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NE-STD-1027-2025

DOE STANDARD

HAZARD CATEGORIZATION OF DOE NUCLEAR FACILITIES

U.S. Department of Energy
Washington, DC 20585

Available to the public on the DOE Technical Standards Program website at
www.standards.doe.gov

FOREWORD

1. This Department of Energy Standard has been approved to be used by DOE-Office of Nuclear Energy.

2. Title 10 of the Code of Federal Regulations Part 830, *Nuclear Safety Management*, Subpart B, *Safety Basis Requirements*, establishes safety basis requirements for hazard category 1, 2, or 3 DOE nuclear facilities. This Standard provides an acceptable methodology to "[c]ategorize the facility consistent with 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)," as required by 10 CFR Section 202(b)(3).

3. The goal of this revised Standard is to maintain consistency with the methodology of DOE-STD-1027-92, CN1, while providing clearer criteria and guidance to support effective and consistent hazard categorization based upon more recent input values and lessons learned in implementing DOE-STD-1027-92, CN1.

4. This revision is not intended to affect existing DOE nuclear facilities previously categorized using the predecessor version of this standard. Further, this revision does not impact programmatic guidance as determined by the appropriate Safety Basis Approval Authority.

5. If a facility, site, or program office chooses to use this revision of the Standard, it should be used in its entirety.

Contents

1.0 INTRODUCTION

1.1 Purpose

This Standard (STD) provides requirements and guidance for determining if a Department of Energy (DOE) nuclear facility is a Hazard Category (HC) 1, 2, 3, or Below HC-3 nuclear facility, as required by Title 10 of the Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*.

1.2 Applicability

This Standard is applicable to all DOE-Office of Nuclear Energy authorized, nuclear facilities and activities. See 10 CFR Part 830, *Nuclear Safety Management*, Subpart B, Section 830.202, *Safety Basis*, (b)(3), which states that:

> "In establishing the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must…[c]ategorize the facility consistent with DOE-STD-1027-92"

This Standard does not apply to certain facilities or activities, irrespective of radioactive material quantities, that are not required to follow 10 CFR Part 830, Subpart B. Activities not required to comply with the provisions of 10 CFR Part 830, Subpart B, are those outside the scope of the regulation, as provided in 10 CFR Section 830.1, explicitly excluded by 10 CFR Section 830.2, *Exclusions*, or classified as Below Hazard Category 3. "[A]ccelerators and their operations," and "activities involving only incidental use and generation of radioactive materials or radiation such as check and calibration sources, use of radioactive sources in research and experimental and analytical laboratory activities, electron microscopes, and X-ray machines" are outside the scope of 10 CFR Part 830 because they are excluded from the regulation's definition of "nuclear facility."

This Standard is not required to be completed for Category A or B reactor facilities. The nature of these facilities requires them to be categorized as Hazard Category 1 and 2, respectively.

1.3 Background

DOE-STD-1027-92 was issued in December 1992 as a companion to DOE Order 5480.23, *Nuclear Safety Analysis Reports*, dated 4-10-1992. The Standard provided guidance for meeting the requirements of DOE Order 5480.23, including a uniform methodology for hazard categorization and insights into the graded approach for safety analysis. The Standard was revised in September 1997 as a routine revision with miscellaneous updates and corrections, including various corrections to Table A.1 on isotope thresholds. DOE Order 5480.23 was subsequently replaced in 2001 by 10 CFR Part 830, Subpart B, which cites DOE-STD-1027-92, Change Notice NO.1 (CN1), as the method for categorizing DOE nuclear facilities.

In November 2002, the DOE Office of Environment, Health and Safety (EH) issued a Nuclear Safety Technical Position (NSTP) 2002-2, *Methodology for Final Hazard Categorization for Nuclear Facilities from Category 3 to Radiological*, to clarify acceptable methods for determining final hazard categorization for HC-3 and Below HC-3 nuclear facilities. This technical position has been evaluated to be "consistent with DOE-STD-1027-92" as documented in *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)*, dated 10-13-2011.

In May 2007, the DOE Office of Health, Safety and Security (HSS) issued Supplemental Guidance for use with DOE-STD-1027-92, CN1, to address areas in need of clarification and improvement. Although the guidance addressed several areas identified by DOE and the Defense Nuclear Facilities Safety Board (DNFSB), the guidance was not formalized into a DOE Directive. The guidance stated that several areas were identified "where DOE Standard 1027 need clarification to support consistent implementation including:

- Sealed Source and Type B Shipping Container Exemptions;
- Applicability of Criticality Controls in Hazard Category 3 and Radiological Facilities;
- Application of Segmentation and Nature of Process in Final Hazard Categorization; and
- Adjustment of Threshold Quantities in Final Hazard Categorization."

In a May 7, 2007, letter from HSS to the DNFSB, the Department stated: "We also plan on revising DOE-STD-1027 to incorporate the supplemental guidance and the other improvements, which impact the intent or fundamental elements of the standard. However, this will be an extended effort; and we therefore believe the issuance of the supplemental guidance is warranted at this time."

In November 2011, the NNSA issued a Supplemental Directive using modern dosimetry and release fractions for hazard categorization, "consistent with DOE-STD-1027-92." NNSA recalculated the thresholds using more recent 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. This Supplemental Directive was revised and updated in May 2014, is used across NNSA facilities, and has been either approved for use or is being evaluated for use by other program offices.

This Standard was developed in an effort to update and consolidate all the previous work into a single document while maintaining consistency with the methodology of DOE-STD-1027-92.

For the NE version of this Standard, reactor hazard categorization is by definition and once defined, there is no reason to continue with the standard process. Changes for clarification of the expectations for considering Beyond Design Basis Accidents in final hazard categorization were removed, and additional considerations for sealed sources were provided. No methodology was changed.

1.4 Overview of the Standard

Section 2 provides the terminology used in the Standard, including acronyms and abbreviations, requirement and recommendation statements, and definitions. Section 3 describes the methodology for initial and final hazard categorization. Section 4 provides key references. Attachment 1 provides the Thresholds of Radionuclides. Appendix A provides the methodology and technical basis for calculation of radionuclide TQs.

2.0 TERMINOLOGY

2.1 Acronyms and Abbreviations

AMDC	Atomic Mass Data Center
ARF	Airborne Release Fraction
CFR	Code of Federal Regulations
CTA	Central Technical Authority
DC	Dose Coefficient
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DSA	Documented Safety Analysis
EPA	Environmental Protection Agency
ENSDF	Evaluated Nuclear Structure Data File
FGR	Federal Guidance Report
HC	Hazard Category
IAEA	International Atomic Energy Agency

ICRP	International Commission on Radiological Protection
JAERI	Japan Atomic Energy Research Institute
MAR	Material at Risk
NNDC	National Nuclear Data Center
NRC	Nuclear Regulatory Commission
NTD	Nuclear Transformation Data
O	Order
PSO	Program Secretarial Officer
R	Release Fraction
RF	Respirable Fraction
RV	Release Value
SOR	Sum of Ratios
STD	Standard
TQ	Threshold Quantity

2.2 Shall, Should, and May

The word “shall” denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes a discretionary action that is neither a requirement nor a recommendation.

2.3 Definitions

Category A Reactor – Those production, test, and research reactors designated by DOE based on power level (i.e., design thermal power rating of 20 megawatts steady state and higher), potential fission product inventory, and experimental capability. Category A reactors are Hazard Category 1 nuclear facilities.

Category B Reactor – A reactor as defined by 10 CFR Part 830, Section 830.3, that is not a Category A Reactor. Category B reactors are Hazard Category 2 nuclear facilities.

Sum of Ratios (SOR) – Method to evaluate whether a facility’s (or area within a facility) radioactive material inventory meets or exceeds the TQ values for a combination of radionuclides, and to determine the hazard category for the DOE nuclear facility. This is done by dividing each radionuclide’s activity or mass by the radionuclide’s respective TQ and summing the resulting ratios.

Threshold Quantity (TQ) – The quantity of a radioactive material that, if released, would result in a dose consequence of 1 rem at just less than 300 meters (for HC-2) or 10 rem at 30 meters (for HC-3).

3.0 HAZARD CATEGORIZATION

Table 1 in Appendix A to Subpart B of 10 CFR Part 830, defines the nuclear facility hazard categories. This table is reproduced below. Following the table, the hazard categories are clarified further.

Table 3.1: Reproduction of Table 1 in Appendix A of Subpart B of 10 CFR Part 830

A DOE nuclear facility categorized as…	Has the potential for…
Hazard Category 1	Significant off-site consequences
Hazard Category 2	Significant on-site consequences beyond localized consequences
Hazard Category 3	Only local significant consequences
Below Hazard Category 3	Only consequences less than those that provide a basis for categorization as a hazard category 1, 2, or 3 nuclear facility.

Hazard Category 1

DEFINITION: Hazard Analysis shows the potential for significant off-site consequences.

INTERPRETATION: Category A reactor or DOE nonreactor nuclear facilities designated by the PSO.

Hazard Category 2

DEFINITION: Hazard Analysis shows the potential for significant on-site consequences.

INTERPRETATION: DOE nonreactor nuclear facilities or DOE nuclear facility, including Category B reactors, with sufficient quantities of hazardous radioactive material and energy (i.e., greater than HC-2 TQs in Attachment 1), which would require on-site emergency planning activities.

Hazard Category 3

DEFINITION: Hazard Analysis shows the potential for significant localized consequences.

INTERPRETATION: DOE nonreactor nuclear facilities with quantities of hazardous radioactive materials which meet or exceed the HC-3 TQs in Attachment 1.

Below Hazard Category 3

DEFINITION: A nuclear facility with radiological materials, but in quantities determined as part of an initial or final hazard categorization to be less than Hazard Category 3 thresholds.

INTERPRETATION: DOE nonreactor nuclear facilities with quantities of hazardous radioactive materials less than the HC-3 TQ values in Attachment 1. These facilities are not required to comply with the requirements of 10 CFR Part 830, Subpart B.

3.1 Initial Hazard Categorization

Initial hazard categorization is intended to be a simple screening step that does not involve detailed computations, which will enable facility managers to quickly determine the likely facility hazard categorization. The consideration of material form, location, dispersibility and interaction with available energy sources called for in final hazard categorization is not applicable to initial hazard categorization. Simple screening, with respect to criticality, in initial hazard categorization for nature of process and segmentation is allowed, see Section 3.1.6. Such arguments will be defended as part of final hazard categorization, as necessary.

Initial hazard categorization of the facility's radioactive material inventory shall be evaluated based on:

1) the Sum of Ratios (SOR) (see Section 3.1.5), and

2) the quantity of fissile material in the facility (see Section 3.1.6).

Initial hazard categorization is determined based on the result (i.e., highest categorization) of the two evaluations above. If the result of the initial hazard categorization concludes that the facility will be categorized as Below Hazard Category 3, final hazard categorization is not performed. Below HC-3 facilities should have administrative controls in place to ensure the facility remains Below HC-3. A facility with an inventory of radioactive materials that varies with time shall be categorized on the basis of its maximum inventory of radioactive material.

Section 3.1.1 provides criteria for facility segmentation in initial hazard categorization. Sections 3.1.2 thru 3.1.4 provide requirements and guidance for excluding radioactive material from the SOR calculation, and Section 3.1.5 discusses the calculation and determination of initial hazard categorization based on the SOR. Section 3.1.6 discusses the evaluation of fissile material for initial hazard categorization and the nature of the process evaluations and their bases to support conclusions that the facility operations preclude a nuclear criticality. Section 3.1.7 provides guidance for the methodology used to calculate the TQs.

3.1.1 Facility Segmentation

The concept of independent facility segments applies where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon. The objective is to understand the physical separation of available hazards that could otherwise interact to cause harm to individuals or the environment.

To demonstrate segmentation as part of initial hazard categorization, the following criteria shall be met:

1. Physical separation exists between segments, such as multiple structures or a structure separated from an inactive waste site;

2. The physically separated structures or facilities react to accident scenarios independently (other than through combination of their plumes from a common external event);

3. The physically separated structures or facilities do not share a common ventilation system[1] or process piping; and

4. A fire in one structure cannot cause failure of the other exposed structure.

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

3.1.2 Treatment of Sealed Sources

Sealed radioactive sources that meet any of the following testing specifications may be excluded from the facility's radioactive inventory as part of the SOR:

- Department of Transportation (DOT) Special Form criteria per 49 CFR Part 173, *Shippers – General Requirements for Shipments and Packages*, Section 469, *Tests for*

[1] Facilities that share a common ventilation stack downstream of individual ventilation systems may be segmented as part of initial hazard categorization where a simple analysis can demonstrate independence of the systems.

special form Class 7 (radioactive) materials;

- Nuclear Regulatory Commission (NRC) Special Form criteria 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*, Section 75, *Qualification of special form radioactive material*;

- ANSI N43.6, *Sealed Radioactive Sources – Classification*, or ISO 2919, *Radiological Protection – Sealed Radioactive Sources – General Requirements and Classification*, Class 6 performance criteria for temperature, and class 4 performance criteria for impact; or

- International Atomic Energy Agency (IAEA) Safety Standards Series TS-R-1, *Regulations for Safe Transport of Radioactive Material*, 2005, Section VII, paragraphs 704-711.

Radiological check and calibration sources that under the activity established in 10 CFR Part 835 Appendix E may be excluded from the facility's radioactive inventory as part of the SOR.

Facilities that exclude material in sealed radioactive sources shall:

- Have in place a source control program or policy that complies with the requirements of 10 CFR Part 835, Subpart M, *Sealed Radioactive Source Control*.

- Maintain records for each excluded sealed source that demonstrates the source is engineered to pass and continues to meet the appropriate ANSI/International Organization for Standardization (ISO) or IAEA special form performance criteria. Examples include current certification documents (e.g., special form certificates, ANSI/ISO certifications, IAEA Certificate of Competent Authority) or engineering, test, and safety analysis documentation. Sealed sources can be excluded only as long as they continue to physically meet the ANSI/ISO or special form performance criteria (i.e., they have not been degraded, and they are within an analyzed design working life).

  Note: Normally the ANSI/ISO or special form compliance documentation or certification provided by a manufacturer, supplier, or regulator is sufficient if the source is within its specified service life, or a service life is not specified and the source is not subject to inherent age-related degradation mechanisms (e.g., internal gas/pressure buildup, corrosion) or environments. At a minimum, service life limitations should be addressed by the manufacturer, supplier, regulator, or user for all actinide alpha sources/special forms, or sources/special forms used in a corrosive or extreme environment.

  Note 2: If the service life of an excluded sealed source is expired, it should be taken out of service until the manufacturer, supplier, regulator, or user provides an updated service life. While the service life is being evaluated, the source does not need to be counted

against a facility's SOR. However, if the source will not have its service life extended within 90 days, then it will need to be counted against the facility SOR.

- Develop and implement procedures to address leaking sealed radioactive sources. Special attention should be placed on excluded sealed radioactive sources that could change the facility hazard category if breached. These procedures should identify appropriate controls that are to be promptly initiated to ensure protection of the public and workers and contingencies for additional hazard analysis (and potentially re-categorization of the facility) if the leaking source cannot be remediated in a timely manner.

Sealed sources are designed for multiple accident scenarios, however, DOE facilities may present hazards not compatible with design of sealed sources. In such a case, the radioactive material should not be excluded as part of the initial hazard categorization SOR and hazard analysis necessary to demonstrate the integrity of the sealed source should be supported in final hazard categorization (see Section 3.2.3).

Exclusion of sealed sources is only applicable to the reduction of radioactive material inventory in the SOR calculation and not the fissile material assessment required by Section 3.1.6.

3.1.3 Commercially Available Products

The following commercially available products may be excluded from summation of a facility's radioactive inventory as part of the initial hazard categorization:

- Commercially available products containing byproduct material as described in 10 CFR Part 30, Sections 30.14-30.21.

- Commercially available products containing source material as described in 10 CFR Part 40, Section 40.13(c).

The exclusion is not extended to a commercially available product that is modified or altered from its intended use (e.g., removal of sources from a smoke detector). Exclusion of commercially available products is applicable to the reduction of radioactive material inventory in the SOR calculation and the fissile material assessment.

3.1.4 DOT Type B Packages

Radioactive material contained in DOT Type B packages may be excluded from the summation of a facility's radioactive inventory if the following criteria are met:

1. Excluded Type B packages remain closed at all times;

2. The Type B packages being excluded have a current Certificate of Compliance; and

3. The materials stored are authorized by the certificate.

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

Exclusion of Type B packages is only applicable to the reduction of radioactive material inventory in the SOR calculation and not the fissile material assessment required by Section 3.1.6. Type B packages without overpack should have heat protection provided by the facility's fire suppression system.

3.1.5 Sum of Ratios Calculation

If the SOR is greater than or equal to a value of 1.0, the facility shall be initially categorized as HC-2 or HC-3 depending upon the TQs used in the calculation. If the SOR is less than 1.0, when compared to the HC-3 TQs, the facility is categorized as Below HC-3; unless criticality cannot be precluded (see Section 3.1.6) or a final hazard categorization is necessary to support exclusion of material in sealed sources (Section 3.1.2) or Type B containers (Section 3.1.4

For mixtures or combinations of radioactive materials, the SOR is determined by dividing each radionuclide's activity or mass by the appropriate TQ and adding the resulting values (see equation below). TQs should be consistent with the hazard category being evaluated against (i.e., HC-2 or HC-3).

$$SOR = \sum_{i=1}^{n} \left| \left(\frac{Q_1}{TQ_1}\right) + \left(\frac{Q_2}{TQ_2}\right) + \cdots + \left(\frac{Q_n}{TQ_n}\right) \right|$$

Where:

n Number of radionuclides

Q Quantity of nuclear material (Ci or gm)

TQ Threshold quantity relative to radionuclide species (Ci or gm)

3.1.6 Fissile Material Limits and the Nature of the Process

Initial hazard categorization assesses the aggregate fissile material in a facility. If a facility's fissile material inventory exceeds any of the fissile mass limits specified in ANSI/ANS-8.1-2014, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, the facility shall be initially categorized as HC-2, unless criticality is precluded by segmentation or a nature of the process evaluation via simple screening. If detailed analytical evaluation for the nature of the process or segmentation is required, this shall be done in final hazard analysis.

If criticality is precluded by segmentation or the nature of the process considering both normal (planned) and abnormal conditions, the resulting initial hazard categorization defaults back to radioactive material inventory alone (i.e., SOR). In cases where the nature of the process and/or segmentation results in a determination that the potential for criticality is precluded, a complete and accurate record of the conditions supporting the determination is required[2] to be maintained.

To support a position that the nature of the process precludes criticality, the criticality documentation shall demonstrate that a potential for criticality is precluded for a given material configuration, based on the consideration of quantity, form, shape, and collocation with moderators and reflectors. Credit may be taken for the fundamental chemistry, physics and distribution of the materials being evaluated, but not for engineered or administrative controls with-in the facility. When evaluating a postulated criticality accident for demonstrating that criticality is precluded by the nature of the process, only the conditions listed below should be considered.

- Controls that restrict the types, forms, amounts, chemical properties and/or the distribution of the fissionable material from entering the facility. An example of these controls would be limits on the amount, type, or form of material in a facility or amount of moderators/reflectors that are more effective than water allowed in the facility.

- Limitations on the scope of the facility activities that are permitted, e.g., surveillance/maintenance (no work activities allowed with only surface contamination); storage/staging only (no opening or processing allowed).

Note: Demonstration that the nature of the process or segmentation precludes criticality is not a sufficient justification to eliminate the contractor's criticality safety program. Additionally, the establishment of defense-in-depth controls by criticality safety does not by itself negate the ability to achieve a nature of the process determination.

[2] See 10 CFR § 830.6, *Recordkeeping.*

3.1.7 Calculation of Threshold Quantities

The calculation of HC-2 and HC-3 TQs that are not listed in Attachment 1 shall follow the methodology in Appendix A. For HC-2 TQs where there is no published dose coefficient, the default values in footnote A to Table 1-1 of Attachment 1 should be followed. For HC-3, radionuclides that do not have a published dose coefficient should calculate the TQ using the remaining dose pathways (i.e., direct point source and air submersion as discussed in Appendix A, Section A.5.4) to select the bounding TQ.

3.2 Final Hazard Categorization

Once a hazards analysis has been performed, the hazard categorization may be finalized. The purpose of the final hazard categorization is to ensure that facility and accident specific factors are addressed that could either (1) change the fraction of material released in an accident or (2) change the amount of the total inventory of material subject to an accident.

The first case (change in fraction of material released) is addressed by considering whether the release fractions (i.e., airborne release fraction (ARF) and respirable fraction (RF)) that were utilized in derivation of the TQs[3] used in the initial hazard categorization should be adjusted. Section 3.2.5 provides the required methodology for modifications to TQs. The methodology should evaluate the potential for either an increase or decrease of the hazard category based on an unmitigated release of available radioactive material, considering only the material's total quantity, form, location, dispersibility, and interaction with available energy sources.

In the second case (change in material subject to an accident), two conditions should be considered in determining the final hazard categorization: (1) whether the facility inventory can be reduced (for the purpose of hazard categorization) due to segmentation (e.g., where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon), and (2) whether the hazard analysis identifies conditions affecting sealed sources, special forms or Type B container exclusions. Further guidance is given in Sections 3.2.2 and 3.2.3, respectively.

[3] See Appendix A, Sections A.4 and A.5 for the equations to derive the HC-2 and HC-3 TQs.

3.2.1 Hazard Analysis to Support Final Hazard Categorization

When analysis suggests that the initial hazard categorization may be altered, a final hazard categorization may performed. Hazard analysis is performed as part of final hazard categorization to determine the effects of available energy sources and radioactive material release mechanisms. The primary objectives of the hazard analysis are to: (1) identify the radioactive material quantities, form(s) and location(s); (2) identify potential energy sources (including chemical hazards) that could interact with the radioactive material; (3) identify plausible hazard scenarios that could release the radioactive material; and (4) identify a bounding material at risk (MAR) and associated release fractions based on these factors.

To support the final hazard categorization, the hazard evaluation results should be used to determine the bounding MAR and release fractions (i.e., ARFs and RFs) associated with energies driving unmitigated releases of radioactive material in accordance with physical realities of the accident phenomena at a given facility, activity, or operation. The MAR is the bounding quantity of radioactive material that is available to be acted upon by a given physical stress from a postulated accident. The MAR may be the total inventory in a facility or a portion of this inventory in one location or operation, depending on the event. MAR values used in the hazard analysis shall be bounding with respect to each accident being evaluated and consistent with the values noted in hazard identification/evaluation.

The ARF is the coefficient used to estimate the amount of a radioactive material that can be suspended in air and made available for airborne transport under a specific set of induced physical stresses. The RF is the fraction of airborne radionuclide particles that can be transported through air and inhaled into the human respiratory system. The RF is commonly assumed to include particles of 10-μm Aerodynamic Equivalent Diameter and less. Bounding estimates, and in many cases median estimates, for radionuclide ARFs and RFs for a wide variety of MAR and release phenomena are presented in DOE-HDBK-3010. The bounding estimates should be used unless a different value is provided in an applicable standard or is otherwise technically justified. In cases where direct shine may contribute significantly to dose, that contribution should be evaluated without the use of the RF, and without the use of the ARF if due to a spill release resulting in exposure to a pool. ARFs and RFs are selected based on physical conditions and stresses anticipated during accidents. Activities supporting the hazard analysis are described below.

Hazard Identification

The methodology used for hazard identification shall comprehensively identify the radiological hazards and energy sources of facility processes; including the characterization of radioactive materials and energy sources in terms of quantity, form, and location. Commercial industry practices for hazard identification, such as those described in the Center for Chemical Process Safety's *Guidelines for Hazard Evaluation Procedures* may be used.

Bounding inventory values of radioactive materials shall be used, i.e., the maximum quantities of material that are permitted to be stored and used in facility processes. Inventory data may be obtained from flowsheets, vessel sizes, contamination analyses, maximum historical inventories, and similar sources. Other possible sources of information supporting hazard identification include fire hazard analyses, health and safety plans, job safety analyses, and occurrence reporting histories.

Identification of standard industrial hazards such as hot surfaces, electrocution, and falling objects is not necessary to support the final hazard categorization unless it can and is likely to be an initiator or contributor to an uncontrolled release of radioactive material (for example, 115-volt wiring as initiator of a fire).

Hazard Evaluation

The hazard evaluation shall analyze:

- Facility radiological hazards associated with the planned activities or operations to be authorized;
- Both normal operations (e.g., startup and maintenance operations) and abnormal/accident conditions; and
- Natural phenomena and man-made external events that can affect the facility.

A graded approach should be applied to the selection of hazard evaluation techniques. The selection should be based on several factors including the complexity and size of the operation being analyzed, the type of operation, and the inherent nature of hazards being evaluated. For example, a hazard evaluation technique such as "What-If" or "What-If/Checklist Analysis" is appropriate for analyzing many HC-3 facilities, as well as simple HC-2 operations such as waste packaging, storage, or transport. More elaborate methods such as Hazard and Operability (HAZOP) Studies or Failure Modes and Effects Analysis (FMEA) may be needed for facilities with higher complexity operations, such as chemical processing. A discussion of hazard evaluation techniques and recommendations on their selection can be found in Part I of the Center for Chemical Process Safety's *Guidelines for Hazard Evaluation Procedures*.

As part of the hazard evaluation, an unmitigated hazard scenario shall be evaluated for each initiating event by assuming the absence of preventive and mitigative controls. Operational events shall be evaluated unless not plausible based on the following criteria:

- A process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive. In evaluating this criterion, a wide range of possible motives, short of intent to cause harm, should be considered; or

- A process deviation for which there is a convincing argument, given physical laws, that they are not possible. The criterion cannot be used if the argument depends on any feature of the design or materials controlled by the facility's safety features or administrative controls (ACs).

3.2.2 Facility Segmentation

A facility segmentation argument may be developed during final hazard categorization if hazards analysis demonstrates that facility features preclude bringing radioactive material together or causing harmful interaction from a common severe phenomenon. In these cases, it is not desirable to estimate the potential consequences from the total inventory of radioactive materials within the facility or adjacent facilities. However, a documented hazards analysis is required to develop the analytical arguments necessary for segmentation.

For segmentation of processes, operations, or activities within a common structure or multiple structures or facilities, formal analysis shall demonstrate that:

1. Facility segments react to accident scenarios independently, such that radioactive material in one facility segment cannot interact with radioactive material from another segment (this does not include the mixing of plumes which could occur from common severe phenomena); and

2. Neutronic interaction between operations or activities is negligible in cases where segmentation of fissionable material is necessary for the purpose of criticality safety.

3.2.3 Sealed Sources and DOT Type B Packages

In cases where facility hazards may challenge the design of sealed sources or Type B packages, hazard analysis should support assumptions that the radioactive material contained in the sealed sources or DOT Type B packages may be excluded in the final hazard categorization. Therefore, in addition to the criteria of Sections 3.1.2 and 3.1.4, hazard analysis should demonstrate that the sealed sources or DOT Type B packages would maintain their integrity under postulated accident conditions (e.g., drops, punctures, fires, seismic activity).

3.2.4 Modification of TQs

Modification of TQs as part of a final hazard categorization, if performed, shall compare release fractions assumed in Appendix A to conditions evaluated by the facility's hazard analysis. Except as provided in footnote 5, other assumptions and parameters used in the Appendix A methodology (i.e., basis for the TQs) should not be altered[4]. When an alternate release fraction is used, it should be based on the bounding estimated release fraction presented in DOE-HDBK-3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* unless a different value is provided in an applicable standard or is otherwise technically justified.

For evaluation of HC-2 facilities to be downgraded to HC-3, alternate release fractions shall be compared to release fractions used to derive the HC-2 TQs (e.g., 1E-3 for nonvolatile solids/powders/liquids based on NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*). For evaluation of HC-2 or HC-3 facilities to be downgraded to Below HC-3, alternate release fractions shall be compared to release fractions used to derive the HC-3 TQs. The basis and associated release fractions used in developing TQs are presented in Appendix A, Section A.3.2.

The release fractions for HC-3 TQ values shall be determined using Table A-7 in Appendix A of this Standard. These thresholds should be adjusted when the exposure scenario would be significantly different from that assumed in the development of the thresholds. Adjustment should account for all release pathways as this may change which pathway is the most limiting. The HC-3 pathways are discussed in Appendix A of this Standard.

When the limiting pathway is ingestion or inhalation, alternate release fractions for HC-3 thresholds should be chosen consistent with the exposure pathway indicated in Table 1-1, unless it can be shown that a different exposure pathway results in greater exposure to workers. If the limiting pathway for the radioisotope and the limiting pathway in the scenario being evaluated both involve a release fraction, an adjustment may be made. When a limiting pathway is direct exposure from a point source or submersion in a radioactive cloud of inert gas, there is no associated release fraction, so the approach of adjusting the threshold by using ratios of release fractions cannot be used.

[4] Where appropriate, recommended default lung absorption types provided in Table 2 of ICRP 72 may be used based on the material form.

A modified TQ value shall be determined by multiplying the TQ value by the ratio of the default release fraction used (see Section A.3.2) and the adjusted release fraction[5]. The hazard categorization may be reduced if the revised sum of ratios of actual radionuclide inventory is less than one, accounting for all isotopes in a facility's inventory and using the modified TQ values for individual isotopes.

The methodology used to modify TQs should also be applied to situations where hazard categorization could be increased because of conditions identified in the hazard analysis. An example would include where a large percentage of the facility inventory is subject to a release fraction well in excess of the nominal release fraction used in determining the threshold quantities. HC-2 facilities are not required to perform this evaluation.

3.2.5 Determination of Below Hazard Category 3

A final hazard categorization determination that a facility is Below HC-3 may be presented in documentation other than a documented safety analysis (DSA)[6]. The documentation should include the following information:

- A description of the facility and associated authorized processes and activities;
- Hazard analysis methodology and results;
- Initial and final categorization results; and
- Assumptions and conditions that form the basis for the final hazard categorization.

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[5] For example, the HC-3 TQ for P-32 is based on the material release fraction of 5E-1 assuming a "highly volatile/combustible" material form. In a different form, such as a solid or aqueous solution, it may be appropriate to assign a release fraction for "semi-volatile" material, 1E-2. In that case, the HC-3 TQ may be adjusted by:

TQrevised = TQinitial * (Rinitial/Rrevised) = 1.2E1 Ci * 5.0E-1/1.0E-2 = 6.0E2 Ci

Note that release fraction (R) adjustments do not affect the direct exposure pathway used to develop HC-3 TQs, so the adjusted release fraction must be compared to the direct exposure pathway value to determine the limiting HC-3 TQ value for the nuclide.

[6] DOE is required to review and approve downgrades in facility hazard categorization to "Below Hazard Category 3" in accordance with Section 6.3 of DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, which is invoked by DOE Order 420.1C, Change 2, *Facility Safety*.

If a change is planned at a facility or new information is discovered that affects a condition or assumption relied on to form the basis of a final hazard categorization downgrade, contractors should ensure that the basis for the hazard categorization remains valid in accordance with 10 CFR Part 830, Section 830.202(c). A revised final hazard categorization may be required to demonstrate that the change or new information does not adversely affect the determination of Below HC-3, or to determine whether it establishes a new hazard category. Examples of changes that may affect a final hazard categorization include:

- Facility mission (e.g., change involving new activities, assumption in the hazard analysis such as new energy sources);
- Radionuclide inventory (e.g., increase in material to be stored or processed, change in the process, new sample data or analysis, discovery of new or different materials [for example during decommissioning of a facility]);
- Form of material (e.g., change in how materials are contained, processed, or treated, or a newly discovered material characteristic);
- Dispersibility (e.g., change in container, process, or treatment, discovery of new or different materials, change in type or intensity of energy sources, change in project environment [drier or wetter than assumed]);
- Interaction with available energy sources (e.g., change in adjacent facility or process, change in process, change in location, change in conditions surrounding area);
- Segmentation (e.g., change in facility physical features, change in process, change in energy sources, change in operations), and;
- Changes in the nature of the process that may affect criticality safety assumptions.

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

4.0 REFERENCES

Users of this Standard are advised to review the list below to determine whether each listed document, a more recent version, or a replacement document is the most pertinent for each application. When alternate documents are used that are not listed here, users are advised to document this decision and its basis.

Code of Federal Regulations

(1) 10 CFR Part 30, *Rules of General Applicability to Domestic Licensing of Byproduct Material*

(2) 10 CFR Part 40, *Domestic Licensing of Source Material*

(3) 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*

(4) 10 CFR Part 830, *Nuclear Safety Management*

(5) 10 CFR Part 835, *Occupational Radiation Protection*

(6) 49 CFR Part 173, *Shippers – General Requirements for Shipments and Packages*

DOE Orders, Technical Standards and Handbooks

(1) DOE O 420.1C, Chg.2, *Facility Safety,* July 2018

(2) DOE-STD-1027-92, Chg. 1*, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, September 1997*

(3) DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, December 2016

(4) DOE-STD-1196-2011, *Derived Concentration Technical Standard*, April 2011

(5) NNSA SD G 1027, Admin Change 1, *Guidance on Using Release Fraction and Modern Dosimetric Information Consistently with DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, Change Notice No. 1*¸ May 2014

(6) DOE-HDBK-3010-94 (R2013), *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, July 1996

International, Consensus, Other Agency Standards and Reports

(1) ANSI/HPS N43.6-2007 (R2013), *Sealed Radioactive Sources – Classification*, September 2013

(2) *CODATA Recommended Values of the Fundamental Constants: 2014.* Mohr, Peter J., Newell, David B. and Taylor, Barry N. Issue No. 3, American Physical Society, Reviews

of Modern Physics, Vol. 88. National Institute of Standards and Technology, September 2016

(3) DOE 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)*, October 2011

(4) Department letter to the Chairman, Defense Nuclear Facilities Safety Board, regarding DOE Standard 1027, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report*, May 7, 2007

(5) *Evaluated Nuclear Structure Data File Search and Retrieval (ENSDF)*, National Nuclear Data Center, Brookhaven National Laboratory

(6) EPA 400-B-92-001, Manual of Protective Action Guidelines and Protective Actions for Nuclear Incidents, May 1992

(7) EPA 402-R-93-081, Federal Guidance Report No.12 (FGR-12), *External Exposure to Radionuclides in Air, Water, and Soil*, September 1993

(8) EPA Technical Report, *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, (Report prepared by ICF Incorporated and C-E Environmental, EPA Contract 68-03-3452) February 1989

(9) *Guidelines for Hazard Evaluation Procedures*, Center for Chemical Process Safety, Third Edition, Wiley/American Institute of Chemical Engineers, 2008

(10) IAEA Safety Standards Series TS-R-1, *Regulations for the Safe Transport of Radioactive Material*, 2005 Edition

(11) ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*, 1979-1981

(12) ICRP Publication 38, *Radionuclide Transformations – Energy and Intensity of Emissions*, 1983

(13) ICRP Publication 56, *Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 1*, 1990

(14) ICRP Publication 67, *Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 2 Ingestion Dose Coefficients*, 1993

(15) ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, 1994

(16) ICRP Publication 69, *Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 3 Ingestion Dose Coefficients*, 1995

(17) ICRP Publication 71, *Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 4 Inhalation Dose Coefficients*, 1995

(18) ICRP Publication 72, *Age-dependent Doses to Members of the Public from Intake of Radionuclides – Part 5 Compilation of Ingestion and Inhalation Coefficients*, 1995

(19) ICRP Publication 107, *Nuclear Decay Data for Dosimetric Calculations*, 2008

(20) ICRP Publication 119, *Compendium of Dose Coefficients Based on ICRP Publication 60*, 2012

(21) ISO 2919:2012, *Radiological Protection – Sealed Radioactive Sources – General Requirements and Classification*, February 2012

(22) JAERI-Data/Code 2002-013, *Dose Coefficients for Radionuclides Produced in High Energy Proton Accelerator Facilities: Coefficients for Radionuclides Not Listed in ICRP Publications*, Japan Atomic Energy Research Institute, May 2002

(23) LAUR-14-20689, *HC-2/3 Threshold Quantity According to DOE Supplemental Guidance NA-1 SD G 1027*, October 2014

(24) NSTP 2002-2, *Methodology for Final Hazard Categorization for Nuclear Facilities from Category 3 to Radiological*, November 2002

(25) NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, 1988

(26) ORNL/TM-2017/467, *Calculation of Hazard Category 2/3 Threshold Quantities Using Contemporary Dosimetric Data*, November 2017.

ATTACHMENT 1: RADIONUCLIDE THRESHOLDS

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
H-3	3.00E+05[C]	3.00E+01[C]	1.60E+04[C]	1.60E+00[C]	--[C]
Be-7	1.31E+08	3.74E+02	1.48E+04	4.25E-02	Direct Exposure
Be-10	2.32E+05	1.04E+07	3.49E+02	1.56E+04	Inhalation
C-10	3.42E+06	5.85E-05	1.29E+06	2.21E-05	Direct Exposure
C-11	4.92E+06	5.88E-03	3.49E+04	4.16E-05	Direct Exposure
C-14	1.40E+05	3.14E+04	3.85E+02	8.64E+01	Inhalation
N-13	5.52E+04	3.80E-05	8.04E+02	5.54E-07	Submersion
N-16	1.04E+04	1.06E-07	1.36E+06	1.37E-05	Direct Exposure
O-14	1.66E+04	1.45E-06	2.30E+02	2.01E-08	Submersion
O-15	5.50E+04	8.95E-06	8.04E+02	1.31E-07	Submersion
O-19	5.88E+04	2.66E-06	1.69E+06	7.65E-05	Direct Exposure
F-17	5.88E+04	5.71E-06	6.60E+05	6.42E-05	Direct Exposure
F-18	3.94E+04	4.14E-04	6.46E+03	6.79E-05	Direct Exposure
Ne-19	5.49E+04	1.59E-06	2.47E+06	7.16E-05	Direct Exposure
Ne-24	1.09E+05	4.70E-05	3.96E+05	1.71E-04	Direct Exposure
Na-22	9.99E+03	1.60E+00	2.54E+02	4.07E-02	Food
Na-24	1.76E+04	2.02E-03	2.92E+02	3.35E-05	Direct Exposure
Mg-27	6.50E+07	8.82E-02	8.60E+04	1.17E-04	Direct Exposure
Mg-28	5.78E+06	1.08E+00	7.68E+02	1.43E-04	Direct Exposure
Al-26	3.97E+05	2.07E+07	2.30E+02	1.20E+04	Food
Al-28	2.91E+07	9.71E-03	1.82E+05	6.06E-05	Direct Exposure
Al-29	4.03E+07	4.07E-02	8.01E+04	8.10E-05	Direct Exposure
Si-31	1.02E+08	2.65E+00	1.02E+05	2.63E-03	Inhalation
Si-32	7.37E+04	2.97E+03	1.02E+02	4.09E+00	Inhalation
P-30	1.09E+05	4.36E-05	2.84E+05	1.13E-04	Direct Exposure
P-32	4.77E+03	1.67E-02	1.13E+01	3.94E-05	Food
P-33	1.08E+04	6.93E-02	8.89E+01	5.70E-04	Food
S-35	8.53E+03	2.00E-01	2.26E+01	5.30E-04	Food
S-37	3.51E+04	3.49E-05	4.90E+04	4.86E-05	Direct Exposure
S-38	2.67E+04	9.19E-04	6.20E+02	2.13E-05	Inhalation
Cl-34	5.67E+04	2.60E-07	2.79E+07	1.28E-04	Direct Exposure
Cl-34m	2.23E+04	1.29E-04	1.07E+04	6.20E-05	Direct Exposure
Cl-36	1.11E+03	3.36E+04	2.51E+02	7.61E+03	Food
Cl-38	2.88E+04	2.17E-04	1.31E+04	9.83E-05	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Cl-39	3.06E+04	3.53E-04	9.06E+03	1.04E-04	Direct Exposure
Cl-40	1.29E+04	3.71E-06	1.31E+05	3.77E-05	Direct Exposure
Ar-37	2.13E+10	2.11E+05	7.84E+08	7.78E+03	Submersion
Ar-39	2.97E+08	8.71E+06	2.92E+05	8.57E+03	Submersion
Ar-41	4.16E+04	9.93E-04	6.07E+02	1.45E-05	Submersion
Ar-42	2.15E+07	8.28E+04	2.47E+05	9.55E+02	Submersion
Ar-43	3.58E+04	4.39E-05	8.79E+04	1.08E-04	Direct Exposure
Ar-44	2.86E+04	7.93E-05	3.97E+02	1.10E-06	Submersion
K-38	3.30E+04	5.08E-05	2.98E+04	4.59E-05	Direct Exposure
K-40	7.63E+03	1.09E+09	1.26E+02	1.80E+07	Food
K-42	9.90E+04	1.64E-02	4.79E+03	7.92E-04	Direct Exposure
K-43	5.79E+04	1.79E-02	1.06E+03	3.28E-04	Direct Exposure
K-44	4.30E+04	2.23E-04	1.44E+04	7.47E-05	Direct Exposure
K-45	5.32E+04	2.54E-04	1.94E+04	9.28E-05	Direct Exposure
K-46	3.68E+04	1.57E-05	1.44E+05	6.17E-05	Direct Exposure
Ca-41	4.50E+07	7.23E+08	2.48E+03	3.97E+04	Food
Ca-45	2.19E+06	1.23E+02	1.01E+03	5.69E-02	Food
Ca-47	3.59E+06	5.84E+00	7.37E+02	1.20E-03	Direct Exposure
Ca-49	1.56E+07	3.55E-02	2.63E+04	5.96E-05	Direct Exposure
Sc-42m	1.37E+07	3.15E-03	1.67E+05	3.85E-05	Direct Exposure
Sc-43	3.03E+07	1.62E+00	2.87E+03	1.53E-04	Direct Exposure
Sc-44	1.64E+07	9.02E-01	1.46E+03	8.04E-05	Direct Exposure
Sc-44m	5.63E+06	4.63E+00	2.14E+03	1.76E-03	Food
Sc-46	1.14E+06	3.37E+01	3.63E+02	1.07E-02	Direct Exposure
Sc-47	1.09E+07	1.31E+01	7.33E+03	8.83E-03	Food
Sc-48	5.05E+06	3.38E+00	2.61E+02	1.74E-04	Direct Exposure
Sc-49	2.00E+08	2.99E+00	1.83E+05	2.74E-03	Inhalation
Sc-50	1.76E+07	7.97E-03	1.32E+05	6.01E-05	Direct Exposure
Ti-44	6.76E+04	3.93E+02	9.31E+01	5.41E-01	Inhalation
Ti-45	3.71E+07	1.64E+00	4.53E+03	2.00E-04	Direct Exposure
Ti-51	1.58E+08	2.47E-01	3.41E+05	5.32E-04	Direct Exposure
Ti-52	4.70E+08	2.21E-01	3.32E+06	1.56E-03	Direct Exposure
V-47	4.69E+07	3.82E-01	2.23E+04	1.82E-04	Direct Exposure
V-48	2.86E+06	1.71E+01	2.54E+02	1.52E-03	Direct Exposure
V-49	2.38E+08	2.95E+04	4.64E+04	5.74E+00	Food
V-50	1.21E+05	2.53E+18	1.13E+02	2.36E+15	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
V-52	3.83E+07	3.96E-02	1.34E+05	1.39E-04	Direct Exposure
V-53	5.48E+07	2.49E-02	4.34E+05	1.97E-04	Direct Exposure
Cr-48	2.88E+07	1.01E+01	2.34E+03	8.23E-04	Direct Exposure
Cr-49	4.36E+07	4.78E-01	1.63E+04	1.79E-04	Direct Exposure
Cr-51	1.95E+08	2.11E+03	2.26E+04	2.44E-01	Direct Exposure
Cr-55	2.70E+09	2.76E+00	3.09E+08	3.16E-01	Direct Exposure
Cr-56	7.79E+08	1.38E+00	1.33E+06	2.35E-03	Direct Exposure
Mn-50m	1.24E+07	5.76E-03	8.92E+04	4.15E-05	Direct Exposure
Mn-51	4.38E+07	5.49E-01	1.57E+04	1.97E-04	Direct Exposure
Mn-52	4.23E+06	9.41E+00	2.23E+02	4.97E-04	Direct Exposure
Mn-52m	2.08E+07	1.22E-01	1.43E+04	8.31E-05	Direct Exposure
Mn-53	1.50E+08	8.23E+10	2.66E+04	1.46E+07	Food
Mn-54	5.00E+06	6.45E+02	8.69E+02	1.12E-01	Direct Exposure
Mn-56	2.14E+07	9.87E-01	2.77E+03	1.28E-04	Direct Exposure
Mn-57	5.10E+08	2.20E-01	5.11E+06	2.20E-03	Direct Exposure
Mn-58m	2.35E+07	7.87E-03	2.80E+05	9.36E-05	Direct Exposure
Fe-52	1.10E+07	1.51E+00	2.28E+03	3.12E-04	Direct Exposure
Fe-53	5.05E+07	1.21E-01	7.23E+04	1.73E-04	Direct Exposure
Fe-53m	1.88E+07	1.34E-02	9.39E+04	6.68E-05	Direct Exposure
Fe-55	1.05E+07	4.37E+03	2.47E+03	1.03E+00	Food
Fe-59	1.94E+06	3.90E+01	5.70E+02	1.15E-02	Food
Fe-60	2.90E+04	4.85E+05	7.33E+00	1.23E+02	Food
Fe-61	4.05E+07	7.84E-02	8.71E+04	1.69E-04	Direct Exposure
Fe-62	1.16E+08	4.35E-02	1.26E+06	4.72E-04	Direct Exposure
Co-54m	1.46E+07	6.20E-03	1.25E+05	5.29E-05	Direct Exposure
Co-55	9.85E+06	3.03E+00	5.64E+02	1.73E-04	Direct Exposure
Co-56	1.12E+06	3.77E+01	2.04E+02	6.87E-03	Direct Exposure
Co-57	7.97E+06	9.42E+02	5.81E+03	6.86E-01	Direct Exposure
Co-58	3.62E+06	1.14E+02	7.48E+02	2.35E-02	Direct Exposure
Co-58m	4.77E+08	8.07E+01	7.88E+05	1.33E-01	Direct Exposure
Co-60	2.58E+05	2.28E+02	2.90E+02	2.56E-01	Direct Exposure
Co-60m	3.95E+09	1.32E+01	1.02E+07	3.40E-02	Direct Exposure
Co-61	1.29E+08	4.14E+00	8.08E+04	2.59E-03	Direct Exposure
Co-62	3.41E+07	1.69E-02	3.01E+05	1.49E-04	Direct Exposure
Co-62m	1.88E+07	8.60E-02	1.93E+04	8.85E-05	Direct Exposure
Ni-56	5.58E+06	1.46E+01	4.46E+02	1.17E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Ni-57	9.53E+06	6.25E+00	4.71E+02	3.09E-04	Direct Exposure
Ni-59	9.77E+06	1.21E+08	1.28E+04	1.58E+05	Food
Ni-63	4.05E+06	6.85E+04	5.36E+03	9.06E+01	Food
Ni-65	1.83E+07	9.54E-01	8.75E+03	4.57E-04	Direct Exposure
Ni-66	4.50E+06	5.17E+00	1.82E+03	2.09E-03	Food
Cu-57	4.78E+07	5.63E-05	1.76E+08	2.06E-04	Direct Exposure
Cu-59	4.05E+07	1.72E-02	3.69E+05	1.57E-04	Direct Exposure
Cu-60	1.29E+07	9.55E-02	8.01E+03	5.93E-05	Direct Exposure
Cu-61	4.10E+07	2.72E+00	4.31E+03	2.86E-04	Direct Exposure
Cu-62	5.56E+07	1.78E-01	7.39E+04	2.37E-04	Direct Exposure
Cu-64	5.50E+07	1.43E+01	6.83E+03	1.77E-03	Direct Exposure
Cu-66	6.06E+08	1.08E+00	1.68E+06	3.00E-03	Direct Exposure
Cu-67	1.29E+07	1.71E+01	7.18E+03	9.49E-03	Direct Exposure
Cu-69	1.07E+08	1.12E-01	4.81E+05	5.03E-04	Direct Exposure
Zn-60	3.91E+07	2.97E-02	1.99E+05	1.51E-04	Direct Exposure
Zn-61	3.74E+07	1.80E-02	3.18E+05	1.53E-04	Direct Exposure
Zn-62	1.32E+07	2.42E+00	3.56E+03	6.52E-04	Direct Exposure
Zn-63	4.12E+07	5.26E-01	1.73E+04	2.21E-04	Direct Exposure
Zn-65	3.55E+06	4.30E+02	2.06E+02	2.50E-02	Food
Zn-69	2.89E+08	6.04E+00	2.60E+05	5.43E-03	Inhalation
Zn-69m	2.46E+07	7.44E+00	3.00E+03	9.09E-04	Direct Exposure
Zn-71	1.78E+08	1.64E-01	9.39E+05	8.68E-04	Direct Exposure
Zn-71m	2.11E+07	1.87E+00	2.01E+03	1.79E-04	Direct Exposure
Zn-72	6.14E+06	6.55E+00	4.27E+03	4.56E-03	Food
Ga-64	1.65E+07	1.47E-02	8.18E+04	7.31E-05	Direct Exposure
Ga-65	4.35E+07	2.28E-01	4.05E+04	2.13E-04	Direct Exposure
Ga-66	9.80E+06	1.94E+00	6.26E+02	1.24E-04	Direct Exposure
Ga-67	3.10E+07	5.18E+01	5.10E+03	8.52E-03	Direct Exposure
Ga-68	4.35E+07	1.07E+00	1.12E+04	2.75E-04	Direct Exposure
Ga-70	4.66E+08	3.67E+00	4.30E+05	3.38E-03	Inhalation
Ga-72	8.56E+06	2.77E+00	4.56E+02	1.48E-04	Direct Exposure
Ga-73	4.40E+07	5.02E+00	8.07E+03	9.22E-04	Direct Exposure
Ga-74	1.74E+07	5.57E-02	2.83E+04	9.03E-05	Direct Exposure
Ge-66	4.30E+07	2.05E+00	7.75E+03	3.70E-04	Direct Exposure
Ge-67	3.51E+07	2.34E-01	2.76E+04	1.83E-04	Direct Exposure
Ge-68	5.79E+05	8.68E+01	6.37E+02	9.54E-02	Food

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Ge-69	1.94E+07	1.67E+01	1.02E+03	8.77E-04	Direct Exposure
Ge-71	7.37E+08	4.72E+03	1.38E+05	8.82E-01	Food
Ge-75	1.98E+08	6.52E+00	2.07E+05	6.82E-03	Inhalation
Ge-77	1.53E+07	4.25E+00	1.28E+03	3.54E-04	Direct Exposure
Ge-78	6.00E+07	2.16E+00	3.00E+04	1.08E-03	Direct Exposure
As-68	1.54E+07	1.40E-02	7.73E+04	7.05E-05	Direct Exposure
As-69	4.83E+07	2.69E-01	4.71E+04	2.62E-04	Direct Exposure
As-70	1.19E+07	2.34E-01	3.36E+03	6.58E-05	Direct Exposure
As-71	1.68E+07	2.47E+01	1.43E+03	2.10E-03	Direct Exposure
As-72	6.97E+06	4.16E+00	5.48E+02	3.27E-04	Direct Exposure
As-73	8.10E+06	3.63E+02	3.56E+03	1.60E-01	Food
As-74	3.67E+06	3.69E+01	9.76E+02	9.81E-03	Direct Exposure
As-76	1.01E+07	6.43E+00	2.28E+03	1.45E-03	Direct Exposure
As-77	2.07E+07	1.97E+01	1.84E+04	1.76E-02	Food
As-78	2.91E+07	1.09E+00	6.38E+03	2.40E-04	Direct Exposure
As-79	1.20E+09	4.54E+00	2.38E+06	9.00E-03	Direct Exposure
Se-70	3.72E+06	5.67E-02	1.77E+04	2.70E-04	Direct Exposure
Se-71	3.65E+06	6.53E-03	9.52E+04	1.70E-04	Direct Exposure
Se-72	1.95E+05	9.01E-01	4.00E+02	1.85E-03	Food
Se-73	2.22E+06	3.70E-01	1.72E+03	2.86E-04	Direct Exposure
Se-73m	1.42E+07	2.15E-01	7.62E+04	1.15E-03	Direct Exposure
Se-75	5.98E+05	4.11E+01	3.41E+02	2.34E-02	Food
Se-77m	6.71E+07	7.98E-03	2.85E+07	3.39E-03	Direct Exposure
Se-79	1.19E+05	1.71E+06	2.78E+02	3.98E+03	Food
Se-79m	7.51E+08	1.24E+00	1.34E+07	2.21E-02	Direct Exposure
Se-81	4.89E+07	3.90E-01	4.65E+05	3.70E-03	Inhalation
Se-81m	1.53E+07	3.78E-01	1.64E+05	4.05E-03	Inhalation
Se-83	2.04E+06	2.03E-02	1.33E+04	1.32E-04	Direct Exposure
Se-83m	5.65E+06	2.91E-03	6.30E+05	3.24E-04	Direct Exposure
Se-84	1.42E+07	1.97E-02	5.56E+05	7.70E-04	Direct Exposure
Br-72	3.83E+04	1.92E-05	1.87E+05	9.36E-05	Direct Exposure
Br-73	8.29E+04	1.09E-04	1.49E+05	1.96E-04	Direct Exposure
Br-74	2.16E+04	2.15E-04	6.30E+03	6.26E-05	Direct Exposure
Br-74m	2.36E+04	3.86E-04	4.28E+03	6.98E-05	Direct Exposure
Br-75	7.11E+04	2.78E-03	6.08E+03	2.38E-04	Direct Exposure
Br-76	2.00E+04	7.84E-03	4.41E+02	1.73E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Br-76m	5.60E+06	4.93E-05	7.67E+08	6.76E-03	Direct Exposure
Br-77	1.25E+05	1.72E-01	2.62E+03	3.60E-03	Direct Exposure
Br-77m	9.07E+06	1.59E-02	8.61E+06	1.51E-02	Direct Exposure
Br-78	1.15E+05	3.09E-04	1.09E+05	2.91E-04	Direct Exposure
Br-80	7.74E+05	5.72E-03	5.23E+05	3.87E-03	Direct Exposure
Br-80m	2.11E+05	2.38E-02	1.12E+05	1.26E-02	Inhalation
Br-82	1.59E+04	1.47E-02	3.45E+02	3.18E-04	Direct Exposure
Br-82m	3.40E+07	9.08E-02	1.46E+07	3.90E-02	Direct Exposure
Br-83	3.30E+05	2.09E-02	1.67E+05	1.05E-02	Inhalation
Br-84	5.08E+04	7.21E-04	1.27E+04	1.81E-04	Direct Exposure
Br-84m	4.13E+04	1.10E-04	4.36E+04	1.17E-04	Direct Exposure
Br-85	1.36E+06	1.78E-03	3.78E+06	4.96E-03	Direct Exposure
Kr-74	4.83E+04	2.19E-04	7.15E+02	3.23E-06	Submersion
Kr-75	4.62E+04	7.90E-05	6.31E+02	1.08E-06	Submersion
Kr-76	1.33E+05	4.77E-02	2.01E+03	7.21E-04	Submersion
Kr-77	5.56E+04	1.70E-03	8.25E+02	2.52E-05	Submersion
Kr-79	2.23E+05	1.97E-01	3.32E+03	2.93E-03	Submersion
Kr-81	1.01E+07	4.81E+08	1.53E+05	7.28E+06	Submersion
Kr-81m	4.40E+05	4.10E-05	6.70E+03	6.25E-07	Submersion
Kr-83m	1.80E+09	8.72E+01	1.53E+07	7.42E-01	Submersion
Kr-85	2.27E+07	5.78E+04	1.46E+05	3.72E+02	Submersion
Kr-85m	3.61E+05	4.39E-02	5.45E+03	6.62E-04	Submersion
Kr-87	6.56E+04	2.31E-03	9.46E+02	3.34E-05	Submersion
Kr-88	2.65E+04	2.11E-03	3.83E+02	3.05E-05	Submersion
Kr-89	2.83E+04	4.21E-05	3.88E+02	5.77E-07	Submersion
Rb-77	3.81E+07	5.77E-02	1.07E+05	1.62E-04	Direct Exposure
Rb-78	1.25E+07	9.17E-02	1.00E+04	7.34E-05	Direct Exposure
Rb-78m	1.78E+07	4.23E-02	3.93E+04	9.34E-05	Direct Exposure
Rb-79	3.84E+07	3.69E-01	2.33E+04	2.24E-04	Direct Exposure
Rb-80	4.45E+07	1.07E-02	1.03E+06	2.47E-04	Direct Exposure
Rb-81	6.60E+07	7.81E+00	4.35E+03	5.14E-04	Direct Exposure
Rb-81m	1.07E+09	1.48E+01	8.59E+05	1.18E-02	Inhalation
Rb-82	5.10E+07	2.89E-02	5.10E+05	2.89E-04	Direct Exposure
Rb-82m	1.50E+07	2.44E+00	7.18E+02	1.16E-04	Direct Exposure
Rb-83	1.06E+07	5.83E+02	4.81E+02	2.63E-02	Food
Rb-84	7.15E+06	1.51E+02	3.93E+02	8.28E-03	Food

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Rb-84m	1.34E+08	1.21E+00	9.34E+04	8.44E-04	Direct Exposure
Rb-86	8.59E+06	1.05E+02	4.78E+02	5.87E-03	Food
Rb-86m	1.11E+08	5.15E-02	1.30E+06	6.06E-04	Direct Exposure
Rb-87	1.62E+07	1.85E+14	5.35E+02	6.11E+09	Food
Rb-88	6.94E+07	5.78E-01	6.48E+04	5.39E-04	Direct Exposure
Rb-89	2.44E+07	1.76E-01	2.30E+04	1.65E-04	Direct Exposure
Rb-90	2.50E+07	3.15E-02	1.36E+05	1.71E-04	Direct Exposure
Rb-90m	1.66E+07	3.41E-02	5.20E+04	1.07E-04	Direct Exposure
Sr-79	5.01E+07	4.74E-02	2.73E+05	2.58E-04	Direct Exposure
Sr-80	5.79E+07	2.46E+00	5.32E+04	2.26E-03	Inhalation
Sr-81	3.42E+07	3.75E-01	2.05E+04	2.25E-04	Direct Exposure
Sr-82	7.37E+05	1.16E+01	1.82E+02	2.85E-03	Food
Sr-83	1.78E+07	1.53E+01	1.16E+03	9.93E-04	Direct Exposure
Sr-85	9.19E+06	3.87E+02	1.43E+03	6.01E-02	Direct Exposure
Sr-85m	2.26E+08	7.11E+00	4.75E+04	1.49E-03	Direct Exposure
Sr-87m	1.22E+08	9.47E+00	1.35E+04	1.05E-03	Direct Exposure
Sr-89	1.03E+06	3.53E+01	3.53E+02	1.22E-02	Food
Sr-90	5.07E+04	3.71E+02	2.65E+01	1.94E-01	Food
Sr-91	1.58E+07	4.35E+00	2.21E+03	6.08E-04	Direct Exposure
Sr-92	1.87E+07	1.49E+00	3.34E+03	2.65E-04	Direct Exposure
Sr-93	2.53E+07	9.27E-02	4.31E+04	1.58E-04	Direct Exposure
Sr-94	3.91E+07	2.45E-02	4.05E+05	2.54E-04	Direct Exposure
Y-81	5.05E+07	2.55E-02	5.28E+05	2.67E-04	Direct Exposure
Y-83	4.39E+07	1.37E-01	7.60E+04	2.37E-04	Direct Exposure
Y-83m	7.17E+07	9.01E-02	3.04E+05	3.82E-04	Direct Exposure
Y-84m	1.29E+07	2.28E-01	4.61E+03	8.14E-05	Direct Exposure
Y-85	3.10E+07	2.25E+00	4.18E+03	3.04E-04	Direct Exposure
Y-85m	2.08E+07	2.74E+00	1.94E+03	2.55E-04	Direct Exposure
Y-86	8.05E+06	3.25E+00	3.37E+02	1.36E-04	Direct Exposure
Y-86m	1.36E+08	2.97E+00	6.85E+04	1.50E-03	Direct Exposure
Y-87	1.78E+07	3.97E+01	1.76E+03	3.91E-03	Direct Exposure
Y-87m	3.93E+07	1.46E+01	4.13E+03	1.53E-03	Direct Exposure
Y-88	1.69E+06	1.21E+02	2.71E+02	1.94E-02	Direct Exposure
Y-89m	6.50E+07	8.02E-03	3.08E+06	3.80E-04	Direct Exposure
Y-90	5.40E+06	9.92E+00	1.77E+03	3.25E-03	Food
Y-90m	4.26E+07	3.90E+00	6.05E+03	5.54E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Y-91	9.11E+05	3.71E+01	4.05E+02	1.65E-02	Food
Y-91m	9.27E+07	2.23E+00	2.75E+04	6.61E-04	Direct Exposure
Y-92	3.70E+07	3.84E+00	1.37E+04	1.42E-03	Direct Exposure
Y-93	1.87E+07	5.59E+00	1.67E+04	4.99E-03	Direct Exposure
Y-94	4.12E+07	3.93E-01	3.42E+04	3.26E-04	Direct Exposure
Y-95	5.08E+07	2.74E-01	7.58E+04	4.09E-04	Direct Exposure
Zr-85	4.01E+07	1.42E-01	6.26E+04	2.22E-04	Direct Exposure
Zr-86	1.73E+07	7.83E+00	4.01E+03	1.81E-03	Direct Exposure
Zr-87	3.46E+07	1.61E+00	7.75E+03	3.61E-04	Direct Exposure
Zr-88	2.22E+06	1.25E+02	1.81E+03	1.02E-01	Direct Exposure
Zr-89	1.13E+07	2.50E+01	6.92E+02	1.54E-03	Direct Exposure
Zr-89m	9.38E+07	1.85E-01	2.74E+05	5.40E-04	Direct Exposure
Zr-93	3.24E+05	1.29E+08	3.85E+02	1.53E+05	Inhalation
Zr-95	1.35E+06	6.28E+01	9.88E+02	4.59E-02	Direct Exposure
Zr-97	8.56E+06	4.47E+00	6.36E+03	3.33E-03	Direct Exposure
Nb-87	4.88E+07	8.46E-02	1.58E+05	2.75E-04	Direct Exposure
Nb-88	1.28E+07	8.55E-02	1.23E+04	8.21E-05	Direct Exposure
Nb-88m	1.42E+07	5.15E-02	2.27E+04	8.25E-05	Direct Exposure
Nb-89l	2.46E+07	1.42E+00	4.27E+03	2.46E-04	Direct Exposure
Nb-89s	2.32E+07	7.26E-01	5.70E+03	1.78E-04	Direct Exposure
Nb-90	6.18E+06	2.59E+00	2.88E+02	1.21E-04	Direct Exposure
Nb-91	4.12E+06	7.12E+05	6.57E+03	1.14E+03	Inhalation
Nb-91m	1.77E+06	7.51E+01	2.35E+03	9.97E-02	Food
Nb-92	2.83E+05	2.53E+09	4.47E+02	3.99E+06	Inhalation
Nb-92m	1.24E+07	8.88E+01	7.75E+02	5.54E-03	Direct Exposure
Nb-93m	4.50E+06	1.59E+04	6.73E+03	2.38E+01	Food
Nb-94	1.65E+05	8.78E+05	2.48E+02	1.32E+03	Inhalation
Nb-94m	1.26E+10	3.93E+01	9.91E+06	3.10E-02	Direct Exposure
Nb-95	4.24E+06	1.08E+02	9.57E+02	2.45E-02	Direct Exposure
Nb-95m	9.12E+06	2.39E+01	6.66E+03	1.75E-02	Food
Nb-96	7.93E+06	5.66E+00	4.11E+02	2.93E-04	Direct Exposure
Nb-97	5.78E+07	2.15E+00	1.53E+04	5.70E-04	Direct Exposure
Nb-97m	7.61E+07	3.92E-02	9.95E+05	5.13E-04	Direct Exposure
Nb-98	1.93E+07	5.16E-01	5.80E+03	1.56E-04	Direct Exposure
Nb-99	3.25E+08	4.27E-02	1.66E+07	2.19E-03	Direct Exposure
Nb-99m	7.00E+07	9.58E-02	3.68E+05	5.04E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Mo-89	4.74E+07	4.73E-02	2.82E+05	2.82E-04	Direct Exposure
Mo-90	1.70E+07	2.76E+00	2.72E+03	4.42E-04	Direct Exposure
Mo-91	5.07E+07	3.80E-01	4.79E+04	3.58E-04	Direct Exposure
Mo-91m	4.19E+07	2.18E-02	4.86E+05	2.53E-04	Direct Exposure
Mo-93	3.53E+06	3.21E+06	3.07E+02	2.80E+02	Food
Mo-93m	1.59E+07	3.24E+00	8.59E+02	1.74E-04	Direct Exposure
Mo-99	8.01E+06	1.67E+01	3.85E+03	8.01E-03	Food
Mo-101	3.49E+07	2.74E-01	3.62E+04	2.84E-04	Direct Exposure
Mo-102	2.45E+08	1.50E+00	2.66E+05	1.63E-03	Inhalation
Tc-91	2.25E+07	3.42E-02	9.29E+04	1.41E-04	Direct Exposure
Tc-91m	4.10E+07	6.53E-02	1.54E+05	2.46E-04	Direct Exposure
Tc-92	1.51E+07	3.14E-02	4.45E+04	9.25E-05	Direct Exposure
Tc-93	3.16E+07	2.58E+00	3.02E+03	2.46E-04	Direct Exposure
Tc-93m	6.29E+07	1.35E+00	2.30E+04	4.94E-04	Direct Exposure
Tc-94	1.56E+07	2.28E+00	9.58E+02	1.40E-04	Direct Exposure
Tc-94m	2.52E+07	6.55E-01	7.50E+03	1.95E-04	Direct Exposure
Tc-95	3.60E+07	2.18E+01	1.34E+03	8.13E-04	Direct Exposure
Tc-95m	6.25E+06	2.77E+02	1.08E+03	4.80E-02	Direct Exposure
Tc-96	7.61E+06	2.39E+01	3.14E+02	9.87E-04	Direct Exposure
Tc-96m	5.70E+08	1.50E+01	2.73E+05	7.18E-03	Direct Exposure
Tc-97	4.50E+06	3.17E+09	7.29E+03	5.14E+06	Food
Tc-97m	1.98E+06	1.28E+02	1.04E+03	6.73E-02	Food
Tc-98	1.79E+05	2.06E+08	2.63E+02	3.02E+05	Food
Tc-99	6.24E+05	3.68E+07	7.75E+02	4.57E+04	Food
Tc-99m	2.15E+08	4.09E+01	1.70E+04	3.22E-03	Direct Exposure
Tc-101	1.34E+08	1.02E+00	1.53E+05	1.16E-03	Direct Exposure
Tc-102	4.62E+08	2.20E-02	1.02E+08	4.86E-03	Direct Exposure
Tc-102m	2.29E+07	5.40E-02	6.73E+04	1.59E-04	Direct Exposure
Tc-104	2.44E+07	2.46E-01	2.01E+04	2.02E-04	Direct Exposure
Tc-105	7.17E+07	3.04E-01	1.19E+05	5.07E-04	Direct Exposure
Ru-92	2.86E+06	5.11E-03	9.52E+04	1.70E-04	Direct Exposure
Ru-94	6.13E+06	1.59E-01	2.62E+04	6.77E-04	Direct Exposure
Ru-95	3.63E+06	1.81E-01	5.92E+03	2.95E-04	Direct Exposure
Ru-97	5.31E+06	1.14E+01	3.40E+03	7.32E-03	Direct Exposure
Ru-103	2.64E+05	8.18E+00	1.44E+03	4.47E-02	Food
Ru-105	2.76E+06	4.10E-01	3.55E+03	5.28E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Ru-106	1.23E+04	3.67E+00	1.19E+02	3.54E-02	Food
Ru-107	1.60E+07	3.41E-02	5.60E+05	1.19E-03	Direct Exposure
Ru-108	9.26E+07	2.42E-01	2.54E+06	6.65E-03	Direct Exposure
Rh-94	1.49E+07	8.78E-03	1.64E+05	9.62E-05	Direct Exposure
Rh-95	2.23E+07	5.66E-02	5.64E+04	1.43E-04	Direct Exposure
Rh-95m	6.30E+07	6.23E-02	4.12E+05	4.08E-04	Direct Exposure
Rh-96	1.49E+07	7.54E-02	1.86E+04	9.41E-05	Direct Exposure
Rh-96m	4.48E+07	3.45E-02	3.74E+05	2.88E-04	Direct Exposure
Rh-97	3.58E+07	5.67E-01	1.63E+04	2.58E-04	Direct Exposure
Rh-97m	2.31E+07	5.50E-01	7.12E+03	1.70E-04	Direct Exposure
Rh-98	3.24E+07	1.47E-01	4.60E+04	2.08E-04	Direct Exposure
Rh-99	8.49E+06	1.03E+02	1.22E+03	1.48E-02	Direct Exposure
Rh-99m	5.85E+07	8.67E+00	3.86E+03	5.73E-04	Direct Exposure
Rh-100	1.05E+07	6.96E+00	3.81E+02	2.53E-04	Direct Exposure
Rh-100m	1.33E+09	3.25E+00	2.47E+06	6.04E-03	Direct Exposure
Rh-101	1.49E+06	1.35E+03	1.47E+03	1.33E+00	Food
Rh-101m	3.21E+07	1.08E+02	2.56E+03	8.59E-03	Direct Exposure
Rh-102	4.68E+05	3.87E+02	3.12E+02	2.58E-01	Food
Rh-102m	1.13E+06	1.83E+02	7.06E+02	1.14E-01	Food
Rh-103m	2.97E+09	9.13E+01	4.47E+06	1.37E-01	Inhalation
Rh-104	1.93E+09	7.52E-01	8.28E+07	3.22E-02	Direct Exposure
Rh-104m	2.96E+09	7.09E+00	3.79E+06	9.08E-03	Direct Exposure
Rh-105	2.25E+07	2.66E+01	1.17E+04	1.39E-02	Direct Exposure
Rh-106	2.60E+08	7.29E-02	7.10E+06	1.99E-03	Direct Exposure
Rh-106m	1.50E+07	1.11E+00	1.88E+03	1.40E-04	Direct Exposure
Rh-107	1.31E+08	1.61E+00	1.07E+05	1.32E-03	Direct Exposure
Rh-108	1.68E+08	2.70E-02	8.16E+06	1.31E-03	Direct Exposure
Rh-109	1.96E+08	1.51E-01	1.81E+06	1.40E-03	Direct Exposure
Pd-96	4.15E+07	4.31E-02	2.47E+05	2.57E-04	Direct Exposure
Pd-97	2.41E+07	3.86E-02	9.82E+04	1.57E-04	Direct Exposure
Pd-98	9.40E+07	8.66E-01	9.85E+04	9.08E-04	Direct Exposure
Pd-99	4.07E+07	4.58E-01	2.64E+04	2.97E-04	Direct Exposure
Pd-100	9.39E+06	2.61E+01	3.93E+03	1.09E-02	Food
Pd-101	7.51E+07	2.00E+01	5.00E+03	1.33E-03	Direct Exposure
Pd-103	1.80E+07	2.41E+02	7.34E+03	9.81E-02	Food
Pd-107	1.37E+07	2.67E+10	2.03E+04	3.95E+07	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Pd-109	2.19E+07	1.02E+01	2.23E+04	1.04E-02	Inhalation
Pd-109m	5.89E+08	1.60E+00	1.39E+06	3.77E-03	Direct Exposure
Pd-111	2.02E+08	2.79E+00	2.86E+05	3.95E-03	Inhalation
Pd-112	6.14E+06	4.61E+00	4.97E+03	3.73E-03	Food
Pd-114	1.81E+09	2.66E+00	1.16E+07	1.70E-02	Direct Exposure
Ag-99	2.50E+07	2.72E-02	1.52E+05	1.65E-04	Direct Exposure
Ag-100m	2.03E+07	2.42E-02	1.15E+05	1.36E-04	Direct Exposure
Ag-101	3.49E+07	2.08E-01	4.16E+04	2.48E-04	Direct Exposure
Ag-102	1.56E+07	1.09E-01	1.68E+04	1.17E-04	Direct Exposure
Ag-102m	2.78E+07	1.16E-01	4.72E+04	1.97E-04	Direct Exposure
Ag-103	5.90E+07	2.12E+00	1.44E+04	5.18E-04	Direct Exposure
Ag-104	1.87E+07	7.16E-01	3.90E+03	1.49E-04	Direct Exposure
Ag-104m	4.04E+07	7.48E-01	1.84E+04	3.41E-04	Direct Exposure
Ag-105	9.18E+06	3.02E+02	1.39E+03	4.59E-02	Direct Exposure
Ag-105m	6.11E+10	2.47E+02	7.95E+07	3.21E-01	Direct Exposure
Ag-106	6.89E+07	9.30E-01	4.25E+04	5.74E-04	Direct Exposure
Ag-106m	5.36E+06	3.65E+01	2.68E+02	1.83E-03	Direct Exposure
Ag-108	2.91E+09	3.96E+00	1.72E+07	2.34E-02	Direct Exposure
Ag-108m	2.18E+05	8.35E+03	3.19E+02	1.22E+01	Inhalation
Ag-109m	1.41E+10	5.38E+00	9.89E+07	3.78E-02	Direct Exposure
Ag-110	1.52E+09	3.64E-01	5.78E+07	1.38E-02	Direct Exposure
Ag-110m	6.53E+05	1.37E+02	2.64E+02	5.56E-02	Direct Exposure
Ag-111	4.76E+06	3.01E+01	1.67E+03	1.06E-02	Food
Ag-111m	1.61E+10	1.02E+01	8.54E+07	5.44E-02	Direct Exposure
Ag-112	3.00E+07	3.34E+00	5.92E+03	6.59E-04	Direct Exposure
Ag-113	3.89E+07	7.52E+00	3.27E+04	6.33E-03	Direct Exposure
Ag-113m	2.83E+08	1.95E-01	2.97E+06	2.04E-03	Direct Exposure
Ag-114	1.85E+08	8.60E-03	3.65E+07	1.70E-03	Direct Exposure
Ag-115	5.91E+07	7.22E-01	5.13E+04	6.26E-04	Direct Exposure
Ag-116	2.53E+07	4.17E-02	1.26E+05	2.08E-04	Direct Exposure
Ag-117	4.16E+07	3.17E-02	4.53E+05	3.46E-04	Direct Exposure
Cd-101	2.31E+07	1.69E-02	2.14E+05	1.56E-04	Direct Exposure
Cd-102	7.25E+07	2.16E-01	1.57E+05	4.69E-04	Direct Exposure
Cd-103	2.70E+07	1.08E-01	4.75E+04	1.90E-04	Direct Exposure
Cd-104	1.17E+08	3.74E+00	4.86E+04	1.55E-03	Direct Exposure
Cd-105	3.82E+07	1.18E+00	1.00E+04	3.11E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Cd-107	9.56E+07	2.12E+01	5.93E+04	1.31E-02	Direct Exposure
Cd-109	1.00E+06	3.87E+02	4.05E+02	1.57E-01	Food
Cd-111m	1.30E+08	3.71E+00	5.26E+04	1.50E-03	Direct Exposure
Cd-113	6.76E+04	1.98E+17	3.16E+01	9.29E+13	Food
Cd-113m	7.37E+04	3.17E+02	3.45E+01	1.48E-01	Food
Cd-115	7.15E+06	1.40E+01	3.63E+03	7.11E-03	Direct Exposure
Cd-115m	1.05E+06	4.13E+01	3.05E+02	1.20E-02	Food
Cd-117	2.43E+07	2.26E+00	4.47E+03	4.15E-04	Direct Exposure
Cd-117m	1.54E+07	1.94E+00	1.77E+03	2.22E-04	Direct Exposure
Cd-118	8.43E+07	2.66E+00	9.31E+04	2.94E-03	Inhalation
Cd-119	3.40E+07	5.78E-02	1.64E+05	2.80E-04	Direct Exposure
Cd-119m	2.43E+07	3.39E-02	1.43E+05	1.99E-04	Direct Exposure
In-103	2.08E+07	1.14E-02	2.63E+05	1.44E-04	Direct Exposure
In-105	3.01E+07	8.52E-02	7.40E+04	2.09E-04	Direct Exposure
In-106	1.66E+07	5.79E-02	3.29E+04	1.15E-04	Direct Exposure
In-106m	2.00E+07	5.86E-02	4.93E+04	1.45E-04	Direct Exposure
In-107	3.30E+07	6.07E-01	1.46E+04	2.69E-04	Direct Exposure
In-108	1.35E+07	4.50E-01	3.19E+03	1.06E-04	Direct Exposure
In-108m	1.80E+07	4.09E-01	6.62E+03	1.50E-04	Direct Exposure
In-109	5.86E+07	8.56E+00	4.36E+03	6.36E-04	Direct Exposure
In-109m	9.86E+07	7.66E-02	8.89E+05	6.90E-04	Direct Exposure
In-110l	1.41E+07	2.41E+00	8.36E+02	1.44E-04	Direct Exposure
In-110s	2.94E+07	1.19E+00	6.74E+03	2.72E-04	Direct Exposure
In-111	2.84E+07	6.82E+01	2.02E+03	4.85E-03	Direct Exposure
In-111m	1.29E+08	5.85E-01	2.00E+05	9.10E-04	Direct Exposure
In-112	1.79E+08	1.54E+00	1.88E+05	1.61E-03	Direct Exposure
In-112m	2.80E+08	3.43E+00	3.10E+05	3.80E-03	Inhalation
In-113m	1.44E+08	8.60E+00	2.83E+04	1.69E-03	Direct Exposure
In-114	1.94E+10	1.41E+01	2.24E+08	1.63E-01	Direct Exposure
In-114m	8.71E+05	3.76E+01	2.45E+02	1.06E-02	Food
In-115	2.08E+04	3.41E+16	2.48E+01	4.07E+13	Inhalation
In-115m	9.99E+07	1.64E+01	1.71E+04	2.82E-03	Direct Exposure
In-116m	1.93E+07	6.44E-01	5.41E+03	1.81E-04	Direct Exposure
In-117	6.32E+07	1.72E+00	2.39E+04	6.51E-04	Direct Exposure
In-117m	9.59E+07	6.94E+00	6.84E+04	4.96E-03	Direct Exposure
In-118	4.73E+08	2.47E-02	1.12E+08	5.84E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
In-118m	2.06E+07	5.65E-02	5.98E+04	1.64E-04	Direct Exposure
In-119	7.23E+07	1.10E-01	3.93E+05	5.96E-04	Direct Exposure
In-119m	4.30E+08	4.90E+00	3.85E+05	4.38E-03	Inhalation
In-121	6.20E+07	1.53E-02	2.03E+06	5.03E-04	Direct Exposure
In-121m	6.89E+08	1.72E+00	2.94E+06	7.34E-03	Direct Exposure
Sn-106	5.01E+07	5.41E-02	3.12E+05	3.38E-04	Direct Exposure
Sn-108	7.89E+07	4.66E-01	1.03E+05	6.07E-04	Direct Exposure
Sn-109	2.46E+07	2.57E-01	1.82E+04	1.90E-04	Direct Exposure
Sn-110	4.03E+07	5.66E+00	1.02E+04	1.43E-03	Direct Exposure
Sn-111	9.37E+07	1.95E+00	4.03E+04	8.39E-04	Direct Exposure
Sn-113	3.00E+06	2.99E+02	1.22E+03	1.21E-01	Food
Sn-113m	1.48E+09	1.90E+01	2.11E+06	2.71E-02	Inhalation
Sn-117m	3.35E+06	4.08E+01	2.19E+03	2.67E-02	Food
Sn-119m	3.69E+06	9.83E+02	2.46E+03	6.57E-01	Food
Sn-121	3.53E+07	3.68E+01	3.99E+04	4.16E-02	Inhalation
Sn-121m	1.80E+06	3.35E+04	2.12E+03	3.94E+01	Food
Sn-123	1.00E+06	1.22E+02	4.19E+02	5.09E-02	Food
Sn-123m	1.74E+08	4.55E+00	1.30E+05	3.40E-03	Direct Exposure
Sn-125	2.58E+06	2.38E+01	6.05E+02	5.58E-03	Food
Sn-125m	1.69E+08	1.07E+00	2.20E+05	1.39E-03	Direct Exposure
Sn-126	2.90E+05	1.02E+07	1.71E+02	6.03E+03	Food
Sn-127	1.94E+07	1.65E+00	3.01E+03	2.56E-04	Direct Exposure
Sn-127m	1.01E+08	2.82E-01	3.09E+05	8.60E-04	Direct Exposure
Sn-128	4.46E+07	1.79E+00	1.84E+04	7.40E-04	Direct Exposure
Sn-129	5.68E+07	8.68E-02	3.22E+05	4.93E-04	Direct Exposure
Sn-130	6.50E+07	1.67E-01	2.08E+05	5.34E-04	Direct Exposure
Sn-130m	6.44E+07	7.56E-02	4.81E+05	5.65E-04	Direct Exposure
Sb-111	4.00E+07	2.95E-02	3.90E+05	2.88E-04	Direct Exposure
Sb-113	4.73E+07	1.90E-01	8.57E+04	3.43E-04	Direct Exposure
Sb-114	2.13E+07	4.50E-02	7.72E+04	1.63E-04	Direct Exposure
Sb-115	5.65E+07	1.10E+00	2.51E+04	4.87E-04	Direct Exposure
Sb-116	2.41E+07	2.34E-01	2.13E+04	2.07E-04	Direct Exposure
Sb-116m	1.58E+07	5.86E-01	3.82E+03	1.42E-04	Direct Exposure
Sb-117	1.98E+08	2.07E+01	2.34E+04	2.45E-03	Direct Exposure
Sb-118	7.40E+07	1.67E-01	2.48E+05	5.60E-04	Direct Exposure
Sb-118m	1.62E+07	3.04E+00	9.69E+02	1.82E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Sb-119	2.21E+08	3.20E+02	3.88E+04	5.61E-02	Direct Exposure
Sb-120s	1.14E+08	1.15E+00	1.01E+05	1.02E-03	Direct Exposure
Sb-120l	5.53E+06	2.93E+01	3.12E+02	1.65E-03	Direct Exposure
Sb-122	6.97E+06	1.76E+01	1.87E+03	4.70E-03	Direct Exposure
Sb-122m	1.53E+09	4.15E+00	2.44E+06	6.64E-03	Direct Exposure
Sb-124	9.14E+05	5.22E+01	3.84E+02	2.20E-02	Food
Sb-124ms	1.59E+08	1.62E-01	1.33E+06	1.36E-03	Direct Exposure
Sb-124ml	1.37E+09	1.83E+01	1.35E+06	1.79E-02	Inhalation
Sb-125	6.72E+05	6.51E+02	7.36E+02	7.12E-01	Food
Sb-126	2.25E+06	2.68E+01	2.63E+02	3.15E-03	Direct Exposure
Sb-126m	3.31E+07	4.21E-01	2.46E+04	3.13E-04	Direct Exposure
Sb-127	4.05E+06	1.52E+01	1.15E+03	4.31E-03	Direct Exposure
Sb-128l	9.29E+06	3.42E+00	5.15E+02	1.89E-04	Direct Exposure
Sb-128s	2.65E+07	1.88E-01	3.51E+04	2.48E-04	Direct Exposure
Sb-129	1.75E+07	3.10E+00	1.99E+03	3.53E-04	Direct Exposure
Sb-130	1.52E+07	4.20E-01	5.55E+03	1.53E-04	Direct Exposure
Sb-130m	2.15E+07	9.34E-02	4.25E+04	1.85E-04	Direct Exposure
Sb-131	2.49E+07	3.99E-01	1.69E+04	2.71E-04	Direct Exposure
Sb-133	2.03E+07	3.59E-02	1.06E+05	1.87E-04	Direct Exposure
Te-113	2.57E+06	2.63E-03	1.92E+05	1.96E-04	Direct Exposure
Te-114	3.76E+06	3.46E-02	3.72E+04	3.43E-04	Direct Exposure
Te-115	2.57E+06	9.12E-03	5.56E+04	1.97E-04	Direct Exposure
Te-115m	2.22E+06	9.07E-03	4.15E+04	1.70E-04	Direct Exposure
Te-116	6.94E+06	6.39E-01	6.57E+04	6.05E-03	Inhalation
Te-117	3.16E+06	1.22E-01	7.54E+03	2.91E-04	Direct Exposure
Te-118	2.75E+05	1.49E+00	8.49E+02	4.60E-03	Food
Te-119	3.45E+06	2.10E+00	1.52E+03	9.25E-04	Direct Exposure
Te-119m	8.62E+05	3.69E+00	5.18E+02	2.22E-03	Direct Exposure
Te-121	1.37E+06	2.16E+01	1.28E+03	2.02E-02	Direct Exposure
Te-121m	1.42E+05	2.02E+01	3.77E+02	5.38E-02	Food
Te-123	6.76E+04	2.32E+14	1.83E+02	6.29E+11	Food
Te-123m	1.58E+05	1.78E+01	6.32E+02	7.13E-02	Food
Te-125m	1.93E+05	1.07E+01	1.12E+03	6.20E-02	Food
Te-127	5.76E+06	2.18E+00	6.20E+04	2.35E-02	Inhalation
Te-127m	8.27E+04	8.76E+00	3.88E+02	4.11E-02	Food
Te-129	1.72E+07	8.19E-01	1.75E+05	8.36E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Te-129m	1.03E+05	3.40E+00	3.66E+02	1.21E-02	Food
Te-131	6.28E+06	1.09E-01	6.89E+04	1.20E-03	Direct Exposure
Te-131m	3.11E+05	3.89E-01	6.64E+02	8.32E-04	Direct Exposure
Te-132	1.58E+05	5.20E-01	1.09E+03	3.60E-03	Food
Te-133	4.18E+06	3.68E-02	6.27E+04	5.51E-04	Direct Exposure
Te-133m	1.44E+06	5.65E-02	5.66E+03	2.21E-04	Direct Exposure
Te-134	3.84E+06	1.14E-01	1.96E+04	5.83E-04	Direct Exposure
I-118	3.35E+04	2.88E-04	1.31E+03	1.13E-05	Inhalation
I-118m	3.16E+04	1.68E-04	2.27E+04	1.21E-04	Direct Exposure
I-119	9.09E+04	1.10E-03	3.99E+03	4.82E-05	Inhalation
I-120	2.27E+04	1.17E-03	7.45E+02	3.85E-05	Inhalation
I-120m	1.66E+04	5.62E-04	1.24E+03	4.19E-05	Inhalation
I-121	1.12E+05	9.20E-03	2.60E+03	2.12E-04	Inhalation
I-122	1.19E+05	2.78E-04	2.12E+05	4.97E-04	Direct Exposure
I-123	6.99E+04	3.62E-02	1.06E+03	5.51E-04	Inhalation
I-124	1.33E+03	5.29E-03	5.09E+00	2.02E-05	Food
I-125	1.16E+03	6.66E-02	1.28E+00	7.38E-05	Food
I-126	6.22E+02	7.81E-03	1.09E+00	1.37E-05	Food
I-128	2.09E+05	3.56E-03	3.44E+03	5.84E-05	Inhalation
I-129	1.69E+02	9.56E+05	1.46E-01	8.25E+02	Food
I-130	7.33E+03	3.76E-03	1.18E+02	6.02E-05	Inhalation
I-130m	1.11E+06	6.77E-03	7.47E+05	4.57E-03	Direct Exposure
I-131	8.09E+02	6.52E-03	1.90E+00	1.53E-05	Food
I-132	2.51E+04	2.43E-03	7.21E+02	6.98E-05	Inhalation
I-132m	5.13E+04	3.01E-03	8.27E+02	4.85E-05	Inhalation
I-133	3.97E+03	3.50E-03	5.58E+01	4.93E-05	Inhalation
I-134	3.00E+04	1.12E-03	1.49E+03	5.58E-05	Inhalation
I-134m	4.54E+05	1.16E-03	6.97E+05	1.79E-03	Direct Exposure
I-135	1.40E+04	3.98E-03	2.43E+02	6.91E-05	Inhalation
Xe-120	1.39E+05	3.55E-03	2.14E+03	5.47E-05	Submersion
Xe-121	2.96E+04	7.63E-04	4.29E+02	1.11E-05	Submersion
Xe-122	1.10E+06	8.59E-01	1.69E+04	1.32E-02	Submersion
Xe-123	8.92E+04	7.28E-03	1.34E+03	1.09E-04	Submersion
Xe-125	2.27E+05	1.54E-01	3.46E+03	2.34E-03	Submersion
Xe-127	2.16E+05	7.65E+00	3.32E+03	1.17E-01	Submersion
Xe-127m	4.11E+05	3.20E-04	5.36E+03	4.17E-06	Submersion

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Xe-129m	2.55E+06	2.01E+01	3.97E+04	3.14E-01	Submersion
Xe-131m	6.95E+06	8.29E+01	1.01E+05	1.20E+00	Submersion
Xe-133	1.73E+06	9.25E+00	2.68E+04	1.43E-01	Submersion
Xe-133m	1.97E+06	4.39E+00	2.92E+04	6.51E-02	Submersion
Xe-135	2.27E+05	8.89E-02	3.35E+03	1.31E-03	Submersion
Xe-135m	1.32E+05	1.45E-03	2.01E+03	2.21E-05	Submersion
Xe-137	2.60E+05	7.22E-04	3.42E+03	9.51E-06	Submersion
Xe-138	4.68E+04	4.87E-04	6.84E+02	7.11E-06	Submersion
Cs-121	5.00E+06	8.30E-03	2.39E+05	3.97E-04	Direct Exposure
Cs-121m	5.02E+06	6.57E-03	3.01E+05	3.94E-04	Direct Exposure
Cs-123	5.53E+06	2.12E-02	1.13E+05	4.36E-04	Direct Exposure
Cs-124	4.98E+06	1.68E-03	1.22E+06	4.11E-04	Direct Exposure
Cs-125	6.78E+06	2.03E-01	2.37E+04	7.10E-04	Direct Exposure
Cs-126	5.16E+06	5.66E-03	4.07E+05	4.47E-04	Direct Exposure
Cs-127	8.45E+06	2.14E+00	4.95E+03	1.25E-03	Direct Exposure
Cs-128	6.26E+06	1.66E-02	2.06E+05	5.47E-04	Direct Exposure
Cs-129	7.10E+06	9.36E+00	3.31E+03	4.36E-03	Direct Exposure
Cs-130	9.27E+06	1.91E-01	4.69E+04	9.69E-04	Direct Exposure
Cs-130m	1.34E+08	3.21E-01	2.84E+06	6.79E-03	Direct Exposure
Cs-131	1.69E+07	1.64E+02	3.22E+04	3.12E-01	Food
Cs-132	2.03E+06	1.33E+01	1.09E+03	7.10E-03	Direct Exposure
Cs-134	4.01E+04	3.10E+01	4.30E+01	3.32E-02	Food
Cs-134m	1.29E+07	1.60E+00	1.56E+05	1.94E-02	Direct Exposure
Cs-135	9.43E+04	8.18E+07	4.02E+02	3.49E+05	Food
Cs-135m	3.26E+06	1.24E-01	8.62E+03	3.28E-04	Direct Exposure
Cs-136	2.60E+05	3.55E+00	3.44E+02	4.69E-03	Direct Exposure
Cs-137	2.08E+04	2.39E+02	6.19E+01	7.11E-01	Food
Cs-138	2.00E+06	4.72E-02	9.53E+03	2.25E-04	Direct Exposure
Cs-138m	1.41E+07	3.00E-02	6.00E+05	1.28E-03	Direct Exposure
Cs-139	1.63E+07	1.12E-01	2.58E+05	1.77E-03	Direct Exposure
Cs-140	3.04E+06	2.40E-03	3.86E+05	3.05E-04	Direct Exposure
Ba-124	7.92E+07	5.74E-01	1.15E+05	8.34E-04	Direct Exposure
Ba-126	6.19E+07	4.00E+00	4.60E+04	2.98E-03	Direct Exposure
Ba-127	7.25E+07	6.22E-01	7.83E+04	6.72E-04	Direct Exposure
Ba-128	5.76E+06	1.37E+01	1.90E+03	4.53E-03	Food
Ba-129	1.04E+08	9.58E+00	1.63E+04	1.49E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Ba-129m	2.98E+07	2.65E+00	3.53E+03	3.14E-04	Direct Exposure
Ba-131	8.69E+06	1.03E+02	1.63E+03	1.93E-02	Direct Exposure
Ba-131m	4.79E+08	4.87E+00	6.48E+05	6.59E-03	Direct Exposure
Ba-133	8.07E+05	3.22E+03	8.04E+02	3.21E+00	Food
Ba-133m	1.73E+07	2.86E+01	1.33E+04	2.20E-02	Food
Ba-135m	2.21E+07	2.73E+01	1.59E+04	1.97E-02	Direct Exposure
Ba-137m	9.38E+07	1.74E-01	4.76E+05	8.84E-04	Direct Exposure
Ba-139	1.24E+08	7.56E+00	2.03E+05	1.24E-02	Inhalation
Ba-140	1.39E+06	1.90E+01	6.40E+02	8.73E-03	Food
Ba-141	5.11E+07	6.99E-01	4.69E+04	6.43E-04	Direct Exposure
Ba-142	4.59E+07	3.68E-01	6.53E+04	5.22E-04	Direct Exposure
La-128	2.08E+07	7.33E-02	4.95E+04	1.74E-04	Direct Exposure
La-129	5.87E+07	4.67E-01	6.78E+04	5.39E-04	Direct Exposure
La-130	2.62E+07	1.58E-01	3.73E+04	2.24E-04	Direct Exposure
La-131	6.92E+07	2.84E+00	1.83E+04	7.52E-04	Direct Exposure
La-132	1.76E+07	3.56E+00	1.29E+03	2.61E-04	Direct Exposure
La-132m	7.14E+07	1.22E+00	4.45E+04	7.58E-04	Direct Exposure
La-133	2.03E+08	3.37E+01	1.95E+04	3.24E-03	Direct Exposure
La-134	8.07E+07	3.83E-01	1.56E+05	7.40E-04	Direct Exposure
La-135	4.84E+08	4.06E+02	3.02E+04	2.54E-02	Direct Exposure
La-136	1.51E+08	1.08E+00	1.80E+05	1.29E-03	Direct Exposure
La-137	9.32E+05	2.14E+07	1.12E+03	2.57E+04	Inhalation
La-138	5.40E+04	2.81E+12	6.20E+01	3.23E+09	Inhalation
La-140	5.59E+06	1.00E+01	3.83E+02	6.88E-04	Direct Exposure
La-141	5.16E+07	9.12E+00	5.08E+04	8.97E-03	Inhalation
La-142	1.56E+07	1.09E+00	2.85E+03	1.99E-04	Direct Exposure
La-143	2.22E+08	2.40E+00	3.38E+05	3.66E-03	Inhalation
Ce-130	7.58E+07	1.20E+00	6.32E+04	1.00E-03	Direct Exposure
Ce-131	3.38E+07	2.40E-01	4.37E+04	3.10E-04	Direct Exposure
Ce-132	3.96E+07	5.85E+00	1.27E+04	1.88E-03	Direct Exposure
Ce-133	6.21E+07	4.26E+00	1.38E+04	9.43E-04	Direct Exposure
Ce-133m	2.13E+07	4.43E+00	1.47E+03	3.05E-04	Direct Exposure
Ce-134	6.23E+06	1.92E+01	1.73E+03	5.33E-03	Food
Ce-135	1.07E+07	8.12E+00	6.32E+02	4.79E-04	Direct Exposure
Ce-137	6.41E+08	2.52E+02	4.49E+04	1.76E-02	Direct Exposure
Ce-137m	1.82E+07	2.73E+01	1.52E+04	2.29E-02	Food

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Ce-139	4.22E+06	6.18E+02	3.37E+03	4.93E-01	Food
Ce-141	2.13E+06	7.46E+01	1.56E+03	5.48E-02	Food
Ce-143	9.33E+06	1.40E+01	3.27E+03	4.93E-03	Direct Exposure
Ce-144	1.53E+05	4.79E+01	1.61E+02	5.06E-02	Food
Ce-145	7.43E+07	1.72E-01	2.96E+05	6.86E-04	Direct Exposure
Ce-146	3.12E+08	3.27E+00	2.54E+05	2.66E-03	Inhalation
Pr-134	1.77E+07	1.39E-01	2.09E+04	1.64E-04	Direct Exposure
Pr-134m	2.24E+07	2.71E-01	1.85E+04	2.23E-04	Direct Exposure
Pr-135	5.74E+07	9.89E-01	3.45E+04	5.95E-04	Direct Exposure
Pr-136	2.51E+07	2.38E-01	2.63E+04	2.49E-04	Direct Exposure
Pr-137	8.83E+07	4.93E+00	1.89E+04	1.05E-03	Direct Exposure
Pr-138	6.89E+07	7.33E-02	6.14E+05	6.54E-04	Direct Exposure
Pr-138m	1.86E+07	1.71E+00	2.32E+03	2.15E-04	Direct Exposure
Pr-139	2.28E+08	4.56E+01	2.25E+04	4.49E-03	Direct Exposure
Pr-140	1.11E+08	2.79E-01	3.91E+05	9.86E-04	Direct Exposure
Pr-142	1.45E+07	1.26E+01	1.09E+04	9.46E-03	Food
Pr-142m	1.16E+09	1.28E+01	1.19E+06	1.31E-02	Inhalation
Pr-143	3.38E+06	5.01E+01	1.30E+03	1.93E-02	Food
Pr-144	3.40E+08	4.50E+00	3.72E+05	4.92E-03	Inhalation
Pr-144m	9.69E+09	5.34E+01	7.99E+06	4.40E-02	Direct Exposure
Pr-145	4.71E+07	1.30E+01	4.30E+04	1.19E-02	Inhalation
Pr-146	4.42E+07	8.29E-01	2.97E+04	5.56E-04	Direct Exposure
Pr-147	5.69E+07	6.05E-01	6.17E+04	6.56E-04	Direct Exposure
Pr-148	5.60E+07	1.01E-01	3.19E+05	5.76E-04	Direct Exposure
Pr-148m	6.18E+07	9.78E-02	3.86E+05	6.10E-04	Direct Exposure
Nd-134	1.16E+08	7.05E-01	1.57E+05	9.52E-04	Direct Exposure
Nd-135	4.04E+07	3.59E-01	4.63E+04	4.12E-04	Direct Exposure
Nd-136	8.80E+07	3.22E+00	4.88E+04	1.79E-03	Direct Exposure
Nd-137	4.18E+07	1.17E+00	1.60E+04	4.48E-04	Direct Exposure
Nd-138	3.19E+07	7.09E+00	2.94E+04	6.52E-03	Inhalation
Nd-139	1.21E+08	2.66E+00	6.02E+04	1.32E-03	Direct Exposure
Nd-139m	2.14E+07	5.22E+00	1.47E+03	3.58E-04	Direct Exposure
Nd-140	6.09E+06	2.20E+01	1.97E+03	7.11E-03	Food
Nd-141	5.94E+08	6.66E+01	6.45E+04	7.22E-03	Direct Exposure
Nd-141m	7.30E+07	5.69E-02	9.17E+05	7.15E-04	Direct Exposure
Nd-144	4.03E+02	3.72E+14	1.51E+00	1.39E+12	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Nd-147	3.35E+06	4.14E+01	1.58E+03	1.96E-02	Food
Nd-149	5.66E+07	4.65E+00	1.82E+04	1.49E-03	Direct Exposure
Nd-151	5.36E+07	5.35E-01	6.36E+04	6.35E-04	Direct Exposure
Nd-152	1.63E+08	1.50E+00	2.79E+05	2.57E-03	Inhalation
Pm-136	2.16E+07	2.79E-02	1.49E+05	1.93E-04	Direct Exposure
Pm-137m	3.37E+07	5.90E-02	1.69E+05	2.96E-04	Direct Exposure
Pm-139	6.30E+07	1.93E-01	1.86E+05	5.70E-04	Direct Exposure
Pm-140	5.48E+07	6.26E-03	4.50E+06	5.13E-04	Direct Exposure
Pm-140m	1.94E+07	8.61E-02	4.02E+04	1.78E-04	Direct Exposure
Pm-141	6.59E+07	1.03E+00	4.66E+04	7.30E-04	Direct Exposure
Pm-142	6.40E+07	3.26E-02	1.24E+06	6.30E-04	Direct Exposure
Pm-143	5.25E+06	1.52E+03	2.30E+03	6.68E-01	Direct Exposure
Pm-144	9.62E+05	3.85E+02	4.65E+02	1.86E-01	Direct Exposure
Pm-145	2.25E+06	1.62E+04	3.28E+03	2.36E+01	Inhalation
Pm-146	3.84E+05	8.67E+02	5.88E+02	1.33E+00	Inhalation
Pm-147	1.62E+06	1.75E+03	2.38E+03	2.56E+00	Inhalation
Pm-148	3.55E+06	2.16E+01	1.02E+03	6.21E-03	Food
Pm-148m	1.35E+06	6.33E+01	3.66E+02	1.71E-02	Direct Exposure
Pm-149	1.11E+07	2.80E+01	5.66E+03	1.43E-02	Food
Pm-150	2.35E+07	3.01E+00	3.15E+03	4.04E-04	Direct Exposure
Pm-151	1.60E+07	2.19E+01	2.99E+03	4.09E-03	Direct Exposure
Pm-152	1.86E+08	6.20E-01	6.14E+05	2.04E-03	Direct Exposure
Pm-152m	3.82E+07	2.32E-01	6.34E+04	3.85E-04	Direct Exposure
Pm-153	7.95E+08	3.39E+00	1.81E+06	7.71E-03	Direct Exposure
Pm-154	3.10E+07	4.38E-02	2.34E+05	3.31E-04	Direct Exposure
Pm-154m	3.18E+07	6.98E-02	1.50E+05	3.30E-04	Direct Exposure
Sm-139	4.07E+07	7.73E-02	1.94E+05	3.68E-04	Direct Exposure
Sm-140	7.04E+07	7.77E-01	8.61E+04	9.50E-04	Direct Exposure
Sm-141	3.67E+07	2.80E-01	5.06E+04	3.87E-04	Direct Exposure
Sm-141m	2.51E+07	4.25E-01	1.62E+04	2.74E-04	Direct Exposure
Sm-142	9.84E+07	5.39E+00	1.02E+05	5.56E-03	Inhalation
Sm-143	1.15E+08	7.62E-01	1.57E+05	1.04E-03	Direct Exposure
Sm-143m	8.69E+07	7.27E-02	9.62E+05	8.05E-04	Direct Exposure
Sm-145	5.05E+06	1.91E+03	3.97E+03	1.50E+00	Food
Sm-146	7.37E+02	3.10E+07	1.13E+00	4.74E+04	Inhalation
Sm-147	8.45E+02	3.68E+10	1.25E+00	5.47E+07	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Sm-148	3.86E+02	1.12E+15	1.45E+00	4.20E+12	Inhalation
Sm-151	2.03E+06	7.70E+04	3.02E+03	1.15E+02	Inhalation
Sm-153	1.27E+07	2.90E+01	8.46E+03	1.93E-02	Food
Sm-155	2.62E+08	4.77E+00	3.18E+05	5.79E-03	Direct Exposure
Sm-156	3.43E+07	1.60E+01	1.28E+04	6.00E-03	Direct Exposure
Sm-157	1.42E+08	9.48E-01	2.18E+05	1.46E-03	Direct Exposure
Eu-142	4.68E+07	1.38E-03	1.55E+07	4.57E-04	Direct Exposure
Eu-142m	1.71E+07	1.58E-02	1.73E+05	1.59E-04	Direct Exposure
Eu-143	5.14E+07	1.01E-01	2.49E+05	4.91E-04	Direct Exposure
Eu-144	5.22E+07	6.79E-03	3.90E+06	5.08E-04	Direct Exposure
Eu-145	1.06E+07	6.97E+01	5.28E+02	3.48E-03	Direct Exposure
Eu-146	6.94E+06	3.57E+01	3.12E+02	1.61E-03	Direct Exposure
Eu-147	6.93E+06	1.87E+02	1.48E+03	4.00E-02	Direct Exposure
Eu-148	2.78E+06	1.72E+02	3.36E+02	2.07E-02	Direct Exposure
Eu-149	2.73E+07	2.90E+03	9.09E+03	9.65E-01	Food
Eu-150l	1.52E+05	2.19E+03	2.23E+02	3.20E+00	Inhalation
Eu-150s	4.12E+07	2.49E+01	2.79E+04	1.69E-02	Direct Exposure
Eu-152	1.92E+05	1.09E+03	2.86E+02	1.62E+00	Inhalation
Eu-152ml	3.09E+07	1.40E+01	5.31E+03	2.40E-03	Direct Exposure
Eu-152ms	4.51E+08	3.50E+01	1.00E+05	7.78E-03	Direct Exposure
Eu-154	1.52E+05	5.78E+02	2.23E+02	8.46E-01	Inhalation
Eu-154m	7.23E+08	2.72E+01	2.23E+05	8.40E-03	Direct Exposure
Eu-155	1.17E+06	2.52E+03	1.72E+03	3.69E+00	Inhalation
Eu-156	2.25E+06	4.08E+01	5.59E+02	1.01E-02	Direct Exposure
Eu-157	2.57E+07	1.95E+01	4.57E+03	3.46E-03	Direct Exposure
Eu-158	3.95E+07	1.52E+00	1.49E+04	5.76E-04	Direct Exposure
Eu-159	1.19E+08	1.82E+00	1.32E+05	2.02E-03	Direct Exposure
Gd-142	5.65E+07	4.99E-02	5.94E+05	5.24E-04	Direct Exposure
Gd-143m	2.77E+07	3.86E-02	1.86E+05	2.60E-04	Direct Exposure
Gd-144	6.36E+07	2.18E-01	1.78E+05	6.10E-04	Direct Exposure
Gd-145	2.22E+07	3.92E-01	1.40E+04	2.47E-04	Direct Exposure
Gd-145m	8.78E+07	9.58E-02	7.51E+05	8.20E-04	Direct Exposure
Gd-146	1.26E+06	6.81E+01	1.05E+03	5.67E-02	Food
Gd-147	1.37E+07	2.44E+01	6.70E+02	1.20E-03	Direct Exposure
Gd-148	3.12E+02	1.20E+01	3.72E-01	1.43E-02	Inhalation
Gd-149	1.03E+07	1.10E+02	1.79E+03	1.92E-02	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Gd-150	3.17E+02	2.38E+05	3.99E-01	2.99E+02	Inhalation
Gd-151	9.36E+06	1.30E+03	4.43E+03	6.14E-01	Food
Gd-152	4.27E+02	1.96E+13	5.08E-01	2.33E+10	Inhalation
Gd-153	3.84E+06	1.09E+03	3.13E+03	8.87E-01	Food
Gd-159	2.93E+07	2.76E+01	2.20E+04	2.07E-02	Direct Exposure
Gd-162	1.45E+08	1.05E+00	2.07E+05	1.50E-03	Direct Exposure
Tb-146	1.55E+07	4.62E-03	5.21E+05	1.55E-04	Direct Exposure
Tb-147	2.62E+07	2.03E+00	4.60E+03	3.56E-04	Direct Exposure
Tb-147m	2.97E+07	4.34E-02	2.03E+05	2.96E-04	Direct Exposure
Tb-148	1.95E+07	9.20E-01	5.12E+03	2.42E-04	Direct Exposure
Tb-148m	1.90E+07	3.29E-02	1.05E+05	1.82E-04	Direct Exposure
Tb-149	1.58E+06	3.11E-01	1.84E+03	3.62E-04	Direct Exposure
Tb-149m	4.36E+07	1.44E-01	1.27E+05	4.17E-04	Direct Exposure
Tb-150	2.27E+07	3.55E+00	2.21E+03	3.46E-04	Direct Exposure
Tb-150m	2.41E+07	1.12E-01	4.96E+04	2.29E-04	Direct Exposure
Tb-151	2.28E+07	1.93E+01	1.26E+03	1.07E-03	Direct Exposure
Tb-151m	8.45E+08	2.82E-01	2.15E+07	7.20E-03	Direct Exposure
Tb-152	1.37E+07	1.16E+01	7.53E+02	6.39E-04	Direct Exposure
Tb-152m	8.24E+07	2.80E-01	2.26E+05	7.68E-04	Direct Exposure
Tb-153	3.69E+07	1.01E+02	3.66E+03	1.00E-02	Direct Exposure
Tb-154	1.12E+07	1.18E+01	4.44E+02	4.67E-04	Direct Exposure
Tb-155	3.43E+07	2.16E+02	5.54E+03	3.50E-02	Direct Exposure
Tb-156	5.52E+06	3.52E+01	4.24E+02	2.70E-03	Direct Exposure
Tb-156ml	3.82E+07	4.64E+01	3.96E+04	4.80E-02	Direct Exposure
Tb-156ms	8.42E+07	2.09E+01	8.59E+04	2.14E-02	Inhalation
Tb-157	6.76E+06	4.45E+05	1.02E+04	6.69E+02	Inhalation
Tb-158	1.76E+05	1.17E+04	2.60E+02	1.72E+01	Inhalation
Tb-160	1.13E+06	1.00E+02	5.87E+02	5.20E-02	Food
Tb-161	6.22E+06	5.30E+01	3.21E+03	2.74E-02	Food
Tb-162	5.36E+07	3.51E-01	8.62E+04	5.64E-04	Direct Exposure
Tb-163	6.46E+07	1.09E+00	4.71E+04	7.96E-04	Direct Exposure
Tb-164	2.37E+07	6.20E-02	9.88E+04	2.58E-04	Direct Exposure
Tb-165	6.69E+07	1.24E-01	4.11E+05	7.60E-04	Direct Exposure
Dy-148	8.58E+07	2.23E-01	3.06E+05	7.95E-04	Direct Exposure
Dy-149	3.59E+07	1.20E-01	1.06E+05	3.54E-04	Direct Exposure
Dy-150	2.29E+08	1.31E+00	3.63E+05	2.07E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Dy-151	2.39E+07	3.43E-01	2.95E+04	4.24E-04	Direct Exposure
Dy-152	7.37E+07	8.50E+00	1.77E+04	2.04E-03	Direct Exposure
Dy-153	3.05E+07	9.53E+00	2.33E+03	7.28E-04	Direct Exposure
Dy-154	2.96E+02	3.82E+05	1.02E+00	1.31E+03	Inhalation
Dy-155	5.06E+07	2.50E+01	2.56E+03	1.26E-03	Direct Exposure
Dy-157	1.03E+08	4.17E+01	4.80E+03	1.95E-03	Direct Exposure
Dy-159	2.17E+07	3.81E+03	8.72E+03	1.53E+00	Food
Dy-165	1.27E+08	1.57E+01	1.28E+05	1.58E-02	Inhalation
Dy-165m	3.82E+09	4.21E+00	3.01E+07	3.32E-02	Direct Exposure
Dy-166	4.26E+06	1.84E+01	2.44E+03	1.06E-02	Food
Dy-167	1.13E+08	6.20E-01	2.19E+05	1.21E-03	Direct Exposure
Dy-168	1.56E+08	1.21E+00	2.11E+05	1.64E-03	Direct Exposure
Ho-150	3.10E+07	3.16E-02	3.00E+05	3.07E-04	Direct Exposure
Ho-153	5.86E+07	9.58E-02	3.51E+05	5.73E-04	Direct Exposure
Ho-153m	5.73E+07	4.33E-01	7.34E+04	5.55E-04	Direct Exposure
Ho-154	2.93E+07	2.82E-01	3.27E+04	3.15E-04	Direct Exposure
Ho-154m	2.48E+07	6.29E-02	9.59E+04	2.43E-04	Direct Exposure
Ho-155	1.10E+08	4.35E+00	3.90E+04	1.54E-03	Direct Exposure
Ho-156	2.26E+07	1.05E+00	6.14E+03	2.85E-04	Direct Exposure
Ho-157	1.14E+08	1.19E+00	1.17E+05	1.23E-03	Direct Exposure
Ho-158	1.04E+09	9.87E+00	7.98E+05	7.57E-03	Inhalation
Ho-159	1.50E+08	4.18E+00	6.00E+04	1.67E-03	Direct Exposure
Ho-160	3.30E+07	7.19E-01	1.67E+04	3.64E-04	Direct Exposure
Ho-161	7.25E+08	9.30E+01	7.86E+04	1.01E-02	Direct Exposure
Ho-162	3.26E+08	4.21E+00	2.88E+05	3.72E-03	Direct Exposure
Ho-162m	7.86E+07	4.60E+00	1.85E+04	1.08E-03	Direct Exposure
Ho-163	2.88E+07	5.99E+07	4.65E+04	9.69E+04	Inhalation
Ho-164	7.29E+08	1.84E+01	8.44E+05	2.13E-02	Direct Exposure
Ho-164m	5.08E+08	1.66E+01	4.09E+05	1.34E-02	Direct Exposure
Ho-166	1.24E+07	1.76E+01	7.39E+03	1.05E-02	Food
Ho-166m	6.74E+04	3.76E+04	1.02E+02	5.66E+01	Inhalation
Ho-167	6.60E+07	1.09E+01	1.07E+04	1.77E-03	Direct Exposure
Ho-168	6.66E+07	1.78E-01	2.77E+05	7.39E-04	Direct Exposure
Ho-168m	1.80E+10	3.54E+01	4.53E+07	8.90E-02	Direct Exposure
Ho-170	3.45E+07	8.61E-02	1.54E+05	3.84E-04	Direct Exposure
Er-154	1.21E+09	3.68E+00	2.56E+06	7.81E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Er-156	2.80E+08	4.53E+00	3.72E+05	6.02E-03	Inhalation
Er-159	5.35E+07	1.63E+00	2.09E+04	6.36E-04	Direct Exposure
Er-161	4.49E+07	7.47E+00	4.10E+03	6.82E-04	Direct Exposure
Er-163	1.80E+09	1.17E+02	2.40E+05	1.56E-02	Direct Exposure
Er-165	7.22E+08	3.94E+02	3.88E+04	2.11E-02	Direct Exposure
Er-167m	6.71E+08	2.26E-02	1.97E+08	6.65E-03	Direct Exposure
Er-169	8.11E+06	9.76E+01	5.18E+03	6.23E-02	Food
Er-171	2.97E+07	1.22E+01	4.73E+03	1.94E-03	Direct Exposure
Er-172	6.91E+06	1.87E+01	1.64E+03	4.43E-03	Direct Exposure
Er-173	7.25E+07	9.56E-02	6.08E+05	8.02E-04	Direct Exposure
Tm-161	3.91E+07	1.01E+00	1.85E+04	4.77E-04	Direct Exposure
Tm-162	2.83E+07	5.29E-01	1.88E+04	3.50E-04	Direct Exposure
Tm-163	3.58E+07	3.37E+00	5.06E+03	4.76E-04	Direct Exposure
Tm-164	7.57E+07	1.32E-01	4.67E+05	8.14E-04	Direct Exposure
Tm-165	2.34E+07	3.71E+01	1.68E+03	2.66E-03	Direct Exposure
Tm-166	1.80E+07	7.34E+00	9.48E+02	3.86E-04	Direct Exposure
Tm-167	7.25E+06	8.57E+01	3.44E+03	4.06E-02	Food
Tm-168	1.41E+06	1.68E+02	5.86E+02	7.02E-02	Direct Exposure
Tm-170	1.16E+06	1.94E+02	6.77E+02	1.13E-01	Food
Tm-171	5.79E+06	5.32E+03	7.45E+03	6.84E+00	Food
Tm-172	6.92E+06	2.41E+01	1.73E+03	6.03E-03	Direct Exposure
Tm-173	3.44E+07	1.57E+01	4.35E+03	1.98E-03	Direct Exposure
Tm-174	3.36E+07	1.68E-01	7.54E+04	3.77E-04	Direct Exposure
Tm-175	4.72E+07	6.67E-01	4.53E+04	6.40E-04	Direct Exposure
Tm-176	2.88E+07	4.98E-02	1.99E+05	3.44E-04	Direct Exposure
Yb-162	2.62E+08	4.26E+00	2.81E+05	4.57E-03	Direct Exposure
Yb-163	7.45E+07	7.13E-01	9.01E+04	8.63E-04	Direct Exposure
Yb-164	1.40E+08	9.25E+00	1.67E+05	1.10E-02	Inhalation
Yb-165	1.97E+08	1.71E+00	2.16E+05	1.87E-03	Direct Exposure
Yb-166	1.04E+07	3.13E+01	5.57E+03	1.67E-02	Food
Yb-167	2.05E+08	3.18E+00	1.55E+05	2.41E-03	Direct Exposure
Yb-169	2.67E+06	1.11E+02	1.57E+03	6.50E-02	Food
Yb-175	1.10E+07	6.19E+01	7.54E+03	4.23E-02	Food
Yb-177	8.39E+07	9.00E+00	3.39E+04	3.64E-03	Direct Exposure
Yb-178	1.01E+08	7.10E+00	1.02E+05	7.11E-03	Inhalation
Yb-179	6.14E+07	4.68E-01	9.30E+04	7.08E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Lu-165	4.86E+07	4.58E-01	6.08E+04	5.73E-04	Direct Exposure
Lu-167	2.86E+07	1.31E+00	8.32E+03	3.80E-04	Direct Exposure
Lu-169	1.52E+07	2.79E+01	8.82E+02	1.62E-03	Direct Exposure
Lu-169m	1.07E+14	2.57E+05	1.62E+08	3.88E-01	Direct Exposure
Lu-170	7.77E+06	2.02E+01	3.46E+02	9.00E-04	Direct Exposure
Lu-171	8.29E+06	8.93E+01	1.09E+03	1.17E-02	Direct Exposure
Lu-171m	2.74E+11	3.28E+02	2.65E+08	3.17E-01	Direct Exposure
Lu-172	4.32E+06	3.81E+01	4.05E+02	3.57E-03	Direct Exposure
Lu-172m	6.93E+13	2.34E+05	1.30E+08	4.39E-01	Direct Exposure
Lu-173	3.36E+06	2.22E+03	3.17E+03	2.10E+00	Food
Lu-174	1.92E+06	3.10E+03	2.79E+03	4.50E+00	Inhalation
Lu-174m	1.93E+06	3.65E+02	1.65E+03	3.12E-01	Food
Lu-176	1.16E+05	2.05E+12	1.69E+02	3.00E+09	Inhalation
Lu-176m	6.66E+07	1.38E+01	6.98E+04	1.44E-02	Inhalation
Lu-177	6.73E+06	6.12E+01	4.45E+03	4.05E-02	Food
Lu-177m	5.02E+05	1.10E+02	5.09E+02	1.11E-01	Food
Lu-178	1.72E+08	4.61E+00	1.82E+05	4.91E-03	Direct Exposure
Lu-178m	4.27E+07	9.17E-01	2.88E+04	6.19E-04	Direct Exposure
Lu-179	6.51E+07	1.71E+01	6.98E+04	1.83E-02	Inhalation
Lu-180	3.81E+07	2.08E-01	8.39E+04	4.58E-04	Direct Exposure
Lu-181	1.05E+08	3.53E-01	3.61E+05	1.21E-03	Direct Exposure
Hf-167	9.90E+07	1.80E-01	5.73E+05	1.04E-03	Direct Exposure
Hf-169	9.72E+07	2.83E-01	3.49E+05	1.01E-03	Direct Exposure
Hf-170	2.05E+07	1.78E+01	2.13E+03	1.85E-03	Direct Exposure
Hf-172	2.53E+05	2.28E+02	3.02E+02	2.71E-01	Inhalation
Hf-173	3.76E+07	4.98E+01	2.47E+03	3.27E-03	Direct Exposure
Hf-174	2.53E+02	2.47E+14	3.10E-01	3.02E+11	Inhalation
Hf-175	6.48E+06	6.08E+02	1.98E+03	1.85E-01	Direct Exposure
Hf-177m	1.99E+07	9.61E-01	6.26E+03	3.03E-04	Direct Exposure
Hf-178m	3.11E+04	4.81E+02	3.60E+01	5.56E-01	Inhalation
Hf-179m	2.07E+06	7.10E+01	8.17E+02	2.81E-02	Direct Exposure
Hf-180m	2.98E+07	9.41E+00	2.29E+03	7.23E-04	Direct Exposure
Hf-181	1.60E+06	9.38E+01	9.43E+02	5.54E-02	Food
Hf-182	2.62E+04	1.20E+08	3.10E+01	1.42E+05	Inhalation
Hf-182m	4.53E+07	2.70E+00	1.26E+04	7.52E-04	Direct Exposure
Hf-183	4.89E+07	3.04E+00	1.51E+04	9.38E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Hf-184	2.23E+07	5.38E+00	1.19E+04	2.88E-03	Direct Exposure
Ta-170	5.54E+07	3.38E-01	1.01E+05	6.18E-04	Direct Exposure
Ta-172	3.09E+07	1.04E+00	1.27E+04	4.28E-04	Direct Exposure
Ta-173	4.21E+07	8.48E+00	5.72E+03	1.15E-03	Direct Exposure
Ta-174	6.14E+07	4.09E+00	1.60E+04	1.07E-03	Direct Exposure
Ta-175	3.04E+07	1.78E+01	1.55E+03	9.09E-04	Direct Exposure
Ta-176	1.54E+07	6.98E+00	7.99E+02	3.62E-04	Direct Exposure
Ta-177	6.90E+07	2.20E+02	1.25E+04	3.99E-02	Direct Exposure
Ta-178s	5.86E+08	5.17E+00	7.17E+05	6.31E-03	Direct Exposure
Ta-178l	3.85E+07	4.81E+00	5.37E+03	6.70E-04	Direct Exposure
Ta-179	1.44E+07	1.31E+04	2.24E+04	2.04E+01	Direct Exposure
Ta-180	3.11E+05	1.57E+15	1.30E+03	6.53E+12	Direct Exposure
Ta-180m	1.65E+08	7.68E+01	3.53E+04	1.64E-02	Direct Exposure
Ta-182	7.96E+05	1.27E+02	5.63E+02	9.02E-02	Direct Exposure
Ta-182m	1.49E+08	2.29E+00	1.82E+05	2.79E-03	Direct Exposure
Ta-183	3.79E+06	2.71E+01	2.65E+03	1.89E-02	Direct Exposure
Ta-184	1.22E+07	6.24E+00	1.01E+03	5.16E-04	Direct Exposure
Ta-185	1.09E+08	5.27E+00	7.67E+04	3.70E-03	Direct Exposure
Ta-186	3.32E+07	3.45E-01	4.42E+04	4.59E-04	Direct Exposure
W-176	1.31E+08	1.69E+01	2.96E+04	3.83E-03	Direct Exposure
W-177	5.34E+07	6.79E+00	5.95E+03	7.56E-04	Direct Exposure
W-178	1.10E+08	3.27E+03	5.06E+03	1.50E-01	Food
W-179	1.26E+09	4.51E+01	3.23E+05	1.15E-02	Direct Exposure
W-179m	1.36E+09	8.27E+00	2.02E+06	1.23E-02	Direct Exposure
W-181	2.60E+08	4.36E+04	1.08E+04	1.81E+00	Food
W-185	6.76E+07	7.19E+03	1.87E+03	1.99E-01	Food
W-185m	2.90E+09	4.55E+00	1.58E+07	2.48E-02	Direct Exposure
W-187	3.14E+07	4.47E+01	2.10E+03	2.99E-03	Direct Exposure
W-188	1.42E+07	1.42E+03	4.10E+02	4.10E-02	Food
W-190	7.90E+07	2.39E+00	1.60E+05	4.84E-03	Direct Exposure
Re-177	7.89E+07	1.04E+00	8.34E+04	1.10E-03	Direct Exposure
Re-178	4.12E+07	5.15E-01	4.51E+04	5.63E-04	Direct Exposure
Re-179	5.06E+07	9.39E-01	3.43E+04	6.36E-04	Direct Exposure
Re-180	4.73E+07	1.10E-01	2.52E+05	5.86E-04	Direct Exposure
Re-181	2.26E+07	2.60E+01	1.39E+03	1.60E-03	Direct Exposure
Re-182l	5.50E+06	2.04E+01	4.37E+02	1.62E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Re-182s	2.17E+07	1.60E+01	1.10E+03	8.14E-04	Direct Exposure
Re-183	2.05E+06	2.01E+02	9.44E+02	9.26E-02	Food
Re-184	4.00E+06	2.14E+02	8.22E+02	4.40E-02	Direct Exposure
Re-184m	1.24E+06	2.88E+02	5.47E+02	1.27E-01	Food
Re-186	7.35E+06	3.95E+01	2.28E+03	1.23E-02	Food
Re-186m	6.76E+05	7.03E+07	3.48E+02	3.62E+04	Food
Re-187	1.29E+09	3.37E+16	1.50E+05	3.93E+12	Food
Re-188	1.48E+07	1.51E+01	1.08E+04	1.10E-02	Food
Re-188m	3.68E+08	6.83E+00	4.86E+05	9.03E-03	Direct Exposure
Re-189	1.84E+07	2.70E+01	1.38E+04	2.02E-02	Food
Re-190	4.47E+07	1.40E-01	1.75E+05	5.47E-04	Direct Exposure
Re-190m	2.20E+07	4.28E+00	4.10E+03	7.95E-04	Direct Exposure
Os-180	3.70E+08	7.80E+00	4.47E+05	9.41E-03	Inhalation
Os-181	3.33E+07	3.37E+00	5.65E+03	5.71E-04	Direct Exposure
Os-182	1.84E+07	2.35E+01	2.38E+03	3.04E-03	Direct Exposure
Os-183	2.70E+07	2.05E+01	2.05E+03	1.55E-03	Direct Exposure
Os-183m	2.59E+07	1.50E+01	1.49E+03	8.61E-04	Direct Exposure
Os-185	4.76E+06	6.34E+02	1.01E+03	1.35E-01	Direct Exposure
Os-186	1.80E+03	1.87E+15	2.94E+00	3.06E+12	Inhalation
Os-189m	1.53E+09	5.53E+02	1.19E+06	4.32E-01	Direct Exposure
Os-190m	3.56E+07	3.56E-01	4.61E+04	4.61E-04	Direct Exposure
Os-191	4.25E+06	9.56E+01	2.57E+03	5.78E-02	Food
Os-191m	5.04E+07	4.00E+01	7.45E+04	5.91E-02	Inhalation
Os-193	1.53E+07	2.83E+01	1.15E+04	2.13E-02	Food
Os-194	9.54E+04	3.11E+02	1.41E+02	4.60E-01	Inhalation
Os-196	1.05E+08	3.81E+00	1.23E+05	4.46E-03	Inhalation
Ir-180	3.73E+07	5.36E-02	3.03E+05	4.35E-04	Direct Exposure
Ir-182	3.70E+07	5.37E-01	3.61E+04	5.23E-04	Direct Exposure
Ir-183	3.83E+07	2.16E+00	1.05E+04	5.93E-04	Direct Exposure
Ir-184	2.02E+07	3.58E+00	2.10E+03	3.73E-04	Direct Exposure
Ir-185	2.91E+07	2.41E+01	2.07E+03	1.71E-03	Direct Exposure
Ir-186l	1.44E+07	1.35E+01	7.15E+02	6.71E-04	Direct Exposure
Ir-186s	4.42E+07	4.59E+00	7.16E+03	7.44E-04	Direct Exposure
Ir-187	6.27E+07	3.93E+01	3.98E+03	2.50E-03	Direct Exposure
Ir-188	1.23E+07	3.06E+01	5.56E+02	1.38E-03	Direct Exposure
Ir-189	1.33E+07	2.56E+02	9.16E+03	1.76E-01	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Ir-190	3.11E+06	5.48E+01	5.18E+02	9.11E-03	Direct Exposure
Ir-190ms	8.11E+08	5.90E+01	5.30E+06	3.85E-01	Direct Exposure
Ir-190ml	2.66E+07	5.00E+00	2.52E+03	4.73E-04	Direct Exposure
Ir-191m	8.95E+08	7.48E-02	1.18E+08	9.85E-03	Direct Exposure
Ir-192	1.21E+06	1.31E+02	8.92E+02	9.70E-02	Direct Exposure
Ir-192ms	1.01E+12	1.49E+03	1.71E+08	2.53E-01	Direct Exposure
Ir-192ml	2.08E+05	2.69E+04	3.10E+03	4.01E+02	Inhalation
Ir-193m	6.24E+06	9.71E+01	1.45E+04	2.25E-01	Water
Ir-194	1.41E+07	1.68E+01	1.20E+04	1.43E-02	Direct Exposure
Ir-194m	6.08E+05	1.54E+02	3.11E+02	7.91E-02	Direct Exposure
Ir-195	1.04E+08	1.62E+01	8.27E+04	1.29E-02	Direct Exposure
Ir-195m	3.56E+07	8.41E+00	7.45E+03	1.76E-03	Direct Exposure
Ir-196	2.33E+08	2.10E-01	3.60E+06	3.25E-03	Direct Exposure
Ir-196m	1.85E+07	1.62E+00	3.50E+03	3.06E-04	Direct Exposure
Pt-184	6.69E+07	1.13E+00	5.76E+04	9.76E-04	Direct Exposure
Pt-186	5.84E+07	6.93E+00	8.16E+03	9.69E-04	Direct Exposure
Pt-187	4.98E+07	6.99E+00	8.32E+03	1.17E-03	Direct Exposure
Pt-188	1.82E+07	2.67E+02	2.38E+03	3.50E-02	Food
Pt-189	9.84E+07	6.45E+01	4.36E+03	2.86E-03	Direct Exposure
Pt-190	1.45E+03	5.02E+11	8.59E+01	2.97E+10	Inhalation
Pt-191	5.40E+07	2.21E+02	2.69E+03	1.10E-02	Direct Exposure
Pt-193	3.86E+08	1.04E+07	2.59E+04	7.00E+02	Food
Pt-193m	6.69E+07	4.28E+02	7.17E+03	4.59E-02	Food
Pt-195m	4.30E+07	2.58E+02	5.42E+03	3.25E-02	Food
Pt-197	9.21E+07	1.06E+02	3.69E+04	4.24E-02	Food
Pt-197m	2.35E+08	2.33E+01	9.20E+04	9.10E-03	Direct Exposure
Pt-199	1.97E+08	6.42E+00	1.17E+05	3.80E-03	Direct Exposure
Pt-200	3.56E+07	2.84E+01	1.77E+04	1.41E-02	Food
Pt-202	3.10E+06	8.80E+00	1.46E+03	4.15E-03	Food
Au-186	3.52E+07	3.72E-01	4.52E+04	4.78E-04	Direct Exposure
Au-187	5.45E+07	4.55E-01	8.10E+04	6.76E-04	Direct Exposure
Au-190	2.15E+07	9.30E-01	7.11E+03	3.07E-04	Direct Exposure
Au-191	5.33E+07	1.03E+01	6.42E+03	1.24E-03	Direct Exposure
Au-192	2.06E+07	6.23E+00	1.31E+03	3.95E-04	Direct Exposure
Au-193	5.77E+07	6.27E+01	7.03E+03	7.64E-03	Direct Exposure
Au-193m	3.23E+08	2.15E-02	5.63E+07	3.76E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Au-194	2.03E+07	4.97E+01	8.34E+02	2.04E-03	Direct Exposure
Au-195	4.74E+06	1.30E+03	3.39E+03	9.25E-01	Food
Au-195m	2.88E+08	1.52E-01	7.08E+06	3.73E-03	Direct Exposure
Au-196	1.85E+07	1.72E+02	1.62E+03	1.50E-02	Direct Exposure
Au-196m	1.53E+07	9.20E+00	6.18E+03	3.71E-03	Direct Exposure
Au-198	8.83E+06	3.61E+01	2.03E+03	8.31E-03	Direct Exposure
Au-198m	3.90E+06	1.36E+01	1.46E+03	5.08E-03	Direct Exposure
Au-199	1.01E+07	4.83E+01	9.11E+03	4.36E-02	Direct Exposure
Au-200	1.07E+08	5.48E+00	5.50E+04	2.83E-03	Direct Exposure
Au-200m	7.93E+06	9.46E+00	5.25E+02	6.27E-04	Direct Exposure
Au-201	3.28E+08	9.26E+00	3.85E+05	1.09E-02	Inhalation
Au-202	3.04E+08	1.57E-01	8.77E+06	4.52E-03	Direct Exposure
Hg-190	7.61E+06	1.54E-01	1.16E+05	2.35E-03	Inhalation
Hg-191m	1.48E+06	7.62E-02	9.58E+03	4.94E-04	Direct Exposure
Hg-192	7.28E+05	2.16E-01	9.36E+03	2.78E-03	Direct Exposure
Hg-193	7.20E+05	1.55E-01	1.02E+04	2.19E-03	Inhalation
Hg-193m	2.49E+05	1.70E-01	1.34E+03	9.16E-04	Direct Exposure
Hg-194	2.03E+04	2.86E+03	1.53E+01	2.16E+00	Food
Hg-195	5.68E+05	3.50E-01	7.36E+03	4.53E-03	Direct Exposure
Hg-195m	9.85E+04	2.55E-01	1.36E+03	3.53E-03	Inhalation
Hg-197	1.84E+05	7.41E-01	2.54E+03	1.02E-02	Inhalation
Hg-197m	1.40E+05	2.09E-01	1.93E+03	2.88E-03	Inhalation
Hg-199m	3.95E+06	1.78E-01	6.20E+04	2.80E-03	Inhalation
Hg-203	1.15E+05	8.35E+00	5.18E+02	3.75E-02	Food
Hg-205	4.37E+08	2.48E+00	2.61E+07	1.48E-01	Direct Exposure
Hg-206	4.86E+07	4.34E-01	8.41E+05	7.51E-03	Direct Exposure
Hg-207	2.11E+06	6.74E-03	9.39E+04	3.00E-04	Direct Exposure
Tl-190	4.55E+07	1.20E-01	2.16E+05	5.67E-04	Direct Exposure
Tl-190m	2.43E+07	9.10E-02	7.98E+04	2.98E-04	Direct Exposure
Tl-194	7.03E+07	2.39E+00	2.82E+04	9.59E-04	Direct Exposure
Tl-194m	2.30E+07	7.79E-01	9.53E+03	3.22E-04	Direct Exposure
Tl-195	3.95E+07	2.85E+00	8.19E+03	5.91E-04	Direct Exposure
Tl-196	2.61E+07	3.00E+00	3.50E+03	4.03E-04	Direct Exposure
Tl-197	1.13E+08	2.01E+01	1.04E+04	1.86E-03	Direct Exposure
Tl-198	2.23E+07	7.48E+00	1.19E+03	3.98E-04	Direct Exposure
Tl-198m	3.90E+07	4.61E+00	5.40E+03	6.38E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Tl-199	1.53E+08	7.22E+01	7.31E+03	3.45E-03	Direct Exposure
Tl-200	2.51E+07	4.19E+01	7.49E+02	1.25E-03	Direct Exposure
Tl-201	1.47E+08	6.86E+02	8.69E+03	4.07E-02	Direct Exposure
Tl-202	3.17E+07	6.01E+02	1.60E+03	3.02E-02	Direct Exposure
Tl-204	2.08E+07	4.48E+04	6.25E+02	1.35E+00	Food
Tl-206	4.02E+10	1.85E+02	1.73E+09	7.94E+00	Direct Exposure
Tl-206m	2.48E+07	1.02E-01	8.01E+04	3.28E-04	Direct Exposure
Tl-207	1.67E+10	8.76E+01	6.90E+07	3.63E-01	Direct Exposure
Tl-208	1.53E+07	5.19E-02	6.99E+04	2.38E-04	Direct Exposure
Tl-209	2.65E+07	6.48E-02	1.62E+05	3.96E-04	Direct Exposure
Tl-210	2.05E+07	2.97E-02	2.04E+05	2.96E-04	Direct Exposure
Pb-194	4.95E+07	6.12E-01	5.57E+04	6.90E-04	Direct Exposure
Pb-195m	3.15E+07	5.16E-01	2.87E+04	4.70E-04	Direct Exposure
Pb-196	8.73E+07	3.37E+00	3.96E+04	1.53E-03	Direct Exposure
Pb-197	3.79E+07	3.17E-01	5.91E+04	4.95E-04	Direct Exposure
Pb-197m	3.82E+07	1.72E+00	1.44E+04	6.47E-04	Direct Exposure
Pb-198	6.18E+07	9.37E+00	1.15E+04	1.74E-03	Direct Exposure
Pb-199	3.16E+07	3.01E+00	5.45E+03	5.19E-04	Direct Exposure
Pb-200	2.15E+07	2.95E+01	4.99E+03	6.85E-03	Direct Exposure
Pb-201	3.54E+07	2.14E+01	2.04E+03	1.23E-03	Direct Exposure
Pb-201m	1.66E+08	1.80E-01	1.95E+06	2.12E-03	Direct Exposure
Pb-202	6.76E+05	1.15E+08	9.25E+01	1.57E+04	Food
Pb-202m	2.03E+07	4.74E+00	1.65E+03	3.85E-04	Direct Exposure
Pb-203	3.08E+07	1.04E+02	2.72E+03	9.17E-03	Direct Exposure
Pb-204m	2.54E+07	1.85E+00	5.12E+03	3.73E-04	Direct Exposure
Pb-205	9.54E+06	7.82E+10	2.87E+03	2.36E+07	Food
Pb-209	1.33E+08	2.88E+01	3.49E+05	7.57E-02	Inhalation
Pb-210	1.45E+03	1.90E+01	1.19E+00	1.55E-02	Food
Pb-211	6.75E+05	2.74E-02	1.99E+03	8.08E-05	Inhalation
Pb-212	4.27E+04	3.07E-02	3.38E+02	2.44E-04	Inhalation
Pb-214	5.39E+05	1.64E-02	2.33E+03	7.10E-05	Inhalation
Bi-197	3.44E+07	3.35E-01	4.59E+04	4.47E-04	Direct Exposure
Bi-200	2.13E+07	8.24E-01	8.32E+03	3.22E-04	Direct Exposure
Bi-201	3.10E+07	3.58E+00	5.01E+03	5.79E-04	Direct Exposure
Bi-202	1.79E+07	1.92E+00	2.67E+03	2.87E-04	Direct Exposure
Bi-203	1.31E+07	9.96E+00	5.69E+02	4.33E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Bi-204	1.03E+07	7.53E+00	4.54E+02	3.32E-04	Direct Exposure
Bi-205	6.84E+06	1.64E+02	4.39E+02	1.06E-02	Direct Exposure
Bi-206	3.71E+06	3.66E+01	2.34E+02	2.30E-03	Direct Exposure
Bi-207	1.39E+06	3.06E+04	4.71E+02	1.04E+01	Direct Exposure
Bi-208	2.09E+05	4.48E+07	2.74E+02	5.87E+04	Direct Exposure
Bi-210	8.72E+04	7.03E-01	1.33E+02	1.07E-03	Inhalation
Bi-210m	2.38E+03	4.20E+06	3.60E+00	6.35E+03	Inhalation
Bi-211	1.22E+09	2.92E+00	7.25E+06	1.74E-02	Direct Exposure
Bi-212	2.61E+05	1.78E-02	2.86E+02	1.95E-05	Inhalation
Bi-212n	6.95E+09	5.48E+01	6.95E+09[E]	5.48E+01[E]	--[E]
Bi-213	2.70E+05	1.40E-02	2.72E+02	1.41E-05	Inhalation
Bi-214	5.70E+05	1.29E-02	5.32E+02	1.20E-05	Inhalation
Bi-215	2.29E+08	1.99E+00	3.76E+05	3.27E-03	Direct Exposure
Bi-216	7.93E+07	1.98E-01	4.52E+05	1.13E-03	Direct Exposure
Po-203	2.90E+06	1.15E-01	1.20E+04	4.76E-04	Direct Exposure
Po-204	1.32E+06	3.03E-01	2.96E+03	6.81E-04	Direct Exposure
Po-205	2.68E+06	3.15E-01	4.24E+03	5.00E-04	Direct Exposure
Po-206	1.14E+04	1.58E-01	2.15E+02	2.98E-03	Inhalation
Po-207	2.92E+06	1.13E+00	1.65E+03	6.36E-04	Direct Exposure
Po-208	1.09E+02	1.84E-01	2.63E+00	4.43E-03	Food
Po-209	7.95E+01	4.74E+00	2.69E+00	1.60E-01	Food
Po-210	1.89E+02	4.20E-02	3.65E+00	8.11E-04	Food
Po-211	7.09E+08	6.85E-03	1.08E+10	1.04E-01	Direct Exposure
Po-212m	6.77E+07	5.74E-02	1.22E+07	1.03E-02	Direct Exposure
Po-213	1.58E+11	1.25E-05	1.58E+11[E]	1.25E-05[E]	--[E]
Po-214	6.62E+10	2.06E-04	6.62E+10[E]	2.06E-04[E]	--[E]
Po-215	3.21E+10	1.09E-03	2.44E+14	8.29E+00	Direct Exposure
Po-216	3.26E+11	9.36E-01	3.26E+11[E]	9.36E-01[E]	--[E]
Po-218	6.03E+11	2.13E+03	6.03E+11[E]	2.13E+03[E]	--[E]
At-204	2.60E+07	2.59E-01	3.39E+04	3.38E-04	Direct Exposure
At-205	8.63E+06	2.46E-01	2.42E+04	6.90E-04	Direct Exposure
At-206	1.36E+07	4.55E-01	9.55E+03	3.20E-04	Direct Exposure
At-207	3.25E+06	3.86E-01	5.07E+03	6.02E-04	Direct Exposure
At-208	7.54E+06	8.15E-01	2.44E+03	2.64E-04	Direct Exposure
At-209	2.42E+06	8.73E-01	1.02E+03	3.70E-04	Direct Exposure
At-210	6.69E+05	3.63E-01	5.77E+02	3.13E-04	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
At-211	7.37E+04	3.58E-02	1.02E+03	4.93E-04	Inhalation
At-215	2.93E+11	5.59E-04	4.35E+15	8.29E+00	Direct Exposure
At-216	4.33E+10	2.49E-04	9.66E+13	5.55E-01	Direct Exposure
At-217	1.83E+11	1.13E-01	4.49E+12	2.79E+00	Direct Exposure
At-218	2.27E+10	8.78E-01	3.24E+09	1.25E-01	Direct Exposure
At-220	1.29E+08	5.61E-01	4.34E+05	1.89E-03	Direct Exposure
Rn-207	6.13E+04	6.24E-04	7.95E+04	8.10E-04	Direct Exposure
Rn-209	4.94E+04	1.57E-03	2.13E+04	6.74E-04	Direct Exposure
Rn-210	2.13E+05	3.42E-02	8.26E+04	1.33E-02	Direct Exposure
Rn-211	3.14E+04	3.08E-02	6.50E+02	6.38E-04	Direct Exposure
Rn-212	1.96E+05	5.28E-03	9.19E+07	2.48E+00	Direct Exposure
Rn-215	1.42E+05	6.24E-12	1.42E+05[E]	6.24E-12[E]	--[E]
Rn-216	1.53E+05	1.32E-10	1.53E+05[E]	1.32E-10[E]	--[E]
Rn-217	1.59E+05	1.65E-09	1.59E+05[E]	1.65E-09[E]	--[E]
Rn-218	7.40E+07	5.01E-05	1.77E+12	1.20E+00	Direct Exposure
Rn-219	1.01E+06	7.75E-05	1.96E+08	1.50E-02	Direct Exposure
Rn-220	1.46E+08	1.58E-01	2.61E+09	2.83E+00	Direct Exposure
Rn-222	1.42E+08	9.20E+02	2.65E+06	1.72E+01	Direct Exposure
Rn-223	1.73E+05	4.99E-03	8.66E+04	2.50E-03	Direct Exposure
Fr-212	1.14E+06	2.56E-02	3.99E+03	8.99E-05	Inhalation
Fr-219	1.63E+10	6.64E-03	6.09E+11	2.48E-01	Direct Exposure
Fr-220	5.49E+09	2.94E+00	1.31E+08	7.01E-02	Direct Exposure
Fr-221	1.85E+09	1.04E+01	4.87E+06	2.75E-02	Direct Exposure
Fr-222	5.79E+05	9.85E-03	5.32E+02	9.04E-06	Inhalation
Fr-223	9.04E+06	2.34E-01	8.59E+03	2.22E-04	Inhalation
Fr-224	1.03E+08	4.09E-01	3.94E+05	1.56E-03	Direct Exposure
Fr-227	1.35E+08	4.03E-01	6.52E+05	1.94E-03	Direct Exposure
Ra-219	3.67E+08	7.12E-05	2.56E+10	4.96E-03	Direct Exposure
Ra-220	1.31E+10	4.56E-03	5.20E+11	1.82E-01	Direct Exposure
Ra-221	1.84E+09	1.01E+00	3.98E+07	2.18E-02	Direct Exposure
Ra-222	6.16E+09	4.60E+00	1.26E+08	9.40E-02	Direct Exposure
Ra-223	9.32E+02	1.82E-02	1.62E+01	3.16E-04	Inhalation
Ra-224	2.38E+03	1.50E-02	3.85E+01	2.42E-04	Inhalation
Ra-225	1.05E+03	2.69E-02	1.93E+01	4.91E-04	Inhalation
Ra-226	8.53E+02	8.63E+02	2.88E+01	2.91E+01	Food
Ra-227	1.68E+07	8.57E-01	1.03E+05	5.25E-03	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Ra-228	5.07E+02	1.86E+00	1.21E+01	4.43E-02	Food
Ra-230	5.59E+07	6.36E+00	9.81E+04	1.12E-02	Direct Exposure
Ac-223	1.31E+10	3.41E+01	5.31E+07	1.39E-01	Direct Exposure
Ac-224	6.24E+04	1.29E-02	9.31E+02	1.93E-04	Inhalation
Ac-225	9.54E+02	1.64E-02	1.41E+01	2.44E-04	Inhalation
Ac-226	6.24E+03	1.30E-02	9.31E+01	1.95E-04	Inhalation
Ac-227	1.47E+01	2.04E-01	1.77E-01	2.45E-03	Inhalation
Ac-228	3.22E+05	1.44E-01	2.17E+03	9.69E-04	Direct Exposure
Ac-229	2.32E+08	1.77E+01	2.07E+06	1.58E-01	Inhalation
Ac-230	1.02E+08	2.53E-01	6.55E+05	1.63E-03	Direct Exposure
Ac-231	1.47E+08	1.35E+00	2.31E+05	2.13E-03	Direct Exposure
Ac-232	4.78E+07	1.17E-01	3.17E+05	7.76E-04	Direct Exposure
Ac-233	1.18E+08	3.54E-01	6.01E+05	1.80E-03	Direct Exposure
Th-223	9.72E+08	1.15E-02	9.61E+08	1.14E-02	Direct Exposure
Th-224	2.77E+09	5.78E-02	1.79E+09	3.72E-02	Direct Exposure
Th-226	1.33E+05	4.94E-03	1.43E+03	5.32E-05	Inhalation
Th-227	8.11E+02	2.64E-02	1.16E+01	3.79E-04	Inhalation
Th-228	2.03E+02	2.47E-01	3.02E+00	3.68E-03	Inhalation
Th-229	3.38E+01	1.59E+02	1.13E+00	5.30E+00	Inhalation
Th-230	8.11E+01	4.02E+03	2.79E+00	1.38E+02	Inhalation
Th-231	2.45E+07	4.60E+01	3.86E+04	7.26E-02	Direct Exposure
Th-232	7.37E+01	6.72E+08	2.66E+00	2.42E+07	Inhalation
Th-233	3.05E+08	8.43E+00	8.67E+05	2.40E-02	Direct Exposure
Th-234	1.05E+06	4.55E+01	3.59E+03	1.55E-01	Food
Th-235	9.22E+08	8.19E+00	1.90E+06	1.69E-02	Direct Exposure
Th-236	1.12E+08	5.29E+00	5.58E+05	2.63E-02	Direct Exposure
Pa-227	1.01E+05	4.69E-03	1.15E+03	5.32E-05	Inhalation
Pa-228	1.08E+05	1.73E-01	9.06E+02	1.45E-03	Direct Exposure
Pa-229	1.04E+06	2.74E+00	1.36E+04	3.58E-02	Direct Exposure
Pa-230	1.07E+04	3.27E-01	1.57E+02	4.82E-03	Inhalation
Pa-231	5.79E+01	1.23E+03	8.59E-01	1.82E+01	Inhalation
Pa-232	8.00E+05	1.86E+00	9.96E+02	2.32E-03	Direct Exposure
Pa-233	2.06E+06	9.95E+01	3.60E+03	1.74E-01	Direct Exposure
Pa-234	1.19E+07	5.96E+00	1.02E+03	5.13E-04	Direct Exposure
Pa-234m	3.76E+09	5.47E+00	5.39E+07	7.84E-02	Direct Exposure
Pa-235	3.90E+08	1.19E+01	3.74E+07	1.15E+00	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Pa-236	6.20E+07	7.08E-01	8.70E+04	9.94E-04	Direct Exposure
Pa-237	9.58E+07	1.05E+00	1.37E+05	1.50E-03	Direct Exposure
U-227	5.57E+08	7.40E-01	5.50E+06	7.30E-03	Direct Exposure
U-228	1.70E+10	1.88E+02	1.43E+07	1.57E-01	Direct Exposure
U-230	5.07E+02	1.86E-02	7.45E+00	2.73E-04	Inhalation
U-231	1.53E+07	1.14E+02	9.60E+03	7.14E-02	Direct Exposure
U-232	2.19E+02	1.02E+01	3.19E+00	1.49E-01	Inhalation
U-233	8.45E+02[D]	8.73E+04[D]	1.28E+01	1.33E+03	Inhalation
U-234	8.63E+02	1.38E+05	1.31E+01	2.10E+03	Inhalation
U-235	9.54E+02[D]	4.41E+08[D]	1.45E+01	6.71E+06	Inhalation
U-235m	8.84E+12	2.87E+05	8.84E+12[E]	2.87E+05[E]	--[E]
U-236	9.32E+02	1.44E+07	1.41E+01	2.19E+05	Inhalation
U-237	4.23E+06	5.18E+01	5.35E+03	6.55E-02	Direct Exposure
U-238	1.01E+03	3.02E+09	1.53E+01	4.55E+07	Inhalation
U-239	2.66E+08	7.95E+00	5.85E+05	1.75E-02	Direct Exposure
U-240	1.40E+07	1.51E+01	1.33E+05	1.44E-01	Inhalation
U-242	2.06E+08	4.45E+00	1.04E+06	2.26E-02	Direct Exposure
Np-231	4.50E+06	2.70E-01	6.57E+04	3.94E-03	Inhalation
Np-232	2.76E+07	5.00E-01	4.10E+04	7.43E-04	Direct Exposure
Np-233	6.12E+08	2.75E+01	2.20E+05	9.89E-03	Direct Exposure
Np-234	1.06E+07	8.33E+01	5.44E+02	4.29E-03	Direct Exposure
Np-235	1.29E+07	9.17E+03	1.02E+05	7.30E+01	Direct Exposure
Np-236l	1.01E+03	7.70E+04	3.72E+01	2.83E+03	Inhalation
Np-236s	9.00E+05	1.53E+00	2.03E+04	3.43E-02	Direct Exposure
Np-237	1.62E+02	2.30E+05	5.32E+00	7.55E+03	Inhalation
Np-238	2.26E+06	8.74E+00	1.54E+03	5.94E-03	Direct Exposure
Np-239	7.93E+06	3.42E+01	4.84E+03	2.09E-02	Direct Exposure
Np-240	2.90E+07	2.41E+00	8.49E+03	7.04E-04	Direct Exposure
Np-240m	1.67E+08	1.58E+00	2.90E+05	2.74E-03	Direct Exposure
Np-241	4.16E+08	7.42E+00	1.32E+06	2.35E-02	Direct Exposure
Np-242	2.03E+08	5.76E-01	1.24E+06	3.51E-03	Direct Exposure
Np-242m	6.50E+07	4.60E-01	1.43E+05	1.01E-03	Direct Exposure
Pu-232	3.13E+05	1.30E-02	4.47E+03	1.86E-04	Inhalation
Pu-234	3.38E+05	2.22E-01	5.08E+03	3.34E-03	Inhalation
Pu-235	6.11E+08	1.93E+01	3.02E+05	9.56E-03	Direct Exposure
Pu-236	2.03E+02	3.82E-01	6.20E+00	1.17E-02	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Pu-237	2.05E+07	1.68E+03	1.40E+04	1.15E+00	Direct Exposure
Pu-238	7.37E+01	4.31E+00	2.60E+00	1.52E-01	Inhalation
Pu-239	6.76E+01[D]	1.09E+03[D]	2.38E+00	3.82E+01	Inhalation
Pu-240	6.76E+01	2.97E+02	2.38E+00	1.04E+01	Inhalation
Pu-241	3.53E+03	3.42E+01	1.31E+02	1.28E+00	Inhalation
Pu-242	7.37E+01	1.88E+04	2.54E+00	6.47E+02	Inhalation
Pu-243	9.10E+07	3.50E+01	9.86E+04	3.79E-02	Direct Exposure
Pu-244	7.37E+01	4.16E+06	2.54E+00	1.43E+05	Inhalation
Pu-245	1.66E+07	1.36E+01	3.47E+03	2.85E-03	Direct Exposure
Pu-246	1.01E+06	2.07E+01	5.31E+03	1.09E-01	Food
Am-237	1.05E+08	9.69E+00	2.69E+04	2.47E-03	Direct Exposure
Am-238	2.53E+07	3.14E+00	8.30E+03	1.03E-03	Direct Exposure
Am-239	2.99E+07	2.71E+01	5.63E+03	5.11E-03	Direct Exposure
Am-240	1.40E+07	5.44E+01	8.28E+02	3.22E-03	Direct Exposure
Am-241	8.45E+01	2.46E+01	2.86E+00	8.35E-01	Inhalation
Am-242	4.05E+05	5.02E-01	6.98E+03	8.64E-03	Inhalation
Am-242m	8.81E+01	9.07E+00	3.19E+00	3.28E-01	Inhalation
Am-243	8.45E+01	4.24E+02	2.86E+00	1.44E+01	Inhalation
Am-244	2.13E+06	1.67E+00	1.83E+03	1.44E-03	Direct Exposure
Am-244m	5.06E+07	1.71E+00	1.41E+06	4.77E-02	Inhalation
Am-245	1.34E+08	2.15E+01	1.82E+05	2.92E-02	Direct Exposure
Am-246	4.84E+07	2.47E+00	2.66E+04	1.36E-03	Direct Exposure
Am-246m	4.66E+07	1.53E+00	2.85E+04	9.31E-04	Direct Exposure
Am-247	1.65E+08	4.98E+00	2.34E+05	7.06E-03	Direct Exposure
Cm-238	1.65E+06	3.01E-01	2.33E+04	4.24E-03	Inhalation
Cm-239	7.23E+07	1.60E+01	1.61E+04	3.56E-03	Direct Exposure
Cm-240	2.32E+03	1.15E-01	3.85E+01	1.91E-03	Inhalation
Cm-241	2.19E+05	1.32E+01	1.46E+03	8.86E-02	Direct Exposure
Cm-242	1.37E+03	4.15E-01	2.33E+01	7.02E-03	Inhalation
Cm-243	1.18E+02	2.28E+00	3.85E+00	7.46E-02	Inhalation
Cm-244	1.42E+02	1.76E+00	4.47E+00	5.52E-02	Inhalation
Cm-245	8.19E+01	4.77E+02	2.79E+00	1.63E+01	Inhalation
Cm-246	8.27E+01	2.69E+02	2.79E+00	9.09E+00	Inhalation
Cm-247	9.01E+01	9.71E+05	3.10E+00	3.34E+04	Inhalation
Cm-248	2.25E+01	5.30E+03	7.98E-01	1.88E+02	Inhalation
Cm-249	1.89E+08	1.61E+01	5.91E+05	5.03E-02	Direct Exposure

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[A]		Hazard Category 3[A]		
	Curies	Grams	Curies	Grams	Limiting Pathway[B]
Cm-250	3.86E+00	1.86E+01	1.41E-01	6.82E-01	Inhalation
Cm-251	1.86E+08	4.18E+00	3.88E+05	8.70E-03	Direct Exposure
Bk-244	8.11E+06	2.75E+00	1.12E+05	3.78E-02	Inhalation
Bk-245	3.80E+06	3.53E+01	3.32E+03	3.08E-02	Direct Exposure
Bk-246	1.73E+07	5.98E+01	9.17E+02	3.16E-03	Direct Exposure
Bk-247	1.18E+02	1.12E+02	1.72E+00	1.64E+00	Inhalation
Bk-248m	2.88E+05	5.41E-01	7.45E+03	1.40E-02	Inhalation
Bk-249	5.07E+04	3.09E+01	7.45E+01	4.54E-02	Inhalation
Bk-250	7.17E+06	1.84E+00	4.25E+03	1.09E-03	Direct Exposure
Bk-251	1.32E+08	9.78E+00	1.42E+05	1.06E-02	Direct Exposure
Cf-244	5.79E+05	1.46E-02	6.20E+03	1.56E-04	Inhalation
Cf-246	1.80E+04	5.05E-02	2.66E+02	7.45E-04	Inhalation
Cf-247	1.29E+08	3.16E+01	3.72E+04	9.11E-03	Direct Exposure
Cf-248	9.21E+02	5.84E-01	1.36E+01	8.63E-03	Inhalation
Cf-249	1.16E+02	2.83E+01	1.69E+00	4.13E-01	Inhalation
Cf-250	2.38E+02	2.18E+00	3.49E+00	3.19E-02	Inhalation
Cf-251	1.14E+02	7.20E+01	1.67E+00	1.05E+00	Inhalation
Cf-252	4.05E+02	7.54E-01	6.20E+00	1.15E-02	Inhalation
Cf-253	6.24E+03	2.15E-01	9.31E+01	3.21E-03	Inhalation
Cf-254	1.98E+02	2.33E-02	3.02E+00	3.55E-04	Inhalation
Cf-255	1.10E+06	1.27E-01	2.07E+04	2.39E-03	Inhalation
Cf-256	4.27E+03	7.15E-05	2.79E+01	4.68E-07	Inhalation
Es-249	2.68E+07	3.63E+00	1.72E+04	2.32E-03	Direct Exposure
Es-250	1.18E+07	1.98E+00	1.45E+04	2.43E-03	Direct Exposure
Es-250m	4.87E+06	8.63E-01	9.81E+03	1.74E-03	Direct Exposure
Es-251	3.84E+06	1.01E+01	9.39E+03	2.48E-02	Direct Exposure
Es-253	3.00E+03	1.19E-01	4.47E+01	1.77E-03	Inhalation
Es-254	9.43E+02	5.06E-01	1.40E+01	7.49E-03	Inhalation
Es-254m	1.72E+04	5.50E-02	2.54E+01	8.09E-05	Inhalation
Es-255	1.64E+03	1.27E-01	3.10E+01	2.41E-03	Inhalation
Es-256	1.78E+05	6.16E-03	3.28E+02	1.14E-05	Inhalation
Fm-251	3.72E+06	1.58E+00	1.50E+04	6.37E-03	Direct Exposure
Fm-252	2.53E+04	4.63E-02	3.72E+02	6.80E-04	Inhalation
Fm-253	2.03E+04	1.18E-01	3.02E+02	1.76E-03	Inhalation
Fm-254	1.33E+05	3.49E-02	1.45E+03	3.81E-04	Inhalation
Fm-255	3.00E+04	4.91E-02	4.30E+02	7.02E-04	Inhalation

TABLE 1-1: THRESHOLDS FOR RADIONUCLIDES					
Radionuclide	Hazard Category 2[(A)]		Hazard Category 3[(A)]		
	Curies	Grams	Curies	Grams	Limiting Pathway[(B)]
Fm-256	2.83E+04	6.07E-03	1.60E+01	3.42E-06	Inhalation
Fm-257	1.14E+03	2.26E-01	1.69E+01	3.35E-03	Inhalation
Md-257	3.24E+05	1.38E-01	4.86E+03	2.07E-03	Inhalation
Md-258	1.37E+03	1.49E-01	2.03E+01	2.21E-03	Inhalation

Table Footnotes:

(A) For isotopes not listed in Table 1-1, users may refer to Appendix A of this Standard for the calculation of HC-2 and HC-3 threshold values. In the event an isotope does not have a published/calculated HC-2 threshold value, the following default HC-2 threshold values should be used:

DEFAULT HC-2 TQ ISOTOPE TYPE (select one)

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

(B) The limiting exposure pathways used for determining the HC-3 threshold value are: (1) inhalation, (2) ingestion of food, (3) ingestion of water, (4) direct exposure, and (5) air submersion.

(C) At the recommendation of the Tritium Focus Group, the HC-2 and HC-3 tritium threshold values were provided by the Tritium Focus Group (TFG) and are not calculated using the methodology in this Standard.

(D) To be used only if segmentation or the nature of the process precludes the potential for criticality. Otherwise, the "*Single-Parameter Limits for Fissile Nuclides*" in Section 5 of ANSI/ANS-8.1-2014 are evaluated consistent with Section 3.1.6 of this Standard.

(E) The HC-3 TQ is set to be equal to the HC-2 TQ for the following nine radionuclides: Bi-212n, Po-213, Po-214, Po-216, Po-218, Rn-215, Rn-216, Rn-217, and U-235m.

APPENDIX A: CALCULATION OF HAZARD CATEGORY THRESHOLDS

The designation of a facility as Hazard Category (HC) 2 or HC-3 is based on a quantitative comparison of a facility's radioactive material inventory against the radionuclide-specific threshold values provided in this standard. The derivation of the threshold values is based on methodologies which model the following: (i) the transport of a radioactive material from the facility to a receptor, and (ii) the dose effects associated with the exposure of the receptor to the radioactive material.

The transport of the radioactive material to the receptor is modeled in accordance with the evaluated receptor exposure pathway. Table A-1 summarizes the various exposure pathways evaluated in the derivation of HC-2 and HC-3 threshold values.

Table A-1 – Exposure Pathways Evaluated in the Derivation of HC-2 and HC-3 TQs

Exposure Pathway	Transport To Receptor	Category 2	Category 3
Inhalation	Atmospheric	X	X
Ingestion (via food consumption)	Atmospheric deposition onto vegetation		X
Ingestion (via water consumption)	Groundwater (advection-dispersion)		X
Direct Exposure (photons)	Unshielded exposure		X
Air Submersion	Atmospheric	X	X *(only inert gases)*

The transport exposure pathways evaluated for the derivation of HC-2 radionuclide thresholds are based on the methodology promulgated by the U. S. Nuclear Regulatory Commission (NRC). A detailed description of the HC-2 transport exposure pathway methodology is described in Section A.4. The transport exposure pathways evaluated for the derivation of HC-3 radionuclide thresholds are based on the methodology promulgated by the U. S. Environmental Protection Agency (EPA). A detailed description of the evaluated HC-3 transport exposure pathway methodologies are described in Section A.5.

The dosimetric effects associated with exposure of the receptor to the radioactive materials is accounted for through the use of radionuclide-specific dose coefficients (DCs) for inhalation, ingestion, and air submersion exposure pathways. Nuclear transformation data was used to obtain radionuclide-specific photon intensity data for evaluating point source exposure dose. The DCs and photon intensity data were obtained from the International Commission on Radiological Protection (ICRP), except as otherwise noted.

The following sections summarize the selection of input data, physical constants, and the methodology used in the calculation of the HC-2 and HC-3 TQs listed in Table 1-1. A detailed discussion of the calculation of the HC-2 and HC-3 TQs in Table 1-1 is contained within the following report[7]: *Calculation of Hazard Category 2/3 Threshold Quantities Using Contemporary Dosimetric Data*, ORNL/TM-2017/467, November 2017.

A.1 Selection of Dose Coefficients

A.1.1 Dose Coefficients Utilized by DOE-STD-1027-92 for Calculating HC-2 and HC-3 TQs

The Dose Coefficients (DCs) utilized for the derivation of the HC-2 and HC-3 TQs published in DOE-STD-1027-92 and the supporting LANL Fact Sheets are listed in Table A-2.

Table A-2 – Origin of Nuclear Transformation Data and the Associated Dose Coefficients Used For Calculating HC-2/3 TQs in DOE-STD-1027-92

	Dose Coefficient	Dose Coefficient Publication	Supporting Nuclear Transformation Data (NTD)
HC-2 TQ	Air Submersion DC	DOE/EH-0070 *(1988)*	DOE/TIC-11026 *(1981)*
	Inhalation DC	DOE/EH-0071 *(1988)*	ICRP Publication 38 *(1983)*
HC-3 TQ	Inhalation DC	ICRP Publication 30 (*1978)*	
	Ingestion DC		
	Air Submersion DC		
	Avg. Photon Energy	**	**

NOTE:

** The EPA Technical Background Document does not state nor imply the source of the radionuclide specific average photon intensity data.

[7] ORNL/TM-2017/467 was developed to expand upon the effort by Los Alamos National Laboratory to calculate updated TQs as documented in LAUR-14-20689, *HC-2/3 Threshold Quantity According to DOE Supplemental Guidance NA-1 SD G 1027*, issued 10-03-2014.

The various DCs were derived by the respective publication via the use of accepted dosimetric models (ingestion, inhalation, and air submersion) and the use of published nuclear transformation data (NTD). The NTD publications listed in Table A-2 provide information associated with the radionuclide-specific radioactive decay characteristics (e.g., half-life, decay modes, and decay energy/intensity). The NTD is based on data files obtained from the Evaluated Nuclear Structure Data File (ENSDF) system. The ENSDF serves as a principal source of data for nuclear structure research, nuclear spectroscopy applications, medical internal radiation dose (MIRD), and publications such as Nuclear Data Sheets and the Table of Isotopes. The ENSDF is maintained by the National Nuclear Data Center (NNDC) by the Brookhaven National Laboratory.

A.1.2 Selection of Contemporary Dose Coefficient Publications

Since the publication of the HC-2 and HC-3 TQs in DOE-STD-1027-92, the DC data source publications have been superseded by subsequent issuance of similar publications. Specifically:

- The NTD information in DOE/TIC-11026 has been superseded by more recent publications from the International Commission on Radiological Protection (ICRP), specifically ICRP Publication 38 (1983) and it successor, ICRP Publication 107 (2008). These ICRP Publications utilize NTD from contemporaneous ENSDF data files.

- The ingestion and inhalation DCs contained within DOE/EH-0071 have been superseded in their usage by subsequent ICRP publications; ICRP Publication 72 and its successor document, ICRP Publication 119.

- The external DCs (e.g., air submersion) contained within DOE/EH-0070 have been superseded by a subsequent EPA publication, Federal Guidance Report No. 12.

As noted in Figure A-1, the NTD in ICRP Publication 38 serves as the basis for the list of radionuclides used in the determination of ingestion, inhalation, and air submersion DCs contained in FGR-12 and ICRP Publication 119. As such, the continued use of ICRP Publication 38 is necessary based on the “family of data” concept.

DOE-STD-1196-2011 was included as an acceptable publication with inhalation and air submersion DCs, since the DCs were derived using the NTD contained within ICRP Publication 107. The use of DOE-STD-1196-2011 was only used for to the calculation of HC-2 TQs and was not used in the calculation of HC-3 TQs. This restriction was based on statements within DOE-STD-1196-2011 which noted that the DCs were computed in a manner similar to ICRP Publication 72. Since ICRP Publication 72 is associated with the derivation of DCs specifically for the public, then the DCs contained within DOE-STD-1196-2011 were similarly limited to use for public dose calculations only.

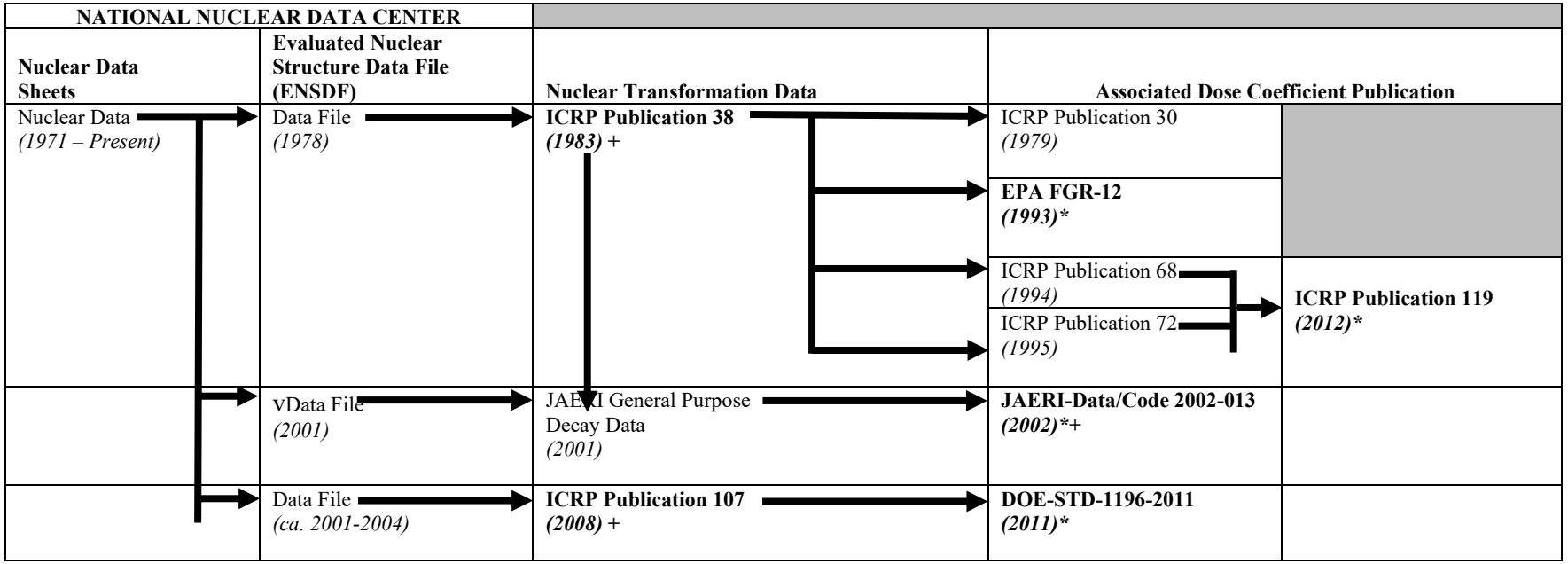
The Japan Atomic Energy Research Institute (JAERI) report in Figure A-1 was noted to provide ingestion and inhalation DCs for radionuclides not addressed by ICRP Publication 68 nor by ICRP Publication 72. The inhalation and ingestion DCs in the JAERI report were calculated using tissue and radiation weighting factors recommended in ICRP Publication 60, the human respiratory tract model of ICRP Publication 66, and the biokinetic models of ICRP Publications-56, 67, 69, and 71. Also, effective dose rates for inert gases (air submersion DCs) were calculated using the methodology described in ICRP Publication 30 and FGR-12. Since the JAERI publication followed the methods of similar ICRP Publications, the DCs were deemed acceptable for use for calculating HC-2 and HC-3 TQs.

NOTE: The ICRP Publications only calculated ingestion and inhalation DCs for radionuclides with a half-life equal to or greater than 10 minutes. The JAERI report contains ingestion and inhalation DCs for radionuclides which include some with half-lives less than 10 minutes. To maintain consistency with the ICRP convention, ingestion and inhalation DCs were only used for radionuclides with half-lives equal to or greater than 10 minutes.

A summary of the selected publications containing contemporary DCs used for the calculation of HC-2 and HC-3 TQs is listed in Table A-3.

Table A-3 – Selection of Contemporary Dose Coefficient Publications for Calculating HC-2 and HC-3 TQs

Dose Coefficient Category	Selected Publication	Applicability	
		HC-2 TQ Calculation	HC-3 TQ Calculation
Inhalation DCs	ICRP Publication 119	X	X
	DOE-STD-1196-2011	X	
	JAERI-Data/Code 2002-013	X	X
Ingestion DCs	ICRP Publication 119		X
	DOE-STD-1196-2011		
	JAERI-Data/Code 2002-013		X
Air Submersion DCs	ICRP Publication 119		X
	FGR-12	X	
	DOE-STD-1196-2011	X	
Avg. Photon Energy/Intensity Data	ICRP Publication 38		X
	ICRP Publication 107		X



Notes:

* Publications containing ingestion, inhalation, and/or air submersion DCs selected for use in calculating updated HC-2 and HC-3 TQs.

\+ Publications containing NTD selected for use of average photon energy/intensity data and for calculating specific activity (using published half-life data).

FIGURE A.1 – Relationship of Dose Coefficient Publications

A.1.3 Hierarchy of Selected Contemporary Dose Coefficient Publications

As noted in Table A-3, multiple publications containing contemporary DCs were selected for use in calculating the HC-2 and HC-3 TQs. The selection of multiple publications was in recognition that no single data source contains all DCs for the scope of radionuclides involved.

A hierarchical ranking of the input data was developed to ensure a consistent calculation of the HC-2 and HC-3 TQs. The selected DC publications were grouped in accordance with the NTD used in derivation of the ingestion, inhalation and air submersion DCs.

I. ICRP Publication 38 Family of Data

The highest ranking data set is assigned to ICRP Publication 38 and its family of publications. The ICRP Publication 38 family ranking is based on the observation that the majority of the available inhalation and ingestion dose coefficients for both worker dose assessments and for members of the public dose assessments currently reside within ICRP Publication 119. The publications assigned to the ICRP Publication 38 family of data include the following:

- ICRP Publication 38
- ICRP Publication 119
- FGR-12

II. ICRP Publication 107 Family of Data

The second highest ranking data set is assigned to ICRP Publication 107 and its family of publications. The ICRP Publication 107 family ranking is based on the observation that ICRP Publication 107 provides a substantial increase in the overall radionuclide data set. Whereas ICRP Publication 38 provides NTD for 838 radionuclides, ICRP Publication 107 expands the available data set to 1252 radionuclides (an additional 414 radionuclides). The publications assigned to the ICRP Publication 107 family of data include the following:

- ICRP Publication 107
- DOE-STD-1196-2011

III. JAERI-Data/Code 2002-013 Family of Data

The third highest ranking data set is assigned to JAERI-Data/Code 2002-013. This designation is based on the observation that the JAERI data is considered to be a minor supplemental source of information outside of the ICRP publications. The publications assigned to the JAERI-Data/Code 2002-013 family of data include the following:

- JAERI-Data/Code 2002-013

Under this “family of data” concept, the NTD and the DCs are all selected from the same family of data, if possible. If an input element is not available from within the family of data, then the next lower “family of data” level is searched for the necessary data element. This search continues until all lower family of data levels has been exhausted.

Table A-4 lists the relevant DC publications in accordance with the DC data type it is associated with for the calculation of HC-2 TQs. Similarly, Table A-5 lists the relevant DC publications in accordance with the DC data type it is associated with for the calculation of HC-3 TQs.

Table A-4 – Hierarchical Organization of Contemporary Dose Coefficient Publications for HC-2 TQ Calculations

Data Type	Selection Order	Publication	Relevant Dose Coefficient Table
Inhalation DCs	1	ICRP Publication 119	**Annex G:** *Effective Dose Coefficients for Inhalation of Radionuclides for Members of the Public* **Annex H:** *Dose Coefficients for Inhalation of Soluble or Reactive Gases and Vapours For Members of the Public*
	2	DOE-STD-1196-2011	**Table A-2:** *Effective Dose Coefficients from Inhaled Air*
	3	JAERI-Data/Code 2002-013	**Table 5:** *Effective Dose Coefficients for Members of the Public – Inhalation Dose Coefficients, e(τ), to age 70 y (Sv Bq^{-1})* **Table 7:** *Effective Dose Coefficients for Members of the Public – Inhalation Dose Coefficients, e(τ), to age 70 y (Sv Bq^{-1}) for Soluble or Reactive Gases and Vapours (Class SR-1 and SR-2)*
Air Submersion DCs	1	FGR-12	**Table A.1:** *Summary Information on the Nuclear Transformation of the Radionuclides*
	2	DOE-STD-1196-2011	**Table A-3:** *Effective Dose Coefficients from Air Submersion*
Half-Life Data	1	ICRP Publication 38	**Entire Report**
	2	ICRP Publication 107	**Table A.1:** *Properties of the Radionuclides: ICRP-07 Collection*
	3	JAERI-Data/Code 2002-013	**Table 1:** *Radionuclides Included in Dose Coefficient Database (Ingestion and Inhalation of Particulates)* **Table 2:** *Radionuclides Included in Dose Coefficient Database (Inert Gases)*

Table A-5 – Hierarchical Organization of Contemporary Dose Coefficient Publications for HC-3 TQ Calculations

Data Type	Selection Order	Publication	Relevant Dose Coefficient Table
Inhalation DCs	1	ICRP Pub-119	**Annex A:** *Effective Dose Coefficients for Ingested and Inhaled Particulates for Workers* **Annex B:** *Effective Dose Coefficients for Inhalation of Soluble or Reactive Gases for Workers*
	2	JAERI-Data/Code 2002-013	**Table 3:** *Effective Dose Coefficients for Workers – Ingestion and Inhalation of Particulates* **Table 6:** *Effective Dose Coefficients for Workers – Soluble or Reactive Gases (Class SR-1 and SR-2)*
Ingestion DCs	1	ICRP Pub-119	**Annex A:** *Effective Dose Coefficients for Ingested and Inhaled Particulates for Workers*
	2	JAERI-Data/Code 2002-013	**Table 3:** *Effective Dose Coefficients for Workers – Ingestion and Inhalation of Particulates*
Air Submersion DCs	1	ICRP Pub-119	**Annex C:** *Effective Dose Rates for Exposure of Workers or Adult Members of the Public to Inert Gases*
	2	JAERI-Data/Code 2002-013	**Table 8:** *Effective Dose Rates for Exposure of Adults – Inert Gases (Class SR-0)*
Half-Life Data and Average Photon Energy/Intensity Data	1	ICRP Pub-38	**Entire Report**
	2	ICRP Pub-107	**Table A.1:** *Properties of the Radionuclides: ICRP-07 Collection*
	3	JAERI-Data/Code 2002-013 *(only for half-life data selection, publication does not provide photon energy data)*	**Table 1:** *Radionuclides Included in Dose Coefficient Database (Ingestion and Inhalation of Particulates)* **Table 2:** *Radionuclides Included in Dose Coefficient Database (Inert Gases)*

A.2 Defining the List of Radionuclides

The use of various NTD publications and their derivative publication that span various agencies (ICRP, DOE, EPA, JAERI) has resulted in noted differences in radionuclide nomenclature. Specifically:

- The treatment of isomer states (i.e., a radionuclide with two different half-lives) has been addressed by the use of the "l" and "s" suffix to denote long and short.

- There are several instances where updated NTD in ICRP Publication 107 has changed a radionuclide identified in ICRP Publication 38 as an isomer to a meta-stable state. An example of this is the radionuclide Eu-150 which was identified in ICRP Publication 38 as existing in an isomeric state (Eu-150a with $t_{1/2}$ =12.62 h and Eu-150b with $t_{1/2}$ =34.2 y). In comparison, ICRP Publication 107 incorporated revised NTD which no longer designated Eu-150 as an isomer, but as a single decay scheme (Eu-150 with $t_{1/2}$ =36.9 y), with a companion metastable state (Eu-150m with $t_{1/2}$ =12.8 h). When such nomenclature differences were encountered, the "family of data" hierarchy was used to resolve the nomenclature discrepancy. Since ICRP Publication 38 is higher in the "family of data" hierarchy, the name was resolved and established as Eu-150l and Eu-150s.

- Several other instances were noted where ground state and meta-stable state radionuclide definitions differed amongst the publications. An example of this would be Ta-180, which ICRP Publication 38 identifies as having both a ground state (Ta-180 with $t_{1/2}$ = 1E+13 y) and meta-stable state (Ta-180m with $t_{1/2}$ = 8.1 h). The updated NTD in ICRP Publication 107 no longer includes the meta-stable state and identifies Ta-180 has having the previous meta-stable state half-life ($t_{1/2}$ =8.152 h). As before, the "family of data" hierarchy was used to resolve the nomenclature discrepancy. As such, since ICRP Publication 38 is higher in the "family of data" hierarchy, the name was resolved and established as Ta-180 and Ta-180m.

A summary of the nomenclature resolution is presented in the form of a crosswalk in Table A-6.

Table A-6 – Radionuclide Nomenclature Crosswalk										
Isotope Name Used in Table 1-1	**DOE-STD-1196**		**FGR-12**		**ICRP-38**		**ICRP-107**		**JAERI**	
	Nuclide	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**
Eu-150l	Eu-150	36.9 y	Eu-150b	34.2 y	Eu-150b	34.2 y	Eu-150	36.9 y		
Eu-150s	Eu-150m	12.8 h	Eu-150a	12.62 h	Eu-150a	12.62 h	Eu-150m	12.8 h		
Eu-152ml	Eu-152m	9.3116 h	Eu-152m	9.32 h	Eu-152m	9.32 h	Eu-152m	9.3116 h		
Eu-152ms	Eu-152n	96 m					Eu-152n	96 m	Eu-152n	96 m
In-110l	In-110	4.9 h	In-110b	4.9 h	In-110b	4.9 h	In-110	4.9 h		
In-110s	In-110m	69.1 m	In-110a	69.1 m	In-110a	69.1 m	In-110m	69.1 m		
Ir-186l	Ir-186	16.64 h	Ir-186a	15.8 h	Ir-186a	15.8 h	Ir-186	16.64 h		
Ir-186s	Ir-186m	1.92 h	Ir-186b	1.75 h	Ir-186b	1.75 h	Ir-186m	1.92 h		
Ir-190ms	Ir-190m	1.12 h	Ir-190m	1.2 h	Ir-190m	1.2 h	Ir-190m	1.12 h		
Ir-190ml	Ir-190n	3.087 h	Ir-190n	3.1 h	Ir-190n	3.1 h	Ir-190n	3.087 h		
Ir-192ms	Ir-192m	1.45 m					Ir-192m	1.45 m		
Ir-192ml	Ir-192n	241 y	Ir-192m	241 y	Ir-192m	241 y	Ir-192n	241 y		
Nb-89l	Nb-89	2.03 h	Nb-89b	122 m	Nb-89b	122 m	Nb-89	2.03 h		
Nb-89s	Nb-89m	66 m	Nb-89a	66 m	Nb-89a	66 m	Nb-89m	66 m		
Nb-98	Nb-98m	51.3 m	Nb-98	51.5 m	Nb-98	51.5 m	Nb-98m	51.3 m		
Np-236l	Np-236	154000 y	Np-236a	115000 y	Np-236a	115000 y	Np-236	154000 y		
Np-236s	Np-236m	22.5 h	Np-236b	22.5 h	Np-236b	22.5 h	Np-236m	22.5 h		
Re-182l	Re-182	64 h	Re-182b	64 h	Re-182b	64 h	Re-182	64 h		
Re-182s	Re-182m	12.7 h	Re-182a	12.7 h	Re-182a	12.7 h	Re-182m	12.7 h		
Rh-102	Rh-102m	3.742 y	Rh-102	2.9 y	Rh-102	2.9 y	Rh-102m	3.742 y		
Rh-102m	Rh-102	207 d	Rh-102m	207 d	Rh-102m	207 d	Rh-102	207 d		
Sb-120s	Sb-120	15.89 m	Sb-120a	15.89 m	Sb-120a	15.89 m	Sb-120	15.89 m		
Sb-120l	Sb-120m	5.76 d	Sb-120b	5.76 d	Sb-120b	5.76 d	Sb-120m	5.76 d		

Table A-6 – Radionuclide Nomenclature Crosswalk										
Isotope Name Used in Table 1-1	**DOE-STD-1196**		**FGR-12**		**ICRP-38**		**ICRP-107**		**JAERI**	
	Nuclide	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**	**Nuclide**	**Half-life (Units)**
Sb-124ms	Sb-124m	93 s	Sb-124m	93 s	Sb-124m	93 s	Sb-124m	93 s	Sb-124m	1.55 m
Sb-124ml	Sb-124n	20.2 m	Sb-124n	20.2 m	Sb-124n	20.2 m	Sb-124n	20.2 m		
Sb-128l	Sb-128	9.01 h	Sb-128b	9.01 h	Sb-128b	9.01 h	Sb-128	9.01 h		
Sb-128s	Sb-128m	10.4 m	Sb-128a	10.4 m	Sb-128a	10.4 m	Sb-128m	10.4 m		
Ta-178s	Ta-178	9.31 m	Ta-178a	9.31 m	Ta-178a	9.31 m	Ta-178	9.31 m	Ta-178	9.31 m
Ta-178l	Ta-178m	2.36 h	Ta-178b	2.2 h	Ta-178b	2.2 h	Ta-178m	2.36 h		
Ta-180			Ta-180	1E+13 y	Ta-180	1E+13 y				
Ta-180m	Ta-180	8.152 h	Ta-180m	8.1 h	Ta-180m	8.1 h	Ta-180	8.152 h		
Tb-156ml	Tb-156m	24.4 h	Tb-156m	24.4 h	Tb-156m	24.4 h	Tb-156m	24.4 h		
Tb-156ms	Tb-156n	5.3 h	Tb-156n	5 h	Tb-156n	5 h	Tb-156n	5.3 h		

A.3 Other Input Data

A.3.1 Atomic Mass Data

Through the use of a radionuclide specific activity value, the calculated HC-2 and HC-3 TQs can be equivalently expressed in terms of mass (e.g., grams). In order to calculate a radionuclide specific activity value, the atomic mass of the associated radionuclide is required.

The Atomic Mass Data Center (AMDC) maintains the official isotope mass tables. The AMDC is hosted by the Institute of Modern Physics (IMP), Chinese Academy of Sciences, Lanzhou, China, with a mirror site maintained by the International Atomic Energy Agency (IAEA). The atomic mass data used were obtained from the latest version of the atomic mass data, dated March 1, 2017. The AMDC data file contained atomic mass values for atomic mass entities ranging from A= 0 to 295.

A.3.2 Element-Specific Constants

A. HC-2 Element-Specific Constants

The release fractions specified by the DOE for the calculation of HC-2 TQs were derived from the release fractions used by the NRC in NUREG-1140. NRC proposed the following set of release fractions based upon experimental data and historical observations:

1.	Noble Gases	1.0
2.	Highly Volatile/Combustible	0.5
3.	Carbon	1 E-2
4.	Semi-volatile	1 E-2
5.	Unknown form	1 E-2
6.	Nonvolatile powder	1 E-3
7.	U and Pu Metal	1 E-3
8.	Nonvolatile solids	1 E-4
9.	Nonvolatiles in flammable liquid	5 E-3
10.	Nonvolatiles in non-flammable liquid	1 E-3

DOE desired to simplify this list because some components could be combined, some of the categories were not used by the NRC, and the regulatory framework for the list clearly allowed lowering release fractions for regulatory calculations.

Therefore, DOE first changed the noble gas category to simply gases and moved specific gases such as tritium from the highly volatile/combustible category into the gas category, where the release fraction of 1.0 was retained. DOE then chose to keep the highly volatile/combustible category as defined by NRC, with the addition of sodium to the group. The release fraction of 0.5 is somewhat higher than is usually estimated for these compounds, but DOE chose to retain the conservative value. At the same time, DOE also noted that use of such a release fraction would not be appropriate if a flammable substance such as phosphorus had been turned into a phosphoric acid solution, the normal form for research activities. At that point, it would be a material best represented by the general powder/liquid/solid category described below.

DOE did not consider carbon-14 thresholds to be a major issue on the basis of typical quantities used. As a result, carbon was grouped as a semi-volatile material with the same release fraction of 1 E-2. The DOE then decided to abandon the use of the unknown form category as an unnecessary complication. NRC used this value for a number of the isotope thresholds, largely relating to materials unlikely to be found outside of fission product mixtures or sources. The use of a curie threshold for fission product mixtures would capture such material in most DOE applications. Additionally, there was no compelling reason to believe these materials would react to physical energy stresses differently from most powders, liquids, or solids.

NRC did not use the nonvolatile in flammable liquid, nonvolatile in non-flammable liquid, or nonvolatile solid categories in final calculations. DOE concurred with this approach and dropped these categories because applying average release fractions over an entire building makes such detailed subdivision of questionable value. DOE believes that the 1 E-3 value is a reasonably conservative approximation because it will be applied to an entire building without scenario-specific considerations. DOE recognizes that some accidents, particularly those involving powders and liquids, can produce much higher values, whereas metal incidents would normally produce slightly smaller release fractions. However, it is unlikely that any event will affect all material in a building, and high release phenomena such as ion exchange explosions, powder pressurization, etc., will affect only a localized fraction of the material. Therefore, the value is believed an adequate average for hazard categorization purposes.

The final release fraction values for Hazard Category 2 were produced by DOE as listed below:

1.	Gases (tritium, krypton, xenon, argon, radon, neon, chlorine, fluorine, nitrogen, oxygen)	1.0
2.	Highly volatile/combustible (phosphorus, sulfur, potassium, iodine, sodium, bromine)	0.5
3.	Semi-volatile (selenium, mercury, cesium, polonium, tellurium, ruthenium, carbon)	1 E-2
4.	Solid/Powder/Liquid (All materials not listed above)	1 E-3

B. HC-3 Element-Specific Constants

The calculation of HC-3 TQs requires the identification of three element-specific constants: (i) release fraction (for the inhalation and food ingestion exposure pathways); (ii) the sorption coefficient (for the water ingestion exposure pathway; and (iii) the soil to plant concentration factor (for the food ingestion exposure pathway).

These element-specific constants were obtained from the following tables in the EPA Technical Background Document and are listed in Table A-7:

- Exhibit A-1: Inhalation Release Fractions
- Exhibit B-2: Sorption Coefficient Values
- Exhibit C-1: Soil To Plant Concentration Factors

The element-specific constants in Table A-7 have not been altered and represent the published values contained within the EPA Technical Background Document. For several elements, the EPA Technical Background Document did not provide for an element-specific constant. These instances are identified in the table with the symbol "--," and the associated pathway was not evaluated for the element. A justification for this disposition is explained as follows:

- **Boron:** The EPA Technical Background Document did not provide any element-specific constants for boron. No radionuclides associated with boron are on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1). Therefore, no element-specific constants are required for boron.
- **Carbon:** As noted in Appendix E of the EPA Technical Background Document, carbon radionuclides were only evaluated for the inhalation, water ingestion, and direct exposure pathways.[8] This standard maintains the same convention as established in the EPA Technical Background Document and only evaluates the inhalation, water ingestion, and direct exposure pathways for carbon radionuclides.
- **Helium:** The EPA Technical Background Document did not provide an element-specific release fraction (R) nor an element-specific sorption coefficient (K_d) for helium. No radionuclides associated with helium are on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1). Therefore, no element-specific constants are required for helium.

[8] The direct exposure pathway was only evaluated in the EPA Technical Background Document when there was a photon emission component associated with the decay of the radionuclide. As such, the EPA Technical Background Document evaluated the direct exposure pathway for C-11 since it had a photon emission component, whereas C-14 was not evaluated for the direct exposure pathway since there was no photon emission component associated with the its decay.

- **Hydrogen:** As noted in Appendix E of the EPA Technical Background Document, the lone hydrogen radionuclide (i.e., H-3) was only evaluated for the inhalation and water ingestion pathways.[9] This standard maintains the same convention as established in the EPA Technical Background Document and only evaluates the inhalation and water ingestion pathways for hydrogen radionuclides.

- **Lithium:** The EPA Technical Background Document did not provide any element-specific constants for lithium. No radionuclides associated with the element lithium are on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1). Therefore, no element-specific constants are required for lithium.

- **Neon:** The EPA Technical Background Document did not provide any element-specific constants for neon. There are two radionuclides associated with neon on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1); Ne-19 ($t_{1/2}$ = 17.22 s) and Ne-24 ($t_{1/2}$ = 3.38 m). Since these radionuclides each have a half-life of less than 10 minutes, the inhalation and ingestion pathways are not evaluated (Refer to section A.1.2 for a discussion of the 10 minute half-life evaluation threshold). Therefore, no element-specific constants are required for neon.

- **Nitrogen:** The EPA Technical Background Document did not provide any element-specific constants for nitrogen. There are two radionuclides associated with nitrogen on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1); N-13 ($t_{1/2}$ = 9.965 m) and N-16 ($t_{1/2}$ = 7.13 s). Since these radionuclides each have a half-life of less than 10 minutes, the inhalation and ingestion pathways are not evaluated (Refer to section A.1.2 for a discussion of the 10 minute half-life evaluation threshold). Therefore, no element-specific constants are required for nitrogen.

- **Oxygen:** The EPA Technical Background Document did not provide any element-specific constants for oxygen. There are three radionuclides associated with oxygen on the master radionuclide list (see ORNL/TM-2017/467, Appendix D, Table D.1); O-14 ($t_{1/2}$ =70.599 s), O-15 ($t_{1/2}$ =122.24 s) and O-19 ($t_{1/2}$ = 26.91 s). Since these radionuclides each have a half-life of less than 10 minutes, the inhalation and ingestion pathways are not evaluated (Refer to section A.1.2 for a discussion of the 10 minute half-life evaluation threshold). Therefore, no element-specific constants are required for oxygen.

[9] The direct exposure pathway was not evaluated in the EPA Technical Background Document since there was no photon emission component associated with the decay of H-3. The updated input documentation used in this report similarly notes there is no photon emission component associated with the decay of H-3.

Table A-7 – Elemental Data Used In The Calculation of Hazard Category 3 Threshold Quantities				
Symbol	**Name**	**Release Fraction[10] (R)**	**Sorption Coefficient[11] (K_d)**	**Soil to Plant Concentration Factor[12] (B_v)**
Ac	Actinium	0.001	1000	0.0035
Al	Aluminum	0.01	0	0.004
Am	Americium	0.001	1000	0.0055
Sb	Antimony	0.01	1	0.2
Ar	Argon	1.0	0	0
As	Arsenic	0.01	0	0.04
At	Astatine	0.001	0	1
Ba	Barium	0.01	100	0.15
Bk	Berkelium	0.001	700	0.001
Be	Beryllium	0.01	75	0.01
Bi	Bismuth	0.01	10	0.035
B	Boron	--	--	--
Br	Bromine	0.01	0	1.5
Cd	Cadmium	0.01	50-100	0.55
Ca	Calcium	0.01	15	3.5
Cf	Californium	0.001	0	0.001
C	Carbon	0.5	0	--
Ce	Cerium	0.01	2000	0.01
Cs	Cesium	0.01	2000	0.08
Cl	Chlorine	0.01	0	70
Cr	Chromium	0.01	0	0.0075
Co	Cobalt	0.001	2000	0.02
Cu	Copper	0.01	0	0.4
Cm	Curium	0.001	500	0.00085
Dy	Dysprosium	0.01	0	0.01
Es	Einsteinium	0.001	0	0.001
Er	Erbium	0.01	0	0.01
Eu	Europium	0.01	500	0.01
Fm	Fermium	0.001	0	0.001
F	Fluorine	0.01	0	0.06
Fr	Francium	0.01	200	0.03
Gd	Gadolinium	0.01	500-1000	0.01
Ga	Gallium	0.01	0	0.004
Ge	Germanium	0.01	0	0.4

[10] From Exhibit A-1 of the EPA Technical Background Document, 102RQ-RN-5-13

[11] From Exhibit B-2 of the EPA Technical Background Document, 102RQ-RN-5-13

[12] From Exhibit C-1 of the EPA Technical Background Document, 102RQ-RN-5-13

Table A-7 – Elemental Data Used In The Calculation of Hazard Category 3 Threshold Quantities				
Symbol	**Name**	**Release Fraction[10] (R)**	**Sorption Coefficient[11] (K_d)**	**Soil to Plant Concentration Factor[12] (B_v)**
Au	Gold	0.01	0	0.4
Hf	Hafnium	0.01	0	0.0035
He	Helium	--	--	0.01
Ho	Holmium	0.01	600	0.01
H	Hydrogen	0.5	0	--
In	Indium	0.01	0	0.004
I	Iodine	0.5	3	0.15
Ir	Iridium	0.001	0	0.055
Fe	Iron	0.01	150	0.004
Kr	Krypton	1.0	0	0
La	Lanthanum	0.01	0	0.01
Pb	Lead	0.01	4000	0.045
Li	Lithium	--	--	--
Lu	Lutetium	0.01	0	0.01
Mg	Magnesium	0.01	0	1
Mn	Manganese	0.01	0	0.25
Md	Mendelevium	0.001	0	0.001
Hg	Mercury	0.01	0	0.9
Mo	Molybdenum	0.01	5	0.25
Nd	Neodymium	0.01	500	0.01
Ne	Neon	--	--	--
Np	Neptunium	0.001	10	0.1
Ni	Nickel	0.01	100	0.06
Nb	Niobium	0.01	2000	0.02
N	Nitrogen	--	--	--
Os	Osmium	0.01	0	0.015
O	Oxygen	--	--	--
Pd	Palladium	0.01	50-100	0.15
P	Phosphorus	0.5	0	3.5
Pt	Platinum	0.01	0	0.095
Pu	Plutonium	0.001	100-10000	0.00045
Po	Polonium	0.01	25	0.0025
K	Potassium	0.01	35	1
Pr	Praseodymium	0.01	500-1000	0.01
Pm	Promethium	0.01	1000-10000	0.01
Pa	Protactinium	0.001	4000	0.0025
Ra	Radium	0.001	100-10000	0.015
Rn	Radon	1.0	0	0

Table A-7 – Elemental Data Used In The Calculation of Hazard Category 3 Threshold Quantities				
Symbol	**Name**	**Release Fraction[10] (R)**	**Sorption Coefficient[11] (K_d)**	**Soil to Plant Concentration Factor[12] (B_v)**
Re	Rhenium	0.01	0	1.5
Rh	Rhodium	0.01	0	0.15
Rb	Rubidium	0.01	500	0.15
Ru	Ruthenium	0.01	0-500	0.075
Sm	Samarium	0.01	500-1000	0.01
Sc	Scandium	0.01	0	0.006
Se	Selenium	0.01	10	0.025
Si	Silicon	0.01	0	0.35
Ag	Silver	0.01	50-100	0.4
Na	Sodium	0.01	10	0.075
Sr	Strontium	0.01	100	2.5
S	Sulfur	0.5	0	1.5
Ta	Tantalum	0.001	0	0.01
Tc	Technetium	0.01	0	9.5
Te	Tellurium	0.01	50-100	0.025
Tb	Terbium	0.01	500-1000	0.01
Tl	Thallium	0.01	2	0.004
Th	Thorium	0.001	1000-10000	0.00085
Tm	Thulium	0.01	0	0.01
Sn	Tin	0.01	50-100	0.03
Ti	Titanium	0.01	0	0.0055
W	Tungsten	0.01	0	0.045
U	Uranium	0.001	1-50	0.0085
V	Vanadium	0.01	0	0.0055
Xe	Xenon	1.0	0	0
Yb	Ytterbium	0.01	0	0.01
Y	Yttrium	0.01	500	0.015
Zn	Zinc	0.01	0	1.5
Zr	Zirconium	0.01	2000	0.002
Bk-249, Bk-250, Es-254m Release Fraction (R) based on NUREG-1140 release fraction for "any other beta-gamma emitter."				

A.3.3 Breathing Rate

A. Breathing Rates Previously Used By DOE-STD-1027-92

For Hazard Category 2, DOE-STD-1027-92 previously specified a breathing rate, also referred to as the respiration rate, of $3.5x10^{-4}$ m^3/s, (=21 L/min) a value which was assumed equal to the standard value for an active man. A literature review indicates this recommended breathing rate is approximately the same value specified by ICRP Publication 23 for an adult male engaged in light-activity (=20 L/min).[13]

For Hazard Category 3, DOE-STD-1027-92 previously used a breathing rate of 2.3 x 10^7 cm^3/day (=$2.64x10^{-4}$ m^3/s) as specified in Appendix A of the EPA Technical Background Document. A literature review indicates this recommended breathing rate as being equal to the time-averaged breathing rates for an adult male engaged in 8-hr of working (light-activity), 8-hr of non-occupational activity, and 8-hr of resting as specified by ICRP Publication 23.[14]

B. Updated Breathing Rate

In 1994, the ICRP updated the human respiratory tract model with the issuance of Publication 66, *Human Respiratory Tract Model for Radiological Protection*. Publication 66 defined light-work for workers on the following basis: 2.5-hr sitting (with an inhalation rate of 0.54 m^3/hr), and 5.5-hr of light exercise (with an inhalation rate of 1.5 m^3/hr).[15] This definition of light-work results in a recommended time-averaged breathing rate of $3.3333x10^{-4}$ m^3/s.

$$BR_{Light-Activity} = \frac{\left(0.54\frac{m^3}{hr} * 2.5\ hr\right) + \left(1.5\frac{m^3}{hr} * 5.5\ hr\right)}{2.5\ hr + 5.5\ hr} = 1.2\frac{m^3}{hr} = 3.3x10^{-4}\frac{m^3}{s}$$

[13] ICRP Pub 23, pg. 347 (Table 120)

[14] ICRP Pub 23, pg. 346

[15] ICRP Pub 66, pg 23 (Table 6)

C. Justification for Use of Updated Breathing Rate

The primary justification for the use of an updated breathing rate is based on the derivation of the DCs in Publication 68 and Publication 72 reliance on the revised human respiratory tract model as defined in Publication 66. As noted in a National Nuclear Security Administration (NNSA) Supplemental Guidance to DOE-STD-1027-92, the NNSA Central Technical Authority (CTA) issued a memorandum regarding the clarification of dose calculation parameters, specifically for the preparation of safety basis documents for transuranic waste facilities. The NNSA Supplemental Guidance (on page AT4-4) cites the following from the CTA memorandum (emphasis added by the Supplemental Directive 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.

The NNSA Supplemental Directive concludes that the CTA position supports the use of an updated breathing rate of 3.3333×10^{-4} m^3/s as an appropriate value to use in conjunction with dose conversion factors pertaining to both the worker (Pub 68) and the public (Pub 72).

This Standard expands the list of DC publications used for the calculation of HC-2 and HC-3 TQs beyond the NNSA CTA justification associated with the use of Publication 68 and Publication 72. However, as previously discussed, and as illustrated in Figure A-1, the inhalation DCs derived in DOE-STD-1196-2011[16] and JAERI-Data/Code 2002-013[17] are computed in a manner consistent with Publication 68 and Publication 72.[18]

Accordingly, the use of the updated breathing rate was determined to be within the scope of the justification proffered by the NNSA CTA. Therefore, the HC-2 and HC-3 TQs utilized the ICRP Publication 66 recommended light-work time-averaged breathing rate of 3.3333×10^{-4} m^3/s.

A.3.4 Atmospheric Dispersion Coefficients (χ/Q)

Atmospheric dispersion coefficients (χ/Q) are utilized to determine the degree by which a passing radioactive plume has dispersed by the time it reaches the downwind location of the analyzed receptor. Since the downwind location of the analyzed receptor differs between the HC-2 and the HC-3 TQ methodologies, the atmospheric dispersion coefficients will be different.

A. Hazard Category 2 Atmospheric Dispersion Coefficient

NRC used F stability at 1 m/sec meteorological conditions whereas DOE used D stability at 4.5 m/sec. DOE chose to modify the NRC meteorological assumptions used for hazard categorization purposes for the following reasons:

1 The NRC use of a conservative value at 100 meters was based on the fact that most of the commercial radionuclide handling facilities for which emergency planning was being considered have boundaries with populated areas at or less than 100 meters. The majority of DOE Category 2 facilities have site boundary distances much greater than 100 meters.

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[16] DOE-STD-1196-2011, pg. 2, "The DCSs of this standard are based on age-specific effective dose coefficients computed in the manner of ICRP Publication 72…."

[17] JAERI-Data/Code 2002-013, pg. i, "The dose coefficients were calculated with the computer code DOCAP based on the respiratory tract model and biokinetic model of ICRP. The effective dose rates were calculated by considering both external irradiation from the surrounding cloud and irradiation of the lungs from the gas within them. The calculated results are presented as tables, which are the same forms as those in ICRP Publs. 68 and 72."

[18] FGR-12 is only utilized in this report for air-immersion DCs in support of the calculation of HC-2 TQs. The assessment of the air immersion dose component in the HC-2 TQ calculation does not require the use of a breathing rate.

2 The calculation of values at 100 meters achieves a less accurate result from dispersion models since building wake effects are still a predominant effect at this distance.

3 The use of F at 1 m/sec was considered to be overly conservative, particularly in light of the difference in application between the DOE and NRC in the resulting calculated quantities. DOE consequently decided to use a Pasquill stability class D at 4.5 m/sec wind speed, a value used for comparison by NRC, as the assumed meteorological conditions for the dispersion calculations. Using a no-buoyancy model, which will by itself be conservative for many releases, a nominal distance for the 1 rem evaluation would be slightly less than 300 meters. These conditions correspond to a χ/Q of approximately 1 E-4 sec/m^3 (per Figure 1 of NUREG-1140), which is considered adequate for a calculation which does not account for mitigation or size distribution of particles.

B. Hazard Category 3 Atmospheric Dispersion Coefficient

The selection of the atmospheric dispersion coefficient for the calculation of HC-3 TQs is based on the recommendations of the EPA Technical Background Document. Per the EPA, the distance from the point source release to the receptor location is assumed to be 30 meters. Additionally, it is assumed that a Gaussian distribution of the released contaminant is established almost immediately within the plume and is fully developed at 30 meters. The meteorological conditions of the plume dispersion are modeled via a Pasquill stability class D with a wind speed of 1 m/s. As noted in Figure 3.3, the EPA concluded that these conditions yield a χ/Q of approximately 8.4×10^{-7} day/m^3 ($=7.2 \times 10^{-2}$ s/m^3) when the deposition velocity (for both wet and dry deposition) is assumed to be 1,000 meter/day (=1.16 cm/s).

A.3.5 Avogadro's constant

The calculation of Specific Activity requires the use of Avogadro's constant. The Committee on Data for Science and Technology (CODATA) in a 2014 update, specifies a published value of $6.022\ 140\ 857 \times 10^{23}$ mol^{-1}. Since the HC-2 and HC-3 TQs in Table 1-1 are only reported to three significant figures, the value of Avogadro's constant used in the TQ calculations will be 6.022×10^{23} mol^{-1}.

A.3.6 Conversion Factors

A. Dose Equivalent and Activity Conversion Factors

The following dosimetric conversion factors are utilized in the calculation of HC-2 and HC-3 TQs:

Dose Equivalent	$0.01\frac{Sv}{rem}$
Activity	$3.7x10^{10}\frac{Bq}{Ci}$

B. Time Conversion Factors

Half-life data is obtained from ICRP Publication 38, Publication 107, and JAERI-Data/Code 2002-013. The half-life data is considered to be a NTD, and as such would be formatted in accordance with ENSDF protocols. The NNDC has issued guidance pertaining to the specification requirements for half-life data. Per the ENSDF preparation manual, valid symbols for half-life units are as follows:

- Y, D, H, M, S, MS, US, NS, PS, FS, AS……for year, day, hour, minute, second(s), 10^{-3} s, 10^{-6} s, 10^{-9} s, 10^{-12} s, 10^{-15} s, and 10^{-18} s….respectively.

A review of ICRP Publication 38, Publication 107, and JAERI-Data/Code 2002-013 NTD noted the smallest reported half-life was in micro-seconds (μs = 10^{-6} s). As such, the following time conversions in Table A-8 are used in the calculations.

Table A-8 – Time Conversion Factors

Unit	Value (s)
y	31556952
d	86400
h	3600
m	60
s	1
ms	0.001
μs	0.000001

The duration of a year ($3.1557x10^7$ s) is based on a mean Gregorian year (365.2425 days per year).

A.4 Hazard Category 2

The approach for designating HC-2 facilities was constructed from NRC guidance which define minimum thresholds for many radionuclides and hazardous chemicals on the basis of consequences from these hazards in the immediate vicinity of a facility. Table 1-1 provides the resulting TQs for radioactive materials which define a HC-2 facility. Such an approach is consistent with the goal of designating nuclear facilities with the potential for "significant on-site consequences beyond localized consequences" as HC-2.

For radioactive materials, 10 CFR Part 30 derived quantities above which byproduct material licensees must provide emergency plans for responding to a release because such a release could give a dose of 1 rem at 100 meters under very conservative meteorological conditions (stable air with intermittent breezes, i.e., F at 1 m/sec). Differences between the NRC calculation and the DOE calculation are explained in the following sections.

The threshold values for fissile material as specified in Section 3.1.6 are the fissile material limits to be used for initial hazard categorization. The aqueous mixture mass limits for ^{233}U, ^{235}U and ^{239}Pu are 500, 700, and 450 grams, respectively. This stipulation is necessary because the on-site effects of a criticality are potentially severe within the immediate vicinity of a facility. Category B nuclear reactors should, therefore, be classified as HC-2 since critical quantities of fissile materials are present in these facilities but not in sufficient quantities to pose significant off-site impacts.

A.4.1 Methodology for Calculating HC-2 Threshold Quantities

The NRC derived 10 CFR Part 30, Schedule C threshold quantities which could result in a dose of 1 rem at 100 meters by using standard air dispersion/dose calculations. The basic calculation stated is as follows (from Section 2.3.1.3 of NUREG-1140):

$$Q = \frac{1\ rem}{R * (H_I + H_G + H_{CS})} \quad (1)$$

Where

- Q = Quantity of material used as threshold (grams)
- R = Release fraction for material of concern (unitless)
- H_I = Effective dose equivalent from inhalation (rem/gm-released)
- H_G = Effective dose equivalent from ground contamination (rem/gm-released)
- H_{CS} = Effective dose equivalent from cloud shine (rem/gm-released)

The NRC then stated that "for all materials of greatest interest for fuel cycle and other radioactive material licensees, the dose from the inhalation pathway H_I will dominate the dose" and dismissed the other contributors. Simplifying assumptions for Gaussian dispersion and particle deposition were then used to calculate inhalation doses.

In modifying the NRC results, DOE has restated the equation above as:

$$TQ_{HC2} = \frac{1\ rem}{R * SA * {}^{X}/_{Q} * (DC_{inhal} * BR + DC_{sub})} * \frac{0.01\frac{Sv}{rem}}{3.7x10^{10}\frac{Bq}{Ci}} \quad (2)$$

Where

TQ_{HC-2}	=	Quantity of material used as threshold (grams)
R	=	release fraction of material averaged over an entire facility (unitless)
SA	=	Specific activity of radionuclide released (Ci/gm)
X/Q	=	Meteorological dispersion coefficient (1E-4 sec/m^3)
DC_{inhal}	=	Inhalation Dose Coefficient (Sv/Bq)
BR	=	Respiration rate (3.3333E-4 m^3/sec)
DC_{sub}	=	Air Submersion Dose Coefficient (Sv/sec per Bq/m^3)

Specific modifications to forms of the equation are discussed in distinct sections below.

A. Exposure Pathways

As can be seen from the modified equation, DOE concurred with the NRC's dismissal of the ground contamination exposure pathway. In general, DOE concurred with the dismissal of cloud shine exposure as well because this path accounted for, on average, slightly less than 2% of dose for all radionuclides but the noble gases. Although, for the types of material that DOE handles, it is expected that the values for noble gases will be included in the mixed fission product threshold, DOE decided to retain this exposure pathway in the calculation for completeness.

B. Dose Coefficients

As documented in Table A-4, both ICRP Publication 119 and JAERI-Data/Code 2002-013 have more than one table that provides radionuclide-specific inhalation DCs. Both the ICRP and the JAERI publication have one table providing DCs (for each analyzed lung clearance class) based on the inhalation of air-borne particulates, and a second table providing inhalation DCs based on the inhalation of gases/vapours. DOE-STD-1196-2011 also includes both particulate inhalation DCs, as well as gases/vapours inhalation DCs. However unlike the other publications, the particulate inhalation DCs and the gases/vapours inhalation DCs in DOE-STD-1196-2011 are all listed in a single data table.

The maximum inhalation DC was selected in consideration of both the particulate inhalation DC and the gases/vapours inhalation DC.

C. Specific Activity

The specific activity was calculated in curies per gram directly from the half-life and the atomic weight using the following formula:

$$\mathrm{SA} = \frac{\ln(2) * N_o}{AW * t_{1/2} * 3.1557x10^7 \frac{s}{yr} * 3.7x10^{10} \frac{Bq}{Ci}} \quad (3)$$

A.5 Hazard Category 3

DOE determined that it is reasonable to set a radionuclide Hazard Category 3 threshold quantity, based upon the value that is accepted by the EPA for protection of workers for planned reentry into a facility after an Incident (EPA In Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA 400-B-92-001) and cited in Appendix 2A of the RadCon Manual, which is 10 rem.

In choosing the EPA model to calculate these thresholds, the following is assumed:

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;
3. there is no radioactive decay (for conservatism and simplicity); and
4. The duration of exposure depends on the release pathway.

The exposure duration is different for each pathway model and is specified as follows:

- The direct exposure pathway model assumes persons are exposed continually for one day.

- For the inhalation pathway model, the exposure period is not a de facto set period of time. Instead, the inhalation pathway exposure duration is based on an individual situated at a position 30 meters downwind from the point of release and remains in that plume centerline, the point of maximum concentration, for the entire release period.

- For the ingestion exposure pathways, the exposure period spans 9 days for the water ingestion pathway model (based on the time for a contaminated groundwater plume to pass through a drinking supply water well), and 60 days exposure for the food ingestion pathway model (a person is assumed to consume one day's worth of vegetables from a contaminated crop for a period of 60 days).

The EPA model used in this Standard to determine HC-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)*

Per the EPA Technical Background Document (see Chapter 4, Methodology for RQ [reportable quantity] Adjustments), a release value (RV) 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." HC-3 threshold quantities were calculated from the minimum of the release values for five 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 inert 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 five exposure pathways.

The HC-3 TQs were obtained by multiplying the minimum EPA RVs for each radionuclide by a factor of 20.

$$TQ_{HC-3} = 20 * RV_{EPA} \quad (4)$$

The factor of 20 was used to adjust the RV to correspond to a worker dose of 10 rem at 30 meters.

The following sections address the specific equations used to derive the HC-3 TQ values for all five pathways (inhalation, food ingestion, water ingestion, and external radiation from a point source, and air-submersion).

A.5.1 Inhalation Pathway

The HC-3 TQ for inhalation from the EPA Technical Background Document is shown as Equation 5:

$$TQ_{HC3,inhale} = \frac{10\ rem}{R * \left(\chi/_{Q}\right) * BR * DC_{inhal}} * \frac{0.01\frac{Sv}{rem}}{3.7x10^{10}\frac{Bq}{Ci}} \quad (5)$$

Where;

$TQ_{HC3,inhale}$ = Inhalation pathway threshold quantity [Ci];

R = Release fraction [dimensionless];

χ/Q = Meteorological dispersion coefficient 30 meters from ground level release [$7.2x10^{-2}$ s/m^3];

BR = Breathing Rate [$3.3333x10^{-4}$ m^3/s]; and

DC_{inhal} = Inhalation dose coefficient [Sv/Bq].

A.5.2 Food Ingestion Pathway

The HC-3 TQ for food ingestion from the EPA Technical Background Document is shown as Equation 6:

$$TQ_{HC3,food} = \frac{10\ rem}{DF * FC * CT * R * DC_{ingest}} * \frac{0.01\frac{Sv}{rem}}{3.7x10^{10}\frac{Bq}{Ci}} \quad (6)$$

Where;

$TQ_{HC3,food}$ = Food ingestion pathway threshold quantity [Ci];

DF = Dilution factor accounting for the transfer of radionuclides from air to vegetation (Ci/kg of vegetables at the point of exposure per curies released to the atmosphere, [kg^{-1}]);

FC = Food (i.e., leafy vegetable) consumption rate of reference man [0.175 kg/day];

CT = Contact Time (effective time over which contaminated vegetables are ingested [days];

R = Release fraction [dimensionless]; and

DC_{ingest} = Ingestion dose coefficient [Sv/Bq].

The dilution factor (DF) is calculated in accordance with the following equation:

$$\mathrm{DF} = 1x10^{-4} + (3.5x10^{-6} * B_V);\ [kg^{-1}] \quad (7)$$

Where;

B_V = Concentration ratio for the transfer of the element to the edible portion of a crop from dry soil (dimensionless)

Values for Contact Time (CT) were determined using the following equation as specified in the EPA Technical Background Document:

$$\mathrm{CT} = \left(\frac{1 - \exp(-[(\lambda_I + \lambda_W)\mathrm{t}_G])}{\lambda_I + \lambda_W}\right);\ [days] \quad (8)$$

Where;

λ_I = Radionuclide decay constant [day^{-1}] = $\ln(2)/t_{1/2}$;

$t_{1/2}$ = Radionuclide half-life [days];

λ_W = Weathering decay constant [day^{-1}] = ln(2)/14 days; and

t_G = Growing season time [60 days].

A.5.3 Water Ingestion Pathway

The HC-3 TQ equation for water ingestion from the EPA Technical Background Document is shown as Equation (9):

$$TQ_{HC3,water} = \frac{10\ rem}{DF * \left[\frac{1 - \exp(-\lambda * CT)}{\lambda}\right] * WC * DC_{ingest}} * \frac{0.01\frac{Sv}{rem}}{3.7x10^{10}\frac{Bq}{Ci}} \quad (9)$$

Where;

$TQ_{HC3,water}$ = Water ingestion pathway threshold quantity [Ci];

DF = Dilution Factor [L^{-1}];

λ = Radionuclide decay constant [day^{-1}] = $\ln(2)/t_{1/2;}$

R_d = Retardation Factor [1 day];

CT = Contact time [9 days];

WC = Water consumption of reference man [2 L/day]; and

DC_{ingest} = Ingestion dose coefficient [Sv/Bq].

The dilution factor (DF) is calculated in accordance with the following equation:

$$DF = \left[7.6x10^{-8} * \exp\left(-4.2 * \frac{R_d}{t_{\frac{1}{2}}}\right)\right];\ [L^{-1}] \quad (10)$$

Where;

R_d = Retardation Factor (1 day)

The EPA noted that radioisotopes with a retardation factor greater than one will have a calculated ground water ingestion release value much larger in comparison with the other pathway release values. Accordingly, the EPA did not develop separate ground water ingestion release value equations for situations where the retardation factor is greater than one. As noted by the EPA, when the sorption coefficient, K_d, is equal to zero, the retardation factor is equal to one. When the sorption coefficient becomes larger, however, the retardation factor increases rapidly. Consistent with the EPA methodology, ground water pathway release values were only calculated for radioisotopes that had a reported sorption coefficient (K_d) less than one.

A.5.4 External Pathway

The methodology for the determination of release values for external exposure to radiation is dependent upon the form of the radionuclide released. For specific inert gas radioisotopes (such as argon, krypton, and xenon), the release values are based on exposure due to total body submersion in a radioactive gas cloud. For all other radionuclides, the direct exposure release values are based on the quantity of radioactivity received by an individual exposed to a point source of radiation.

A. Direct (a.k.a., Point Source) Exposure Pathway

Except for inert gases[19], the Direct Exposure release value is based on a gamma dose incurred over a 24-hour period from a point source located 30 meters away. The equation for calculating the Direct Exposure pathway threshold quantity is expressed as (Equation 11):

$$TQ_{\text{HC3,direct}} = \frac{10\ \text{rem} * \text{S}^2 * C_{gamma}}{\text{E}_1 * \mu_a * \left(24\frac{hr}{day}\right) * \left(\frac{1-\exp(-\lambda t)}{\lambda}\right) * \exp\left[\ \left(-100\frac{cm}{m}\right)\mu_a S\right]} \quad (11)$$

Where;

$TQ_{HC3,direct}$ = Direct exposure pathway threshold quantity [Ci];

S = Distance from the point source [30 m];

C_{gamma} = Equation coefficient [$6.41 \times 10^{-5}\ \frac{\text{Ci}-\text{MeV}-\text{hr}}{rem-m^2-cm}$];

E_1 = Sum of the products of the photon energies and the photon fraction or intensities [MeV];

μ_a = Linear energy absorption coefficient for gamma rays in air [$3.7 \times 10^{-5}\ cm^{-1}$];

λ = Radionuclide decay constant [day^{-1}] = $\ln(2)/t_{1/2}$;

t = Duration of exposure [1 day].

B. Air Submersion Exposure Pathway

For inert gases (such as argon, krypton, and xenon), the air submersion release value is based on the dose an individual receives when submerged in a cloud of the radioactive gas. The release value for the air submersion pathway threshold quantity is expressed as (Equation 12):

$$TQ_{HC3,sub} = \frac{10\ rem}{\left(\chi/_Q\right) * \left(day/_{86{,}400\ sec}\right) * DC_{sub}} * \frac{0.01\frac{Sv}{rem}}{3.7x10^{10}\frac{Bq}{Ci}} \quad (12)$$

[19] The ICRP has not published air immersion DCs for radon radionuclides in Publication 119. Accordingly, radon radionuclides are considered only for the TQ_{direct} exposure pathway.

Where;

$TQ_{HC3,sub}$ = Submersion Dose Threshold Quantity [Ci];

χ/Q = Meteorological dispersion coefficient 30 meters from ground level release [$7.2x10^{-2}$ s/m^3]; and

DC_{sub} = Air submersion Dose Coefficient [Sv/day per Bq/m^3].

A.5.5 Final HC-3 TQ

After calculating the pathway specific TQ values, the HC-3 TQ is determined by selecting the pathway with the lowest calculated activity content that results in a 10-rem dose to the receptor located 30-meters from the facility.

$$TQ_{HC3} = \min\begin{bmatrix} TQ_{HC3,inhale'} \\ TQ_{HC3,food'} \\ TQ_{HC3,water'} \\ TQ_{HC3,direct'} \\ TQ_{HC3,sub} \end{bmatrix} \quad (13)$$

A.5.6 HC-3 Inhalation, Air Submersion, Ingestion Dose Coefficient Selection Criteria

Criteria for the Selection of the HC-3 Maximum Inhalation Dose Coefficient

As observed in Table A-5, both ICRP Publication 119 and JAERI-Data/Code 2002-013 have more than one table that provide radionuclide specific inhalation DCs. Both the ICRP and the JAERI publications have one table providing DCs (for each analyzed lung clearance class) based on the inhalation of air-borne particulates, and a second table providing inhalation DCs based on the inhalation of gases/vapours. The maximum inhalation DC was selected in consideration of both the particulate inhalation DC and the gases/vapours inhalation DC.

Criteria for the Selection of the HC-3 Maximum Ingestion Dose Coefficient

As observed in Table A-5, ICRP Publication 119 and JAERI-Data/Code 2002-013 only have one table each that provides radionuclide specific ingestion DCs. As such, following similar guidance used by the EPA Technical Background Document, when more than one ingestion DC was reported for a particular radionuclide, the maximum value was used in the calculations.