repo1ts, Under the Provisions of 10 C.F.R. § 830.202(b)(3), October 13, 2011

6. CONTACT. Questions concerning this guidance should be addressed to the Office of the Chief of Defense Nuclear Safety, at 202-586-3885.

BY ORDER OF THE ADMINISTRATOR:

Administrative Change Approved : 05-10-2021

Attachments
1. Hazard Categorization Guidance
2. Hazard Categorization Threshold Tables for Dosimetric Update
3. Additional Affected Language in DOE STD 1027-92
4. Technical Basis for Revised Radionuclide Threshold Values
5. ERRATA Sheet
6. EPA Tech STD Exhibit A-1 Release Fractions

Tables
1. Revised Thresholds for Radionuclides
2. Comparative Table of HC-2 and HC-3 values (Original and Revised)

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ATTACHMENT 1: HAZARD CATEGORIZATION GUIDANCE

1. **Hazard Categorization.**

The guidance in this Attachment and Attachment 2 provides a consistent approach to implement the following sections from DOE STD 1027-92 using modern dosimetry and alternate release fractions in categorizing nuclear facilities:

- (Deletion of two bullets per 5/30/12 Board comments)Section 3.1.2, Final Hazard Categorization
- Attachment 1, Table A.1, Thresholds for Radionuclides

The principal areas affected by this guidance are:

- Use of modern dosimetry to adjust the hazard category thresholds for use in final hazard categorization. To facilitate and standardize this use, this guidance provides re-calculated Hazard Category Thresholds (Table 1 in Attachment 2) that were calculated using updated dose conversion information for breathing rates and dose coefficients (Attachment 2, Table 2 provides a comparison of the revised threshold values to those in Table A.1 of DOE STD 1027-92; a detailed description of the technical basis for the revised radionuclide thresholds is provided in Attachment 4);
- For final hazard categorization, this guidance explains how to adjust the Hazard Category 3 radionuclide thresholds in addition to Hazard Category 2 radionuclide thresholds. Primary exposure mechanisms are provided to enable adjustments that are consistent with the assumptions on which the thresholds were derived; and,
- For completeness, this guidance resolves references to affected sections of supporting discussion associated with the methodology in Sections 2.1, 3.1.1 and 3.1.2 of DOE STD 1027-92. Details of those modifications are provided in Attachment 3.

NOTE: Topics not treated in this document that are relevant to hazard categorization, such as nuclear criticality, segmentation, the treatment of sealed sources and Department of Transportation approved shipping containers, the summation of radionuclide threshold ratios, and part time inventory, should be addressed in accordance with DOE STD 1027-92 and previous guidance disseminated by the Office of Health, Safety and Security. For example, facilities with the potential for nuclear criticality events will continue to be categorized as Hazard Category 2. Similarly, the acceptable methodologies set forth in 10 C.F.R. 830 for preparing a DSA, including DOE STD 3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, as well as DOE STD 1189-2008, *Integration of Safety into the Design Process*, are to be used as appropriate in conjunction with the hazard categorization provisions of this guidance.

2.1. Initial Radiological Hazards Screening/Categorization

Initial radiological hazards screening enables facility managers to determine quickly the likely facility categorization. This process is to provide an initial screening of the potential radiological hazards represented by a facility. It should be used for preliminary assessment of facility hazards in "plans and schedules" for new nuclear facilities when a Hazards Analysis has not been performed, or for proposed upgrades to existing nuclear facilities. Per DOE STD 1027-92, all nuclear facilities (i.e., radiological, Hazard Category 1, 2 and 3) must be screened to ensure they are properly categorized.

Facilities initially categorized as Hazard Category 3 are facilities with quantities of hazardous radioactive materials that meet or exceed the Hazard Category 3 thresholds provided in Attachment 1, Table A.1 of DOE STD 1027-92 using the summation of ratios approach described in the Standard (see note below).

Facilities initially categorized as Hazard Category 2 are facilities with quantities of hazardous radioactive materials that meet or exceed the Hazard Category 2 thresholds provided in Attachment 1, Table A.1 of DOE STD 1027-92 using the summation of ratios approach described in the Standard (see note below), or that have a potential for criticality (see discussion in DOE STD 1027-92).

Facilities initially categorized as Hazard Category 1 are Category A reactors and facilities designated by PSO.

Initial facility hazard categorization is per DOE-STD-1027-92.

2.2. Final Hazard Categorization

Once a Hazards Analysis (or other analysis for less-than Hazard Category 3 nuclear facilities) has been performed, consistency with DOE STD 1027-92 requires the hazard categorization to be finalized for facilities initially categorized as Hazard Category 1, 2, or 3. A final categorization for facilities that are initially categorized as less-than Hazard Category 3 should also be performed for situations where mechanisms exist that could result in a greater radiological release than assumed when creating the tabulated thresholds.

For the purposes of final hazard categorization, "unmitigated" is meant to consider material quantity, form, location, dispersibility and interaction with available energy sources, but not to consider safety features (e.g., ventilation system, fire suppression, etc.) which will prevent or mitigate a release. For less-than Hazard Category 3 nuclear facilities (i.e., radiological facilities) the analysis supporting final hazard categorization need not comply with Subpart B of 10 C.F.R. 830, but should be of sufficient rigor and documented to provide confidence that the final hazard categorization determination is conservative.

For determining the HC-3 Threshold Quantity (TQ), the methodology is that used by Reference 'p' of this SD G. That methodology considers multiple exposure pathways, of which the inhalation and vegetable ingestion pathways use the release fraction variable, while the ground water ingestion and direct exposure pathways do not. The assumed release fractions are documented in Exhibit A-1 of Reference ‘p’ and are provided in Attachment 6 of this SD G for ease of reference. The limiting pathway for a specific radionuclide is then chosen as the pathway with the smallest TQ. If it is determined in the final hazard categorization analysis that the associated release fractions for a specific radionuclide are not bounded by the assumed release fractions, then the facility should re-calculate the TQs for the different exposure pathways and verify the limiting pathway and associated TQ, as further described in Section 2.2.1 below.

For determining the HC-2 TQ, the methodology is per Attachment 1 in DOE-STD-1027-92 CN1 and the assumed release fractions are documented on Pages A-8 and A-9. If it is determined in the final hazard categorization analysis that the associated release fraction is not bounded by the assumed release fraction, then the facility should re-calculate the threshold by dividing the listed TQ by the ratio of the maximum potential release fraction to the assumed release fractions, as further discussed in Section 2.2.1 below.

This supplemental directive, approved in 2011, was written to be consistent with STD-1027-1992, which is based on the ICRP 26 system, while permitting the use of dose coefficients from the ICRP 60 system. In 2018 DOE updated the hazard categorization standard based on dose coefficients from the ICRP 60 system.

DOE-STD-1027-2018 and this supplemental directive provide a consistent framework but made different choices in developing the HC2 threshold tables. The ICRP recognizes that different chemical compounds of a radionuclide behave differently in the body, specifically in how inhaled radionuclides move from the lungs to the blood. DOE-STD-1027-1992 and 1027-2018 always choose the most conservative lung absorption class in developing their tables while this supplemental directive uses the ICRP “Recommended default absorption type for particulates when no specific information is available” where a recommendation exists and otherwise uses the most conservative option. This results in differences between the tables in STD-1027-2018 and this supplemental directive. There is value in both approaches and by presenting tables based on the ICRP’s recommended default values the NNSA provides supplementary information that can be used to avoid excessive conservatism where appropriate.

If the final hazard categorization analysis shows that the release fractions assumed in Table 1 of Attachment 2 or Attachment 6 are not conservative, then the Table 1 threshold values should be adjusted following the approach included in Section 2.2.1 below. In particular, the lung absorption classes must be reviewed to assure the proper class has been selected given the form of the material and the postulated accident scenarios when inhalation of material is a concern.

NOTE: Any adjustments to the release fraction should be technically defensible and appropriately conservative and documented and cannot be accounted for in any other parameter in determining the adjusted threshold quantity.

The Hazards Analysis (or other existing safety analyses) provides an understanding of the material which can physically be released from the facility. This inventory should be compared against the thresholds identified in Table 1 of Attachment 2. The release fractions used in generating the thresholds for Category 2 and 3 are provided in the table. These are intended to be generally conservative for a broad range of possible situations. Therefore, the inventory values of Table 1 may be used directly for determination as to whether a facility should be categorized as Hazard Category 2 or 3.

The hazard or safety analysis should demonstrate that the assumptions made in developing the adjusted threshold values or reducing the material at risk apply in the facility being analyzed. A bases section has been provided as Attachment 4 of this guidance as a reference for understanding the assumptions that were used in the derivation of the threshold quantities provided in Table 1 of Attachment 2.

Regardless of the thresholds in Table 1 of Attachment 2, facilities that would be categorized as Hazard Category 2 based on the consideration of criticality are required by consistency with DOE STD 1027-92 to have a final categorization of Hazard Category 2.

2.2.1. Adjusted Release Fractions (Airborne Release Fractions (ARF) x Respirable Fractions (RF))

Note - This section does not apply to the H-3 (tritium) and Rn-222 thresholds. The tritium thresholds were established by recommendation, not based on the analytic methodology used for other isotopes. Therefore, adjustment of the H-3 thresholds is not permitted.

Similarly, information was not available to calculate the Rn-222 thresholds, so they were left unchanged from the values in DOE STD 1027-92 but may be adjusted using a consistent approach should updated information be available.

For compliance with this guidance, the threshold values for Hazard Category 2 or 3 in Table 1 should be adjusted if non-conservative (and may be adjusted if conservative). This applies to final categorization of facilities initially classified as Hazard Category 3 (HC-3) or less than HC-3 (i.e. radiological), if the applicable ARFxRF product for the scenario being evaluated is significantly different than the values provided in Table 1. This process may result in an increase or decrease of a facility hazard category.

Adjustments to these values may be needed based on consideration of the physical and chemical form and available dispersive energy sources. For Hazard Category 2 thresholds, the adjustment is performed by multiplying the table value by the ratio of the ARFxRF used in the table to a defensible, adjusted value of ARFxRF.

The thresholds for Hazard Category 3 are in some cases based on inhalation, and in other cases based on other mechanisms such as ingestion, direct exposure from a point source and submersion in a radioactive cloud of noble gas. These thresholds should be adjusted when the exposure scenario would be significantly different and less conservative from that assumed in the development of the thresholds; adjustment should account for all release pathways as well. When the limiting pathway is ingestion or inhalation, alternate release fractions for Hazard Category 3 thresholds should be chosen consistent with the exposure pathway indicated in Table 1, unless it can be shown that a different exposure pathway results in greater exposure to workers. If both the limiting pathway in Table 1 and the limiting pathway in the scenario being evaluated involve a release fraction, the adjustment is made by multiplying the table value by the ratio of the release fraction used in the table to a defensible, adjusted value.

When a limiting pathway is direct exposure from a point source or submersion in a radioactive cloud of noble gas, there is no associated release fraction, so the approach of adjusting the threshold by using ratios of release fractions cannot be used. In that case, when the conditions being evaluated are significantly different than the assumptions used to develop the thresholds in Table 1, the only potential adjustment of the threshold is to recalculate it using the methodology described in **Attachment 4** of this guidance, adjusted to account for the difference in exposure pathways or other relevant differences.

ATTACHMENT 2: HAZARD CATEGORIZATION THRESHOLD TABLES FOR DOSIMETRIC UPDATE

Table 1 of this attachment provides recalculated and revised Hazard Category 2 and Hazard Category 3 radionuclide threshold quantities using modern dose conversion factors and a modern breathing rate. In 1996, the International Commission on Radiological Protection (ICRP) adopted new dose factors relative to the public in ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*; these dose factors have been incorporated into the determination of revised Hazard Category 2 thresholds. Similarly, in 1994, ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers,* adopted new dose factors for workers; these dose factors have been incorporated into the determination of revised Hazard Category 3 thresholds. These factors and a new breathing rate consistent with the new ICRP references of 3.3333×10^{-4} m^3/s have been used in the determination of revised threshold quantities for both Hazard Category 2 and Hazard Category 3 facilities. This breathing rate has been adopted for "light work" as defined in ICRP Publication 68.

Table 2 of this attachment highlights the revised radionuclide threshold quantities in yellow where they decreased and in green where they increased, relative to the values currently in

DOE STD 1027-92. This should facilitate the comparison of the revised versus original radionuclide threshold quantity values in determining associated impacts to the sites. Although errors were identified for some of the original DOE STD 1027-92 values, these errors (and the corrected values) are not identified in this table.

For isotopes that do not have threshold values supplied in this document, threshold values may be selected with appropriate justification by applying the methodology used to develop these tables. For final hazard categorization, a χ/Q of 1×10^{-4} sec/m^3 should be used relative to Hazard Category 2 evaluations, and a χ/Q of 7.2×10^{-2} sec/m^3 shoould be used relative to Hazard Category 3 evaluations. The technical basis for the calculations and assumptions used in developing Table 1 is provided in Attachment 4 to this guidance. This information may be used by site personnel in support of the calculation of threshold values for radionuclides that are not listed in Table 1.

Naturally occurring isotopes such as Rn-222 or Ra-226 do not need to be considered as part of Hazard Categorization unless facility processes actively collect, store or produce them as part of facility operations. Incidental processing, collection or trapping of naturally occurring isotopes (such as accumulation of Rn-222 daughter products on filters) is not considered active collection, storage or production.

Sites are ultimately responsible for assuring the requisite quality assurance of their calculations, per 10 C.F.R. 830, Subpart A, and associated DOE software quality assurance requirements.

NOTE: When implementing this SD G, for radionuclides not listed in Table 1 of Attachment 2, the threshold values should be calculated in accordance with Attachment 4 of this SD G.

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Table 1 - Revised Thresholds for Radionuclides

HC-2				HC-3			
Isotope	**Release Fraction (ARFxRF)**	**HC-2 (Ci)**	**HC-2 (g)**	**Release Fraction (ARFxRF)**	**Limiting* Pathway**	**HC-3 (Ci)**	**HC-3 (g)**
H-3	**	3.0E+05	3.0E+01	**	**	1.6E+04	1.6E+00
C-14	1.0E-02	4.05E+05	9.07E+04	5.0E-01	i	3.88E+02	8.69E+01
Na-22	5.0E-01	9.99E+03	1.60E+00	1.0E-02	ing	2.48E+02	3.98E-02
P-32	5.0E-01	4.77E+03	1.67E-02	5.0E-01	ing	1.13E+01	3.95E-05
P-33	5.0E-01	1.08E+04	6.91E-02	5.0E-01	ing	8.84E+01	5.64E-04
P-32, acid	1.0E-03	2.38E+06	8.34E+00	5.0E-01	ing	1.13E+01	3.95E-05
P-33, acid	1.0E-03	5.41E+06	3.45E+01	5.0E-01	ing	8.84E+01	5.64E-04
S-35	5.0E-01	1.16E+04	2.70E-01	5.0E-01	ing	2.21E+01*	5.18E-04*
Cl-36	1.0E+00	1.11E+03	3.36E+04	1.0E-02	ing	2.49E+02	7.55E+03
K-40	5.0E-01	7.63E+03	1.10E+09	1.0E-02	ing	1.23E+02	1.77E+07
Ca-45	1.0E-03	3.00E+06	1.68E+02	1.0E-02	ing	9.94E+02	5.57E-02
Ca-47	1.0E-03	3.93E+06	6.42E+00		de	7.37E+02	1.20E-03
Sc-46	1.0E-03	1.14E+06	3.37E+01		de	3.63E+02	1.07E-02
Ti-44	1.0E-03	6.76E+04	3.93E+02*	1.0E-02	i	9.38E+01	5.46E-01*
V-48	1.0E-03	2.86E+06	1.68E+01		de	2.54E+02	1.49E-03
Cr-51	1.0E-03	1.95E+08	2.11E+03		de	2.26E+04	2.44E-01
Mn-52	1.0E-03	4.23E+06	9.41E+00		de	2.23E+02	4.97E-04
Fe-55	1.0E-03	2.13E+07	8.95E+03	1.0E-02	ing	2.41E+03	1.01E+00
Fe-59	1.0E-03	2.09E+06	4.20E+01	1.0E-02	ing	5.61E+02	1.13E-02
Co-60	1.0E-03	7.81E+05	6.90E+02		de	2.90E+02	2.56E-01
Ni-63	1.0E-03	1.69E+07	2.97E+05	1.0E-02	ing	5.24E+03	9.21E+01
Zn-65	1.0E-03	4.81E+06	5.83E+02	1.0E-02	ing	2.01E+02	2.44E-02
Ge-68	1.0E-03	5.79E+05	8.16E+01	1.0E-02	ing	6.24E+02	8.79E-02
Se-75	1.0E-02	7.68E+05	5.28E+01	1.0E-02	ing	3.33E+02	2.29E-02
Kr-85	1.0E+00	1.06E+07*	2.70E+04*	1.0E+00	sub	1.46E+05*	3.71E+02*
Sr-89	1.0E-03	1.33E+06	4.57E+01	1.0E-02	ing	3.48E+02	1.20E-02
Sr-90	1.0E-03	2.25E+05	1.63E+03	1.0E-02	ing	2.59E+01	1.87E-01
Y-91	1.0E-03	9.11E+05	3.71E+01	1.0E-02	ing	3.98E+02	1.62E-02
Zr-93	1.0E-03	8.11E+05	3.16E+08	1.0E-02	i	3.88E+02	1.51E+05
Zr-95	1.0E-03	1.65E+06	7.69E+01		de	9.93E+02	4.62E-02
Nb-94	1.0E-03	7.22E+05	3.79E+06		i	2.49E+02*	1.33E+03*
Mo-99	1.0E-03	8.89E+06	1.85E+01	1.0E-02	ing	3.76E+03*	7.84E-03*
Tc-99	1.0E-03	2.03E+06	1.19E+08	1.0E-02	ing	7.61E+02	4.48E+04
Ru-106	1.0E-02	2.90E+04	8.74E+00	1.0E-02	ing	1.15E+02	3.49E-02

HC-2				HC-3			
Isotope	**Release Fraction (ARFxRF)**	**HC-2 (Ci)**	**HC-2 (g)**	**Release Fraction (ARFxRF)**	**Limiting Pathway**	**HC-3 (Ci)**	**HC-3 (g)**
Ag-110m	1.0E-03	1.01E+06	2.13E+02		de	2.63E+02	5.54E-02
Cd-109	1.0E-03	1.00E+06	3.86E+02	1.0E-02	ing	3.96E+02	1.53E-01
Cd-113	1.0E-03	6.76E+04	1.92E+17	1.0E-02	ing	3.09E+01	8.77E+13
In-114m	1.0E-03	8.71E+05	3.76E+01	1.0E-02	ing	2.40E+02	1.04E-02
Sn-113	1.0E-03	3.00E+06	2.99E+02	1.0E-02	ing	1.19E+03	1.19E-01
Sn-123	1.0E-03	1.00E+06	1.22E+02	1.0E-02	ing	4.10E+02	4.98E-02
Sn-126	1.0E-03	2.90E+05	1.02E+07*	1.0E-02	ing	1.67E+02	5.89E+03*
Sb-124	1.0E-03	1.21E+06	6.94E+01	1.0E-02	ing	3.77E+02	2.16E-02
Sb-126	1.0E-03	2.53E+06	3.02E+01		de	2.64E+02*	3.15E-03*
Te-127m	1.0E-02	1.10E+05	1.16E+01	1.0E-02	ing	3.80E+02	4.03E-02
Te-129m	1.0E-02	1.23E+05	4.07E+00	1.0E-02	ing	3.61E+02	1.20E-02
I-125	5.0E-01	3.18E+03	1.81E-01	5.0E-01	ing	1.26E+00	7.17E-05
I-131	5.0E-01	2.18E+03	1.75E-02	5.0E-01	ing	1.93E+00	1.56E-05
Xe-133	1.0E+00	1.95E+06*	1.04E+01*	1.0E+00	sub	2.67E+04*	1.43E-01*
Cs-134	1.0E-02	1.19E+05	9.18E+01	1.0E-02	ing	4.20E+01	3.24E-02
Cs-137	1.0E-02	1.76E+05	2.03E+03	1.0E-02	ing	6.04E+01	6.95E-01
Ba-133	1.0E-03	2.57E+06	1.01E+04	1.0E-02	ing	7.85E+02	3.07E+00
Ba-140	1.0E-03	1.58E+06	2.16E+01	1.0E-02	ing	6.44E+02	8.80E-03
Ce-141	1.0E-03	2.53E+06	8.86E+01	1.0E-02	ing	1.54E+03	5.41E-02
Ce-144	1.0E-03	2.25E+05	7.06E+01	1.0E-02	ing	1.58E+02	4.95E-02
Pm-145	1.0E-03	2.25E+06	1.61E+04	1.0E-02	i	3.31E+03	2.37E+01
Pm-147	1.0E-03	1.62E+06	1.75E+03	1.0E-02	i	2.40E+03	2.58E+00
Sm-151	1.0E-03	2.03E+06	7.70E+04	1.0E-02	i	3.04E+03	1.16E+02
Eu-152	1.0E-03	1.92E+05	1.11E+03	1.0E-02	i	2.89E+02	1.66E+00
Eu-154	1.0E-03	1.52E+05	5.64E+02	1.0E-02	i	2.25E+02	8.33E-01
Eu-155	1.0E-03	1.17E+06	2.41E+03	1.0E-02	i	1.73E+03	3.56E+00
Gd-153	1.0E-03	3.84E+06	1.09E+03	1.0E-02	ing	3.06E+03	8.66E-01
Tb-160	1.0E-03	1.13E+06	1.00E+02	1.0E-02	ing	5.76E+02	5.10E-02
Ho-166m	1.0E-03	6.74E+04	3.75E+04	1.0E-02	i	1.02E+02	5.70E+01
Tm-170	1.0E-03	1.16E+06	1.94E+02	1.0E-02	ing	6.63E+02	1.11E-01
Hf-181	1.0E-03	1.60E+06	9.38E+01	1.0E-02	ing	9.28E+02	5.45E-02
Ir-192	1.0E-03	1.21E+06	1.31E+02		de	8.82E+02	9.57E-02
Au-198	1.0E-03	8.83E+06	3.61E+01		de	2.03E+03	8.30E-03
Hg-203	1.0E-02	3.33E+05	2.41E+01	1.0E-02	ing	5.06E+02*	3.67E-02*

HC-2				HC-3			
Isotope	**Release Fraction (ARFxRF)**	**HC-2 (Ci)**	**HC-2 (g)**	**Release Fraction (ARFxRF)**	**Limiting Pathway**	**HC-3 (Ci)**	**HC-3 (g)**
Pb-210	1.0E-03	7.37E+03	9.78E+01	1.0E-02	ing	1.16E+00	1.53E-02
Bi-207	1.0E-03	1.39E+06	3.06E+04*		de	4.71E+02*	1.04E+01*
Bi-210	1.0E-03	8.72E+04	7.01E-01	1.0E-02	i	1.34E+02	1.08E-03
Po-210	1.0E-02	2.46E+02	5.47E-02	1.0E-02	ing	3.57E+00	7.94E-04
Rn-222	1.0E+00	1.6E+08	1.1E+03	1.0E+00	i	1.0E+01	6.5E-05
Ra-223	1.0E-03	1.10E+03	2.14E-02	1.0E-03	i	1.63E+01	3.19E-04
Ra-224	1.0E-03	2.70E+03	1.70E-02	1.0E-03	i	3.88E+01	2.44E-04
Ra-225	1.0E-03	1.29E+03	3.30E-02	1.0E-03	i	1.94E+01	4.99E-04
Ac-225	1.0E-03	9.54E+02	1.64E-02	1.0E-03	i	1.43E+01	2.46E-04
Ac-227	1.0E-03	1.47E+01	2.04E-01	1.0E-03	i	1.78E-01*	2.45E-03*
Th-228	1.0E-03	2.03E+02	2.47E-01	1.0E-03	i	2.89E+00	3.52E-03
Th-230	1.0E-03	5.79E+02	2.81E+04	1.0E-03	i	2.82E+00	1.36E+02
Th-232	1.0E-03	3.24E+02	2.96E+09	1.0E-03	i	2.68E+00	2.44E+07
U-232	1.0E-03	1.04E+03	4.71E+01	1.0E-03	i	3.21E+00*	1.49E-01*
U-233	1.0E-03	2.25E+03	2.34E+05	1.0E-03	i	1.29E+01	1.34E+03
U-234	1.0E-03	2.32E+03	3.73E+05	1.0E-03	i	1.32E+01	2.13E+03
U-235	1.0E-03	2.62E+03	1.21E+09	1.0E-03	i	1.46E+01	6.76E+06
U-236	1.0E-03	2.53E+03	3.92E+07	1.0E-03	i	1.43E+01	2.20E+05
U-238	1.0E-03	2.80E+03	8.32E+09	1.0E-03	i	1.54E+01	4.59E+07
Np-237	1.0E-03	3.53E+02	5.00E+05	1.0E-03	i	5.36E+00	7.60E+03
Np-238	1.0E-03	3.72E+06	1.43E+01		de	1.54E+03	5.93E-03
Pu-238	1.0E-03	1.76E+02	1.03E+01	1.0E-03	i	2.62E+00	1.53E-01
Pu-239	1.0E-03	1.62E+02	2.61E+03	1.0E-03	i	2.40E+00	3.86E+01
Pu-240	1.0E-03	1.62E+02	7.14E+02	1.0E-03	i	2.40E+00	1.05E+01
Pu-241	1.0E-03	9.01E+03	8.74E+01	1.0E-03	i	1.32E+02	1.29E+00
Pu-242	1.0E-03	1.69E+02	4.29E+04	1.0E-03	i	2.56E+00	6.49E+02
Am-241	1.0E-03	1.93E+02	5.63E+01	1.0E-03	i	2.89E+00	8.42E-01
Am-242m	1.0E-03	2.19E+02	2.09E+01	1.0E-03	i	3.22E+00	3.07E-01
Am-243	1.0E-03	1.98E+02	9.90E+02	1.0E-03	i	2.89E+00	1.45E+01
Cm-242	1.0E-03	1.56E+03	4.71E-01	1.0E-03	i	2.35E+01	7.08E-03
Cm-245	1.0E-03	1.93E+02	1.12E+03	1.0E-03	i	2.82E+00	1.64E+01
Cf-252	1.0E-03	4.05E+02	7.56E-01	1.0E-03	i	6.26E+00	1.17E-02

* Yellow filled boxes are updated value per the enclosed errata sheet

***** de - direct exposure from a point source
i - inhalation
ing – ingestion
sub – submersion in a radioactive cloud of noble gas

****** Consistent with the method used in DOE STD 1027-92, these values were provided by the Tritium Focus Group and are not calculated values using the methodology in this guidance.

Note: Naturally occurring isotopes such as Rn-222 or Ra-226 do not need to be considered as part of Hazard Categorization unless facility processes actively collect, store or produce them as part of facility operations. Incidental processing, collection or trapping of naturally occurring isotopes (such as accumulation of Rn-222 daughter products on filters) is not considered active collection, storage or production.

Radionuclide thresholds for U-232, U-236, Pu-240, and Pu-242 are not included in Table A.1 of DOE STD 1027-92 (although the Standard references other documents to determine thresholds for isotopes not included in Table A.1). The threshold values for these isotopes are included in this document for completeness.

Table 2 - Comparative Table of HC-2 and HC-3 values (Original and Revised)

	HC-2		HC-3	
Isotope	**Original DOE STD 1027-92 Value(g)**	**Revised* Value (g)**	**Original DOE STD 1027-92 Value (g)**	**Revised* Value (g)**
H-3	3.0E+01	3.0E+01	1.6E+00	1.6E+00
C-14	3.1E+05	9.1E+04	9.4E+01	8.7E+01
Na-22	1.0E+00	1.6E+00	3.8E-02	4.0E-02
P-32	1.5E-04	1.7E-02	4.2E-05	4.0E-05
P-33	1.9E-01	6.9E-02	6.0E-04	5.6E-04
P-32, acid	7.7E-02	8.3E+00	4.2E-05	4.0E-05
P-33, acid	9.6E+01	3.5E+01	6.0E-04	5.6E-04
S-35	5.8E-01	2.7E-01	1.8E-03	5.2E-04**
Cl-36	4.3E+04	3.4E+04	1.0E+04	7.5E+03
K-40	6.8E+08	1.1E+09	2.4E+07	1.8E+07
Ca-45	2.6E+02	1.7E+02	6.2E-02	5.6E-02
Ca-47	7.8E+00	6.4E+00	1.1E-03	1.2E-03
Sc-46	4.0E+01	3.4E+01	1.1E-02	1.1E-02
Ti-44	1.9E+02	3.9E+02**	3.6E-01	5.5E-01**
V-48	1.8E+01	1.7E+01	3.8E-03	1.5E-03
Cr-51	1.1E+03	2.1E+03	2.4E-01	2.4E-01
Mn-52	8.8E+00	9.4E+00	7.6E-04	5.0E-04
Fe-55	4.6E+03	8.9E+03	2.2E+00	1.0E+00
Fe-59	3.7E+01	4.2E+01	1.2E+02	1.1E-02
Co-60	1.7E+02	6.9E+02	2.5E-01	2.6E-01
Ni-63	8.0E+04	3.0E+05	9.5E+01	9.2E+01
Zn-65	1.9E+02	5.8E+02	2.9E-02	2.4E-02
Ge-68	8.8E+01	8.2E+01	1.5E-01	8.8E-02
Se-75	2.4E+01	5.3E+01	2.2E-02	2.3E-02
Kr-85	7.2E+04	2.7E+04**	5.1E+01	3.7E+02**
Sr-89	2.7E+01	4.6E+01	1.2E-02	1.2E-02
Sr-90	1.6E+02	1.6E+03	1.2E-01	1.9E-01
Y-91	2.7E+01	3.7E+01	1.5E-02	1.6E-02
Zr-93	3.6E+07	3.2E+08	2.5E+04	1.5E+05
Zr-95	6.9E+01	7.7E+01	3.3E-02	4.6E-02
Nb-94	4.6E+05	3.8E+06	1.1E+03	1.3E+03**
Mo-99	1.6E+01	1.9E+01	7.1E-03	7.8E-03**
Tc-99	2.3E+08	1.2E+08	1.0E+05	4.5E+04
Ru-106	1.9E+00	8.7E+00	3.0E-02	3.5E-02

	HC-2		HC-3	
Isotope	**Original DOE STD 1027-92 Value(g)**	**Revised Value (g)**	**Original DOE STD 1027-92 Value (g)**	**Revised Value (g)**
Ag-110m	1.1E+02	2.1E+02	5.5E-02	5.5E-02
Cd-109	1.1E+02	3.9E+02	7.0E-02	1.5E-01
Cd-113	5.3E+16	1.9E+17	3.2E+13	8.8E+13
In-114m	1.6E+01	3.8E+01	9.5E-03	1.0E-02
Sn-113	3.2E+02	3.0E+02	1.3E-01	1.2E-01
Sn-123	1.2E+02	1.2E+02	3.9E-02	5.0E-02
Sn-126	1.2E+07	1.0E+07**	6.0E+03	5.9E+03**
Sb-124	7.5E+01	6.9E+01	2.1E-02	2.2E-02
Sb-126	3.0E+01	3.0E+01	3.4E-03	3.2E-03**
Te-127m	1.6E+01	1.2E+01	4.2E-02	4.0E-02
Te-129m	4.7E+00	4.1E+00	1.3E-02	1.2E-02
I-125	1.4E-01	1.8E-01	3.2E-05	7.2E-05
I-131	1.4E-02	1.7E-02	7.4E-06	1.6E-05
Xe-133	9.6E+00	1.0E+01**	1.1E-01	1.4E-01**
Cs-134	4.6E+01	9.2E+01	3.3E-02	3.2E-02
Cs-137	1.0E+03	2.0E+03	6.9E-01	7.0E-01
Ba-133	1.6E+04	1.0E+04	4.3E+00	3.1E+00
Ba-140	1.1E+02	2.2E+01	8.2E-03	8.8E-03
Ce-141	1.2E+02	8.9E+01	3.5E-02	5.4E-02
Ce-144	2.6E+01	7.1E+01	3.1E-02	4.9E-02
Pm-145	7.6E+03	1.6E+04	1.4E+01	2.4E+01
Pm-147	9.0E+02	1.7E+03	9.5E-01	2.6E+00
Sm-151	3.7E+04	7.7E+04	3.8E+01	1.2E+02
Eu-152	7.5E+02	1.1E+03	1.2E+00	1.7E+00
Eu-154	4.2E+02	5.6E+02	7.6E-01	8.3E-01
Eu-155	1.6E+03	2.4E+03	2.0E+00	3.6E+00
Gd-153	3.9E+02	1.1E+03	2.8E-01	8.7E-01
Tb-160	1.1E+02	1.0E+02	5.0E-02	5.1E-02
Ho-166m	2.2E+04	3.8E+04	4.0E+01	5.7E+01
Tm-170	2.1E+02	1.9E+02	8.7E-02	1.1E-01
Hf-181	1.3E+02	9.4E+01	4.5E-02	5.5E-02
Ir-192	1.3E+02	1.3E+02	1.0E-01	9.6E-02
Au-198	3.8E+01	3.6E+01	8.2E-03	8.3E-03
Hg-203	3.1E+01	2.4E+01	2.6E-02	3.7E-02**

	HC-2		HC-3	
Isotope	**Original DOE STD 1027-92 Value(g)**	**Revised Value (g)**	**Original DOE STD 1027-92 Value (g)**	**Revised Value (g)**
Pb-210	2.9E+01	9.8E+01	4.7E-03	1.5E-02
Bi-207	4.3E+04	3.1E+04**	1.1E+01	1.0E+01**
Bi-210	1.2E+00	7.0E-01	2.6E-03	1.1E-03
Po-210	7.8E-02	5.5E-02	4.2E-04	7.9E-04
Rn-222	1.1E+03	1.1E+03	6.5E-05	6.5E-05
Ra-223	7.4E-02	2.1E-02	1.2E-03	3.2E-04
Ra-224	6.1E-02	1.7E-02	1.2E-03	2.4E-04
Ra-225	9.6E-02	3.3E-02	1.8E-03	5.0E-04
Ac-225	4.9E-02	1.6E-02	5.5E-04	2.5E-04
Ac-227	5.9E-02	2.0E-01	5.8E-04	2.5E-03**
Th-228	1.1E-01	2.5E-01	1.2E-03	3.5E-03
Th-230	4.4E+03	2.8E+04	3.1E+01	1.4E+02
Th-232	1.6E+08	3.0E+09	9.1E+05	2.4E+07
U-232		4.7E+01		1.5E-01
U-233	2.3E+04	2.3E+05	4.4E+02	1.3E+03
U-234	3.5E+04	3.7E+05	6.7E+02	2.1E+03
U-235	1.1E+08	1.2E+09	1.9E+06	6.8E+06
U-236		3.9E+07		2.2E+05
U-238	7.1E+08	8.3E+09	1.3E+07	4.6E+07
Np-237	8.3E+04	5.0E+05	6.0E+02	7.6E+03
Np-238	3.5E+00	1.4E+01	5.0E-03	5.9E-03
Pu-238	3.6E+00	1.0E+01	3.6E-02	1.5E-01
Pu-239	9.0E+02	2.6E+03	8.4E+00	3.9E+01
Pu-240		7.1E+02		1.1E+01
Pu-241	2.8E+01	8.7E+01	3.1E-01	1.3E+00
Pu-242		4.3E+04		6.5E+02
Am-241	1.6E+01	5.6E+01	1.5E-01	8.4E-01
Am-242m	5.8E+00	2.1E+01	5.3E-02	3.1E-01
Am-243	2.8E+02	9.9E+02	2.6E+00	1.4E+01
Cm-242	5.1E-01	4.7E-01	9.7E-03	7.1E-03
Cm-245	3.1E+02	1.1E+03	3.0E+00	1.6E+01
Cf-252	4.1E-01	7.6E-01	5.9E-03	1.2E-02

***** Green background values are threshold values that increased when compared to DOE STD 1027

Yellow background values are threshold values that decreased when compared to DOE STD 1027

** Value changed as a result of SD G Update 2013 per enclosed errata sheet

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ATTACHMENT 3: Additional Affected Language in DOE STD 1027-92

The methodology in Attachments 1 and 2 of this guidance implements an approach to consistently update the dosimetric values and release fractions used for categorizing nuclear facilities described in Section3.1.2 of DOE STD 1027-92.

The categorization methodology in the standard is supported by discussions in several other locations of the Standard. For use with this guidance, the text in those sections should be read in a way that is consistent with this guidance, as follows:

- In Table 3.1, Nuclear Hazard Categorization Summary, on page 7, and Figure 3.1, Hazard Classification Decision Process (Section 3), page 8, the references to Table A.1 for Category 2 and 3 are replaced with a reference to Table 1 in Attachment 2 of this guidance.

- In Figure 3.1, the wording in the top block is replaced with "IDENTIFY NUCLEAR FACILITIES," which clarifies the point that all existing nuclear facilities (including less than Hazard Category 3) should be screened in accordance with the provisions of this guidance.

- In Section 4.1.2.a, Nuclear Hazard Category 3 Facilities, page 16, the reference to Table A.1 in the single paragraph labeled "INTERPRETATION" is replaced with a reference to Table 1 in Attachment 2 of this guidance.

- In Attachment 1, pages A-4 and A-5, the references to Table A.1 are replaced with references to Table 1 in Attachment 2 of this guidance.

- In Attachment 1, page A-6, Calculation of Category 2 Radiological Thresholds, the respiration rate that is cited (3.5×10^{-4} m^3/s) is modified to 3.3×10^{-4} m^3/s to be consistent with this guidance.

<u>All other provisions of DOE STD 1027-92 affecting hazard categorization, including those for nuclear criticality, are unaffected by this guidance in their entirety.</u>

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ATTACHMENT 4: Technical Basis for Revised Radionuclide Threshold Values

This guidance for hazard categorization was developed in order to establish a reproducible table of Hazard Category 2 and 3 radionuclide threshold values using the qualitative hazard categorization criteria and analytical methodology defined in DOE STD 1027-92, but with updated scientific information taken from international radiation protection consensus documents. During the process of calculating the revised thresholds, errors were identified and corrected for some of the original DOE STD 1027-92 values.

Change Notice 1 of DOE STD 1027-92 recommended the use of LA-12846-MS and LA-12981-MS to determine HC2 and HC3 threshold values for isotopes not listed in the Standard, and these documents were used in the development of this guidance. Due to the use of updated information, the methodology used in LA-12846-MS and LA-12981-MS should be used in conjunction with the approach described here for calculating thresholds for isotopes not listed in Table 1 of Attachment 2, to prevent inconsistency with the threshold values included in Table 1. Appropriate quality controls should be applied to the analysis as required by Subpart A of 10 C.F.R. 830.

Hazard Category 2:

The methodology used to calculate the revised Hazard Category 2 radionuclide thresholds is the same as what is presented in Attachment 1 of DOE STD 1027-92. The dose from the inhalation pathway can be significant; however, cloud shine can also be a major contributor to dose in some cases. Reference the formula and associated discussion regarding the calculation of Hazard Category 2 threshold values (see page A-6 of the Standard). For completeness, DOE retained the cloud shine exposure pathway in the formula. This formula calculates a maximum plausible radionuclide quantity that, if released without mitigation, will result in a 1 rem inhalation exposure to an individual at slightly less than a 300 meter distance. The duration of exposure is the plume passage time.

Reproduction of Original DOE STD 1027 Hazard Category 2 Threshold Values:

In order to gain understanding of the Hazard Category 2 methodology and provide confidence in the revised threshold values, an attempt was made to reproduce the original values from Table A.1 of DOE STD 1027-92. The same committed effective dose equivalent (CEDE) and cloud shine dose equivalent (CSDE) data used in the Standard were used to reproduce Table A.1; CEDE and CSDE data were taken from DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, and DOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public*, respectively. Use of these two DOE documents in reproducing the Table A.1 values is consistent with the process noted in LANL Fact Sheet LA-12846-MS, *Specific Activities and DOE-STD-1027-92 Hazard Category 2 Thresholds*; this LANL Fact Sheet is referenced in a footnote to Table A.1 of the Standard regarding calculation of thresholds for isotopes not listed in the table.

As specified in the Standard, a respiration rate of 3.5×10^{-4} m^3/s and a χ/Q of 1.0×10^{-4} sec/m^3 were used in calculating the original values in Table A.1. These values were also used in reproducing the Table A.1 values. Per the Standard, the Hazard Category 2 threshold values correspond to a dose of 1 rem at slightly less than 300 meters.

Overall, there was general agreement between the Table A.1 Hazard Category 2 threshold values and the reproduced values; however, errors were identified for some of the threshold values in the Standard. Due to lack of information regarding the calculation of the original threshold values in the Standard, further comparisons in the calculations could not be made.

Revised Hazard Category 2 Radionuclide Threshold Values:

The methodology used to calculate the revised Hazard Category 2 radionuclide thresholds is presented in Attachment 1 of DOE STD 1027-92. The specific equation used to calculate threshold quantities is on page A-6 of the Standard.

In the time since DOE STD 1027-92 was originally published in 1992, updated radiological dose coefficient and breathing rate information has become available compared to what was used in the development of the Standard's Hazard Category 2 thresholds. This updated information was taken from international radiation protection consensus documents, ICRP 72 and ICRP 68, and used in calculating revised threshold values. Additional details are provided in Sections a. through c. below.

a. Updated Dose Conversion Coefficients:

DOE STD 1027-92 used CEDE and CSDE data from DOE/EH-0071 (public) and

DOE/EH-0070 (public), respectively; these documents date back to 1988.

In 1996, the ICRP adopted new public dose factors in ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*; these dose coefficients were used in the determination of revised Hazard Category 2 thresholds. The following assumptions pertain to the selection of dose coefficients from ICRP 72:

- Consistent with DOE/EH-0071, for members of the public, the ICRP 72 dose coefficients are based on an activity median aerodynamic diameter (AMAD) of 1 μm particle size.

- Per Table 2 (footnotes a and b) of ICRP 72, the default lung absorption type used (F – fast; M – moderate; S – slow) in selecting an inhalation dose coefficient for the various radionuclides was as recommended by ICRP 72 for particulate aerosols when no specific information is available. If no such value was recommended (F, M, S), then the largest inhalation dose coefficient available in Table A.2 (*Inhalation dose coefficients)* for an adult was selected in accordance with the DOE STD 1027-92 methodology. Specifically, this approach is consistent with what is presented in LANL Fact Sheet LA-12846-MS (which is referenced in Table A.1 of the Standard). LA-12846-MS indicates that the DOE STD 1027-92 used the largest CEDE values of the inhalation class (D –days; W – weeks; Y – years) from DOE/EH-0071 in the interest of conservatism in calculating Hazard Category 2 thresholds.

b. Similarly, in 1993, Federal Guidance Report (FGR) No. 12, *External Exposure to Radionuclides in Air, Water, and Soil,* was issued. Updated data from FGR 12 pertaining to the determination of CSDE values were used in the calculation of revised Hazard Category 2 thresholds, Radionuclide Reference Data:

For purposes of this SD G 1027 Update, a change in the use of reference data for radionuclide information was updated. Because the International Commission on Radiological Protection (ICRP) publication 68 references ICRP-38 for radionuclide information, that same publication for radionuclide reference data will be used in this update. Further, it was also decided that should data be unavailable in ICRP-38, then the succession for reference data would then be ICRP-107.

The Cloud Shine Dose Coefficients (CSDE) are obtained from Table III.1 'Dose coefficients for Air Submersion' of Federal Guidance Report NO. 12 (FGR-12) dated September 1993 except as updated in ICRP-72 Table A.4 'Effective dose rates for exposure of adults to inert gases'.

The Committed Effective Dose Equivalent (CEDE) values are obtained from ICRP-72 Table A.2 'Inhalation does coefficients' and Table A.3 'Inhalation dose coefficients for soluble or reactive gases and vapors' as appropriate.

c. Updated Breathing Rates:

DOE STD 1027-92 used a breathing rate of 3.5 x 10^{-4} m^3/s in the Hazard Category 2 methodology (see page A-6 of the Standard); a breathing rate of 2.66x10^{-4} m^3/s was used in the Hazard Category 3 methodology (see Chapter 4 of the EPA Technical Background Document). In light of new science pertaining to breathing rates since DOE STD 1027-92 was published in 1992, an updated breathing rate of $\underline{3.3333 \times 10^{-4}\ m^3/s}$ has been used in the determination of revised threshold quantities for both Hazard Category 2 and Hazard Category 3 facilities. This updated value has been adopted for "light work" as defined in ICRP Publication 68 (1994). Specifically, ICRP 68 has revised the 8-hour day breathing rates (see Table 1, footnote c.) as follows: light work is defined as: 2.5 hr sitting (inhalation rate 0.54 m^3/hr, breathing frequency 12 min^{-1}) and 5.5 hr light exercise (inhalation rate 1.5 m^3/hr, breathing frequency 20 min^{-1}). Based upon this information, the time weighted breathing rate would be:

$$BR_{Light-Activity} = \frac{0.54\frac{m^3}{hr}\cdot 2.5hr + 1.5\frac{m^3}{hr}\cdot 5.5hr}{5.5hr + 2.5hr} = 1.2\frac{m^3}{hr} = 3.3 \times 10^{-4}\ \frac{m^3}{sec}$$

Given the magnitude of the weighting factors applied in this formula, this average value is considered to be conservative in light of the application environment. In addition, use of this breathing rate in the determination of both Hazard Category 2 and 3 threshold values is also consistent with a position taken by the NNSA Central Technical Authority (CTA) per an October 22, 2007 memorandum regarding the clarification of dose calculation parameters in

DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. The relevant portions of this memo are provided below (emphasis added in italics):

> …the Standard specifies the use of 3.3×10^{-4} m^3/s as BR [breathing rate] in conjunction with dose conversion factors (DCFs) from International Commission on Radiation Protection (ICRP) Publications 72 and 68. *The DCFs in ICRP 72 and 68 are based on a model described in ICRP 66. ICRP 66 provides a range of BRs depending on the age and sex of the person and the type of activity being modeled.* The BR specified in the Standard has been called into question because it is not specifically listed in ICRP 66. Since the DCFs in ICRP 72 and 68 are based on the ICRP 66 model, a conclusion was drawn that the BR used in dose calculations must be one of the values explicitly used in ICRP 66.
>
> *The BR in the Standard represents a weighted average of two BRs in ICRP 66. This average BR is widely used. It is defined and used in ICRP 68* [worker dose coefficients] *to represent light work: a combination of 2½ hours of rest/sitting and 5½ hours of light exercise, as defined in ICRP 66. This BR is used by DOE in 10 C.F.R. 835, Occupational Radiation Protection, for establishing derived air concentrations for worker protection and in its toolbox modeling codes.*
>
> *…The DCFs documented in ICRP 72* [public dose coefficients] *are not explicitly linked to the BRs identified in ICRP 66. Therefore, using a BR that is within the range specified in ICRP 66 and in conjunction with the DCFs in ICRP 72 is acceptable for a member of the public at a similar activity level. Using this criterion, the BR used in the Standard is within the range of BR values given in ICRP 66 and is reasonable for calculating dose to the public, assuming that the activity level being modeled is the same. That is, the BR specified in DOE-STD-5506 is consistent with that in ICRP 72 for calculating public doses.* If a higher activity is likely for a member of the public based on the local conditions at the site boundary, it may then be appropriate to use a higher BR within the range provided in ICRP 66 in the dose calculations.

It can be reasonably concluded from this CTA position that a breathing rate of

3.3333×10^{-4} m^3/s is an appropriate value to use in conjunction with dose conversion factors pertaining to both the worker (ICRP 68) and the public (ICRP 72). Accordingly, the revised Hazard Category 3 and 2 thresholds use dose coefficients from ICRP 68 and ICRP 72 respectively, in conjunction with a consistent breathing rate value of

3.3333×10^{-4} m^3/s.

d. Determination of Revised Hazard Category 2 Threshold Value for Tritium:

Table A.1 of DOE STD 1027-92 specifies a Hazard Category 2 threshold for tritium of

30 grams. Per discussions with Tritium Focus Group Members and other personnel involved with the development of the Standard, it appears this value was chosen based on consensus, taking into account operational considerations at the time. A revised threshold value was calculated to be 62.4 grams, and assumed the following:

- The inhalation dose coefficient selected from Table A.3 of ICRP 72 is for tritiated water for an adult (1.8E-11 Sv/Bq). Per discussions with the Chairman for the ICRP Task Group on Dose Calculations (at the time of publication of ICRP 72), this dose coefficient does not take into account skin absorption. Therefore, consistent with DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*, a multiplication factor of 1.5 was used in the threshold calculation to address skin absorption. This factor can be applied to either the dose coefficient or the respiration rate – the resulting numerical value is the same.

- The airborne release fraction was conservatively chosen to be 0.5, which is consistent with the value specified in Appendix A (Modeling the Airborne Release and Inhalation of Radionuclides) of the EPA Technical Background Document used for the determination of Hazard Category 3 threshold values.

A footnote (*) to Table A.1 of DOE STD 1027-92 stated that the DOE Tritium Focus Group provided a recommendation to increase the Hazard Category 3 threshold value from 0.1 grams to 1.6 grams. Given that the original Hazard Category 2 value was determined by consensus, and in light the Tritium Focus Group's past involvement with the Standard, NNSA requested that that they evaluate the revised Hazard Category 2 threshold value, and provide a recommendation to NNSA on an appropriate value to use.

On August 25, 2010, Bill Weaver responded to NNSA on behalf of the Tritium Focus Group as follows:

> The position of the TFG [Tritium Focus Group] is to retain the existing DOE STD 1027 thresholds for tritium Category 2 and 3 nuclear facilities as is. The next meeting of the TFG is tentatively scheduled for the spring at SRS [Savannah River Site] and signed correspondence by all participants of that meeting can be obtained at that time, if desired.

Accordingly, the radionuclide threshold values for tritium in Table 1 of this guidance default to the values in DOE STD 1027-92 (30 grams for Hazard Category 2, and 1.6 grams for Hazard Category 3).

UPDATE: On June 19, 2013, Bill Weaver communicated via email (B. Weaver to I. Trujillo) that the TFG has met since the publication of the SD G 1027. At that meeting, it was voted on that the TFG continues to endorse the Threshold Quantities as is currently while working on new values for recommendation for the upcoming TFG meeting in the

Spring of 2014.

e. HC-2 Threshold Quantities Clarification When No Reference or DCF Data is Available for Calculation

Per DOE-STD-1027-92 Attachment 1, Table A-1 sub-note 1, provides the following TQ's:

- Any other beta-gamma emitter – 4.3E+05 Ci
- Mixed fission products – 1.0E+03 Ci
- Any other alpha emitter – 5.5E+01 Ci

Hazard Category 3:

The methodology used to calculate the revised Hazard Category 3 radionuclide thresholds is the same as what is presented in Attachment 1 of DOE STD 1027-92. As noted in the Standard, DOE chose to use an Environmental Protection Agency (EPA) model to calculate these thresholds; and assumes the following: 1) the distance from the point of release to the point of exposure is 30 meters; 2) the dose-equivalent limit is 10 rem effective whole body dose; and 3) there is no radioactive decay (for conservatism and simplicity). The duration of exposure depends on the release pathway per the EPA model. As stated on page A-9 of the Standard, the model assumes that persons are exposed for one day for inhalation and direct exposure, but that persons are exposed for longer periods through the ingestion pathway.

The EPA model used in the Standard to determine Hazard Category 3 thresholds is set forth in the following document:

> *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides*, a Report to the Emergency Response Division, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, February 1989 (Report prepared by ICF Incorporated and C-E Environmental, EPA Contract 68-03-3452)

This EPA Technical Document is referenced in LANL Fact Sheet LA-12981-MS, *Table of DOE-STD-1027-92 Hazard Category 3 Threshold Quantities for the ICRP-30 List of 757 Radionuclides;* this LANL Fact Sheet is referenced in a footnote to Table A.1 of DOE STD 1027-92 for the threshold values of any isotopes of interest.

Per the EPA Technical Document (see Chapter 4, Methodology for RQ [reportable quantity] Adjustments), a release value represents the "quantity of radionuclides (in curies) that, if released under the conditions assumed, could result in a whole-body dose-equivalent of 500 millirem via each of the exposure pathways." DOE STD 1027-92 Hazard Category 3 threshold quantities were calculated from the smallest of the release values for four exposure pathways ultimately considered by the EPA model: 1) inhalation; 2) ingestion of water; 3) ingestion of food (vegetable); and 4) direct exposure (direct exposure from a point source, and submersion in a radioactive cloud of noble gas). This approach is conservative and establishes the limiting release pathway. Chapter 4 of the EPA Technical Document describes the methodology used to calculate release values for each of the four exposure pathways. In order to determine the Hazard Category 3 threshold value (10 rem dose at 30 meters), the calculated release values/thresholds were multiplied by a factor of 20. Use of this multiplication factor is described in LANL Fact Sheet LA-12981-MS for Hazard Category 3 threshold quantities.

Note: Based on the results shown in Appendix E (radionuclide release values) of the EPA document, along with sampling calculations, the ingestion of ground water pathway was not identified as having the lowest release value for the isotopes of interest. Therefore, this pathway was not pursued further in this alternate methodology. If other isotopes are subsequently added to Table 1, this pathway would need to be evaluated as appropriate.

Reproduction of Original DOE STD 1027 Hazard Category 3 Threshold Values:

As was done for Hazard Category 2 threshold values, an attempt was made to reproduce the original Hazard Category 3 threshold values from Table A.1 of DOE STD 1027-92. This was done in order to gain understanding of the Hazard Category 3 (EPA) methodology and provide confidence in the revised threshold values. The same source for Annual Limit on Intake (ALI) data referenced in the EPA methodology, ICRP 30, *Limits for Intakes of Radionuclides by Workers*, was used to reproduce Table A.1. The ICRP 30 ALI is the basis for the inhalation and ingestion models used in the EPA Technical Document, and represents the quantity of radionuclides that, if taken in by reference man, will give a CEDE dose of 5 rem. Per the EPA methodology (see Chapter 4), the ALIs from ICRP 30 were divided by 10 to adjust the dose that they are based on to an effective dose-equivalent of 500 millirem. As noted above, a multiplication factor of 20 was then used in reproducing the threshold values to arrive at an effective whole body dose of 10 rem at 30 meters, per the Hazard Category 3 criteria in DOE STD 1027-92.

As specified in the EPA Technical Document, a breathing rate of 2.3E7 cubic cm/day (or 2.66E-4 m^3/s) and a χ/Q of 8.33E-13 day/cubic cm were used in calculating the original values in Table A.1. These values were also used in reproducing the Table A.1 values. Consistent with the EPA methodology, when more than one inhalation or ingestion ALI was available for a particular radionuclide the lowest value was used for the threshold calculations. This approach assures that the release of the radionuclide in its most hazardous chemical form is taken into account.

Overall, there was general agreement between the Table A.1 Hazard Category 3 threshold values and the reproduced values; however, errors were identified for some of the threshold values in the Standard. Due to lack of information regarding the calculation of the original threshold values in the Standard, further comparisons in the calculations could not be made.

In addition, the EPA Technical Document upon which the Standard's Hazard Category 3 threshold values are based has error propagation issues that range from 0.5% to 155%. This is attributable to simplifications used in the mathematical formulas and values of the constants used. This was not a concern for the EPA in deriving the 40 C.F.R. 302.4 RQs, because they are determined by rounding the lowest release value down to the nearest decade. However, DOE used the uncorrected EPA Technical Document release values in constructing the associated threshold values in the Standard. For example, for ^{233}U, the EPA release value yields a DOE

STD 1027-92 Hazard Category 3 threshold of 440 grams. The correct threshold should be about 292 grams (a 50% nonconservative error).

<u>Revised Hazard Category 3 Radionuclide Threshold Values</u>:

The methodology used to calculate the revised Hazard Category 3 radionuclide threshold values is presented in Chapter 4 (Methodology for RQ Adjustments) of the EPA Technical Document. This is the same methodology used to develop the original DOE STD 1027-92 Hazard Category 3 threshold values.

Since DOE STD 1027-92 was originally published in 1992, updated radiological dose coefficient and breathing rate information has become available compared to what was used in the development of the Standard's Hazard Category 3 thresholds. This updated information was taken from an international radiation protection consensus document, ICRP 68, and used in calculating revised threshold values. Additional details are provided in Sections a. through c. below.

a. Updated Dose Conversion Coefficients:

DOE STD 1027-92 used ALI data from ICRP 30 (workers); the various parts of ICRP 30 were published between 1979 (Part 1) and 1988 (Part 4).

In 1994, the ICRP adopted new worker dose factors in ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers;* these dose coefficients were used in the determination of revised Hazard Category 3 thresholds. The following assumptions pertain to the selection of dose coefficients from ICRP 68:

- According to ICRP 68 (see Secondary Limits, page 17), ALIs (Bq) are defined using an e(50) dose coefficient value (Sv/Bq):

  ALI (Bq) = 0.02 Sv/e(50)

Accordingly, the largest e(50) value was chosen from ICRP 68 for a given radionuclide in order to produce the lowest ALI of exposure from ingestion and inhalation in the associated EPA models. This approach conservatively establishes the revised Hazard Category 3 thresholds consistent with the precepts of DOE STD 1027-92.

Per the above formula, the ALI is based on a committed effective dose of 0.02 Sv

(2 rem). The calculated ALIs therefore need to be multiplied by a factor of 2.5 to be consistent with the EPA methodology used to calculate revised ingestion and inhalation release values. As previously noted, the EPA methodology used ALIs from

ICRP 30, which were based on a whole body CEDE of 5 rem. Per the EPA methodology, the ICRP 30 ALIs were divided by 10 to adjust the dose that they are based on to an effective dose-equivalent of 500 millirem. A multiplication factor of 20 was then used in the revised threshold calculations to arrive at an effective whole body dose of 10 rem at 30 meters, per the Hazard Category 3 criteria in DOE STD 1027-92.

- ICRP 30 ALI values used in DOE STD 1027-92 were based on a 1µm particle size. For the revised threshold calculations, the largest e(50) inhalation dose coefficients were chosen from ICRP 68, regardless of particle size (ICRP 68 provides inhalation dose coefficients for both 1 µm and 5 µm AMAD particle size). This approach resulted in the lowest ALI and therefore a conservative threshold value.

b. Radionuclide Reference Data:

For purposes of this SD G 1027 Update, a change in the use of reference data for radionuclide information was updated. Because the International Commission on Radiological Protection (ICRP) publication 72 references ICRP-38 for radionuclide information, that same publication for radionuclide reference data will be used in this update. Further, it was also decided that should data be unavailable in ICRP-38, then the succession for reference data would then be ICRP-107.

c. Updated Breathing Rates:

See Section c. in the Hazard Category 2 discussion above.

d. Determination of Revised Hazard Category 3 Threshold Value for Tritium:

Table A.1 of DOE STD 1027-92 specifies a Hazard Category 3 threshold for tritium of

1.6 grams. A revised threshold value was calculated to be 0.87 grams, and assumed the following:

- The inhalation dose coefficient selected from Annex C of ICRP 68 is for tritiated water (1.8E-11 Sv/Bq). Per footnote b in Annex C, the dose from activity absorbed through the skin is not included in this value. Per input from both the Chairman for the ICRP Task Group on Dose Calculations (at the time of publication of ICRP 68) along with input from a member of the DOE Tritium Focus Group, and consistent with DOE-HDBK-1129-2008, a multiplication factor of 1.5 was used in the threshold calculation to address skin absorption.

- The airborne release fraction was conservatively chosen to be 0.5, which is consistent with the value specified in Appendix A (Modeling the Airborne Release and Inhalation of Radionuclides) of the EPA Technical Background Document used in the determination of Hazard Category 3 threshold values.

A footnote (*) to Table A.1 of DOE STD 1027-92 states that the DOE Tritium Focus Group provided a recommendation to increase the Hazard Category 3 threshold value from 0.1 grams to 1.6 grams. In light their prior involvement in recommending a Hazard Category 3 threshold of 1.6 grams, NNSA requested that the Tritium Focus Group evaluate the revised Hazard Category 3 threshold value, and provide a recommendation to NNSA on an appropriate value to use.

On August 25, 2010, Bill Weaver, responded to NNSA on behalf of the Tritium Focus Group as follows:

> The position of the TFG [Tritium Focus Group] is to retain the existing DOE STD 1027 thresholds for tritium Category 2 and 3 nuclear facilities as is. The next meeting of the TFG is tentatively scheduled for the spring at SRS [Savannah River Site] and signed correspondence by all participants of that meeting can be obtained at that time, if desired.

Accordingly, the radionuclide threshold values for tritium in Table 1 of this guidance default to the values in DOE STD 1027-92 (30 grams for Hazard Category 2, and 1.6 grams for Hazard Category 3).

UPDATE: On June 19, 2013, Bill Weaver communicated via email (B. Weaver to I. Trujillo) that the TFG has met since the publication of the SD G 1027. At that meeting, it was voted on that the TFG continues to endorse the Threshold Quantities as is currently while working on new values for recommendation for the upcoming TFG meeting in the Spring of 2014.

e. Reference Data for Energy Level (E1) Direct Exposure Point Source

The EPA Technical Background Document (reference p.), which provides the methodology as used by DOE-STD-1027 and this SD G 1027, provides an equation (Equation 6, p 4-13 of reference p) for calculating the release value for direct exposure point source. A variable in that equation is known as E1, which is described as “the sum of the products of the gamma ray energies and the gamma ray fractions (MeV)”. To account for the various gamma ray energies and fractions when using this equation, the energy level for a given radionuclide was derived by taking the sum of the products of the gamma ray energies and the gamma ray fractions. For the initial SD G, this approach was used to derive the E1 value in the hand calculations. For this SD G Update, it was decided to use ICRP Publication 38 (ICRP-38) as the reference data for radionuclides. A benefit of using the ICRP-38 Publication is that it provides the E1 values for the radionuclides as listed. For note, ICRP-38 provides those values as both ‘LISTED’ and ‘OMITTED’. The omitted values are defined as those energies and fractions that contribute less than 0.100% of the energy level. For purposes of this SD G Update, the value used for E1 obtained from ICRP-38 considered both the listed and omitted by summing the two as provided.

f. Direct Exposure Cloud Submersion

The EPA Technical Background Document (reference p.), which provides the methodology as used by DOE-STD-1027 and this SD G 1027, provides an equation (Equation 10, p 4-17 of reference p) for calculating the release value for direct exposure cloud submersion. Argon, Krypton, and Xenon are the only noble gases whose release values are calculated based on total submersion in a cloud as discussed in reference p. A different equation for calculating direct exposure is provided for these noble gases because submersion in a cloud results in an integrated dose from all directions at varying distances from the body. The equation for this calculation considers the Derived Airborne Concentration (DAC) value for these isotopes. The DAC value is derived by considering the effective dose rates as published in ANNEXE D of ICRP-68. Assumptions considered in deriving the DAC value are 1 DAC = 0.05 Sieverts over a 2000 hour work year.

Quality Assurance Process for Determination of Revised Radionuclide Threshold Values:

For this SD-G-1027 rev.1 update, a Quality Assurance (QA) plan for Re-calculating Errata Thresholds was developed and approved. The following QA Process, according to the approved plan, was followed in performing the re-calculations.

1. All thresholds will be re-calculated as hand calculations, either by calculator or by use of an Excel spreadsheet (as an extension of a hand calculation).

2. If an Excel spreadsheet is used:

   a. The calculations will be conducted on DOE computers using the Excel software installed by the DOE CIO.

   b. Formulas for the Excel spreadsheet will be confirmed by calculator using existing threshold values.

   c. Software versions used will be documented. Hardware systems and versions used will be documented.

   d. A master controlled copy of spreadsheet calculations will be maintained by NA-SH-80.

3. Each revised threshold will be calculated independently by NNSA personnel with safety basis experience and qualified as either Senior Technical Safety Manager or Nuclear Safety Specialist. The individuals conducting the calculations will resolve any discrepancies between their calculations.

4. The revised threshold values will be distributed for peer review, at a minimum that will include review by qualified Senior Technical Safety Managers and/or Nuclear Safety Specialists in (1) NA-SH, (2) NA-00.

5. Upon resolving any discrepancies identified in the peer review, a draft revised NA-1 SD G 1027 will be distributed for review/comment to each NNSA Site Office, NA-00, NA-10, NA-SH. A copy of the draft revised NA-1 SD G 1027 will be provided to the DFNSB staff.

HC-2 and HC-3 TQ values were calculated independently by ORNL staff. NA-SH-60 NSS qualified and experienced staff performed independent calculations of HC-3 TQ values. The NA-SH-80 staff re-calculated values as documented in the errata sheet are consistent with ORNL values. Overall, all values re-calculated by NA-SH-80 staff are consistent with ORNL independent calculations.

QA Process for SD-G-1027 revision 0:

Two technical staff members from the Office of the Chief of Defense Nuclear Safety performed and independently verified the analysis as described below.

- Calculations were conducted by a highly qualified and experienced individual (Lead Investigator I (LI)):
  - LI performed hand calculations conducted to reproduce a subset of existing 1027 Standard values for Hazard Category 3 and Hazard Category 2 thresholds;
  - Checks were conducted of formulae used in the EPA Technical Document and of spreadsheet values against hand calculations;
  - LI then entered in all required ICRP input data and isotopic data and formula required to re-calculate DOE STD 1027-92 Hazard Category 3 and Hazard Category 2 values;
    - Microsoft Excel spreadsheet was developed as an extension of the hand calculations, using the validated formulas;
    - Microsoft Excel program was on an NNSA computer with software controlled by the DOE Common Operating Environment infrastructure[1];
  - LI conducted error-trapping by comparison to existing Hazard Category 3 and Hazard Category 2 values in the spreadsheet (ratio tests, etc.);
  - LI compared all anomalous (as compared to the existing Hazard Category 3 and Hazard Category 2 threshold values) against the spreadsheet values and investigated why deviations exist, resulting in error trapping by the LI in the formulae used as well as the ICRP input data;
  - Formulae and isotope input data were corrected. Over the course of two months, all discovered errors were resolved by LI;
- Calculations were independently verified by Independent Investigator (II):
  - II performed multiple hand calculations to check spreadsheet calculated values;
  - II independently looked up and verified all ICRP 30, 68, and 72 data and other data inputs in spreadsheet;

[1] The use of the Microsoft Excel program was considered to be an extension of hand calculations, with quality assurance activities focusing on validating the accuracy of the calculations as described in this section, as opposed to reliance on Microsoft Excel as a safety software program as defined in DOE Order 414.1C. In any event, the quality assurance process detailed in this section would provide adequate steps of a documented, graded software quality assurance plan. During the course of developing the guidance, emphasis was properly placed on validating the calculations for the revised radionuclide threshold values.

  - II performed hand calculations, independently looking up all isotopic data and relevant ICRP 30, 68, and 72 data and other data;

  - II compared hand calculations to existing and revised DOE STD 1027-92 Hazard Category 2 and Hazard Category 3 threshold values. All anomalous inputs and outputs were rectified; About 80 errors out of about 11,000 entries were discovered and corrected (0.73% error rate by LI).

- The resulting threshold tables and supporting guidance was sent out for peer review throughout the interested NNSA community.

ATTACHMENT 5: ERRATA SHEET

HC-3 Threshold Quantity (TQ)

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
			GENERAL COMMENT: HC-2 and HC-3 TQ values were calculated independently by ORNL. NA-SH-60 NSS qualified and experienced staff performed independent calculations of HC-3 TQ values. The NA-SH-80 staff re-calculated values as documented in this errata sheet are consistent with ORNL values. Overall, all values re-calculated by NA-SH-80 staff are consistent with ORNL independent calculations. **GENERAL COMMENT**: NNSA chose to use more exact constants in the mathematical formulas, compared to ORNL who used rounded constants consistent with EPA Tech Std (ORNL). This results in slight differences between values. **GENERAL COMMENT**: NNSA will update and reference ICRP-38 data to use in conjunction with ICRP-68 for the SD G update. This results in some updates to NNSA HC-3 and HC-2 Threshold Quantity calculated values.

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
S-35	**2.21E+01 Ci** **5.18E-04 g**	1.22E+02 Ci 2.85E-03 g	The discrepancy is due to the fact that the original SD G did not consider the 'organic' dose coefficients as published in ICRP-68, which are more conservative. It was discussed within NA-SH and ORNL personnel and it was decided that the 'organic' dose coefficients shall be considered. Therefore, the correct coefficient value to use is 7.7E-10 Sv/Bq versus the previously used value of 1.4E-10 Sv/Bq. By using this coefficient, a release value of 22.1 Ci is calculated compared to 122 Ci as listed in the original SD G. The NNSA recalculated values for both Curies and grams will be updated.
Ti-44	9.38E+01 Ci **5.46E-01 g**	9.38E+01 Ci 6.91E-01 g	The discrepancy is due to the difference in Half Life values used, which affects the Specific Activity value. The Original SD G used a Half-Life (yr.) = 59.9 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 47.3 years, which had a 26.5% reduction in HC-3 TQ ***gram*** quantity.
Kr-85	**1.46E+05 Ci** **3.71E+02 g**	3.33E+04 Ci 8.49E+01 g	The NOBLE Gas submersion formula considers a DAC value for each radio-isotope. That DAC value is derived directly by using the inert gas effective dose rate out of ICRP-68 ANNEXE D. The DAC value used in the original NNSA calculation is 1.68E-04 uCi/cm^3 vs 7.37E-04 uCi/cm^3 as used by ORNL and in the NNSA re-calculation. The DAC value of 1.68E-04 could not be re-produced, assumed error is data entry or data source. It was verified that the correct inert gas effective dose rate from ICRP-68 is used by ORNL and NNSA Re-calculation efforts. The NNSA re-calculated value is consistent with the ORNL value. The NNSA recalculated value for both Curies and grams will be updated.

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
Nb-94	**2.49E+02 Ci** **1.33E+03 g**	4.62E+04 Ci 2.43E+03 g	The value of 4.62E+02Ci is for Direct Exposure. It is verified that in the original SD G calc, the limiting pathway is INHALATION, with a value of 250Ci. This errata is due to error in choosing the limiting pathway. The re-calculated value for INHALATION value for Curies and grams will be updated.
Mo-99	**3.76E+03 Ci** **7.84E-03 g**	4.25E+03 Ci 8.84E-03 g	The cause for this discrepancy is error with-in the spreadsheet calculation. A reference to an incorrect 'column' of Dilution Factor data within EXCEL was used. When the correct column of Dilution Factor data is referenced, results consistent with ORNL are produced. The NNSA re-calculated value for Curies and grams will be updated.
Sb-126	**2.64E+02 Ci** **3.15E-03 g**	6.77E+02 Ci 8.10E-03 g	This discrepancy is due to selecting the wrong pathway value (Typo). It was verified that the limiting pathway is Direct Exposure in the original spreadsheet, which has a calculated value of 272Ci versus the 677Ci (ingestion value) as noted in this errata sheet. That value of 272Ci is consistent with ORNL value, and with the NNSA re-calculated value. There are slight differences in the E1 (average photon energy) values, which is due to differences in reference data (BNL vs ICRP-38). The NNSA recalculated value for Curies and grams will be updated.
Sn-126	1.67E+02 Ci **5.89E+03 g**	1.67E+02 Ci 1.35E+04 g	The discrepancy is due to the difference in Half Life values used, which affects the Specific Activity value. The Original SD G used a Half-Life (yr.) = 2.3E+05 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 1.0E+05 years, which had a 157 % reduction in HC-3 TQ ***gram*** quantity.

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
Xe-133	**2.67E+04 Ci** **1.43E-01 g**	6.12E+03 Ci 3.26E-02 g	The NOBLE Gas submersion formula considers a DAC value for each radio-isotope. That DAC value is derived directly by using the inert gas effective dose rate out of ICRP-68 ANNEXE D. The DAC value used in the original NNSA calculation is 3.1E-05 uCi/cm^3 vs 1.35E-04 uCi/cm^3 as used by ORNL and in the NNSA re-calculation. The DAC value of 3.1E-05 could not be re-produced, assumed error is data entry or data source. It was verified that the correct inert gas effective dose rate from ICRP-68 is used by ORNL and NNSA Re-calculation efforts. The NNSA re-calculated value is consistent with the ORNL value. The NNSA calculated value for Curies and grams will be updated.
Hg-203	**5.06E+02 Ci** **3.67E-02 g**	1.79E+03 Ci 1.30E-01 g	The discrepancy is due to the fact that NNSA did not consider the ‘organic’ dose coefficients as published in ICRP-68, as ORNL did. It was discussed within NA-SH and it was decided that the ‘organic’ dose coefficients shall be considered. Therefore, the correct coefficient value to use is 1.9E-09 Sv/Bq versus the previously used value of 5.4E-10 Sv/Bq. By using this coefficient, a release value of 506 Ci is calculated compared to 517Ci as calculated by ORNL. The NNSA recalculated value for Curies and grams will be updated.

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
Bi-207	**4.71E+02 Ci** **1.04E+01 g**	3.90E+02 Ci 7.21E+00 g	For Direct Exposure Point Source, the mathematical formula considers the average photon (E1) energy for that particular isotope. The original SD G value used for E1 is 1.86 MeV, which was calculated by a table of data of gamma ray energy and probability obtained from a Brookhaven National Lab database. ORNL used a value of E1 published in ICRP-38 as 1.54 MeV. This is the cause of discrepancy. NNSA chose to update and use ICRP-38 for reference data, which has listed E1=1.54216 MeV, which results in a re-calculated value of 470.7Ci, consistent with ORNL. The NNSA re-calculated value for Curies and grams will be updated. Adding to the ***gram*** discrepancy is due to the difference in Half Life values used, which affects the Specific Activity value. The Original SD G used a Half-Life (yr.) = 32 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 38 years.
Ac-227	**1.78E-01 Ci** **2.45E-03 g**	2.09E-01 Ci 2.88E-03 g	The correct inhalation dose coefficient value to use is 6.3E-4 Sv/Bq. The original SD G calculation used this coefficient correctly, which results in a value of 0.1787Ci. A Typo is the cause for the discrepancy. This will be corrected. The re-calculated value for Curies and grams will be used.
U-232	**3.21E+00 Ci** **1.49E-01 g**	3.40E+00 Ci 1.46E-01 g	The original NNSA spreadsheet has a calculated value of 3.21E+00Ci. Typo is the reason for this discrepancy. The NNSA calculated value will be used, which is consistent with the ORNL value.

HC-2 Threshold Quantity

ISOTOPE	Re-Calculated TQ	Original TQ	*ERRATA* COMMENT
Ti-44	6.76E+04 Ci **3.93E+02 g**	6.76E+04 Ci **4.97E+02 g**	The Original SD G used a Half-Life (yr.) = 59.9 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 47.3 years This affects the Specific Activity value as used in calculating the HC-2 Threshold Quantity in grams. Multiplying the TQ(g) value by S.A. to convert to Curies makes the formula independent of Half Life resulting in the same Ci value as listed. Therefore, changes in half-life values only impacts TQ in grams, which had a 26.5% reduction in HC-2 TQ gram quantity.
Kr-85	**1.06E+07 Ci** **2.70E+04 g**	2.27E+07 Ci 5.80E+04 g	Reason for discrepancy is original SD G used effective an dose rate CSDE = 4.4E-04 (Rem-m3)/(Ci-s) from FGR12 vs. the updated CSDE from ICRP 72 = 9.42E-04 (Rem-m3)/(Ci-s) Table A.4 .
Sn-126	2.90E+05 Ci **1.02E+07 g**	2.90E+05 Ci 2.34E+07 g	The Original SD G used a Half-Life (yr.) = 23,000 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 10,000 years This affects the Specific Activity value as used in calculating the HC-2 Threshold Quantity in grams. Multiplying the TQ(g) value by S.A. to convert to Curies makes the formula independent of Half Life resulting in the same Ci value as listed. Therefore, changes in half-life values only impacts TQ in grams.
Xe-133	**1.95E+06 Ci** **1.04E+01 g**	1.73E+06 Ci 9.23E+00 g	Reason for discrepancy is original SD G used an effective dose rate CSDE = 5.77E-03 (Rem-m3)/(Ci-s) from FGR12 vs. the updated CSDE from ICRP 72 = 5.14E-03 (Rem-m3)/(Ci-s) Table A.4 .
Bi-207	1.39E+06 Ci **3.06E+04 g**	1.39E+06 Ci 2.58E+04 g	The Original SD G used a Half-Life (yr.) = 32 years. Re-calculation uses ICRP-38 value Half-Life (yr.) = 38 years This affects the Specific Activity value as used in calculating the HC-2 Threshold Quantity in grams. Multiplying the TQ(g) value by S.A. to convert to Curies makes the formula independent of Half Life resulting in the same Ci value as listed. Therefore, changes in half-life values only impacts TQ in grams.

Attachment 6: EPA Tech STD Exhibit A-1 Release Fractions

WHC-SD-GN-HC-20002, REV. 0

EXHIBIT A-1

INHALATION RELEASE FRACTIONS

Element	Symbol	Release Fraction (R)
Actinium	Ac	0.001
Aluminum	Al	0.01*
Americium	Am	0.001
Antimony	Sb	0.01
Argon	Ar	1.0
Arsenic	As	0.01*
Astatine	At	0.001**
Barium	Ba	0.01
Berkelium	Bk	0.001**
Bk-249 & Bk-250		0.01*
Beryllium	Be	0.01*
Bismuth	Bi	0.01
Bromine	Br	0.01
Cadmium	Cd	0.01
Calcium	Ca	0.01
Californium	Cf	0.001
Carbon	C	0.5
Cerium	Ce	0.01
Cesium	Cs	0.01
Chlorine	Cl	0.01
Chromium	Cr	0.01
Cobalt	Co	0.001
Copper	Cu	0.01
Curium	Cm	0.001
Dysprosium	Dy	0.01*
Einsteinium	Es	0.001**
Es-254m		0.01*
Erbium	Er	0.01*
Europium	Eu	0.01
Fermium	Fm	0.001**

EXHIBIT A-1 (Cont.)

Element	Symbol	Release Fraction (R)
Fluorine	F	0.01*
Francium	Fr	0.01*
Gadolinium	Gd	0.01
Gallium	Ga	0.01*
Germanium	Ge	0.01
Gold	Au	0.01
Hafnium	Hf	0.01
Holmium	Ho	0.01
Hydrogen	H	0.5
Indium	In	0.01
Iodine	I	0.5
Iridium	Ir	0.001
Iron	Fe	0.01
Krypton	Kr	1.0
Lanthanum	La	0.01*
Lead	Pb	0.01
Lutetium	Lu	0.01*
Magnesium	Mg	0.01*
Manganese	Mn	0.01
Mandelevium	Md	0.001**
Mercury	Hg	0.01
Molybdenum	Mo	0.01
Neodymium	Nd	0.01*
Neptunium	Np	0.001
Nickel	Ni	0.01
Niobium	Nb	0.01
Osmium	Os	0.01*
Palladium	Pd	0.01*
Phosphorus	P	0.5
Platinum	Pt	0.01*

EXHIBIT A-1 (Cont.)

Element	Symbol	Release Fraction (R)
Plutonium	Pu	0.001
Polonium	Po	0.01
Potassium	K	0.01
Praseodymium	Pr	0.01*
Promethium	Pm	0.01
Protactinium	Pa	0.001
Radium	Ra	0.001
Radon	Rn	1.0
Rhenium	Re	0.01*
Rhodium	Rh	0.01*
Rubidium	Rb	0.01
Ruthenium	Ru	0.01
Samarium	Sm	0.01
Scandium	Sc	0.01
Selenium	Se	0.01
Silicon	Si	0.01*
Silver	Ag	0.01
Sodium	Na	0.01
Strontium	Sr	0.01
Sulfur	S	0.5
Tantalum	Ta	0.001
Technetium	Tc	0.01
Tellurium	Te	0.01
Terbium	Tb	0.01
Thallium	Tl	0.01
Thorium	Th	0.001
Thulium	Tm	0.01
Tin	Sn	0.01
Titanium	Ti	0.01

EXHIBIT A-1 (Cont.)

Element	Symbol	Release Fraction (R)
Tungsten	W	0.01
Uranium	U	0.001
Vanadium	V	0.01
Xenon	Xe	1.0
Ytterbium	Yb	0.01
Yttrium	Y	0.01
Zinc	Zn	0.01
Zirconium	Zr	0.01

* Indicates that the release fraction is based on the NUREG-1140 release fraction for "any other beta-gamma emitter."

** Indicates that the release fraction is based on the NUREG-1140 release fraction for "any other alpha emitter."

Source: McGuire, S.A., "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees," NUREG-1140.