Department of Energy
Washington, DC 20585

March 30, 2006

The Honorable A. J. Eggenberger
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue. SW. Suite 700
Washington, D.C. 20004-2901

Dear Mr. Chairman:

The enclosed copy of draft DOE Manual M441.1, *Nuclear Material Packaging Manual*, is forwarded for your review and comment. This satisfies commitment 5.1-3 in Appendix D of the implementation plan (IP) for recommendation 2005-1, *Nuclear Material Packaging*.

The next milestone in Section 5.1 of the 2005-1 IP is forwarding the manual to the DOE 2005-1 Technical Review Board (TRB) by April 30, 2006 to begin the final TRB review. Therefore, your comments are requested by April 21, 2006, in order to allow one week for resolution and updating the manual before it is sent to the TRB.

Please contact me at 301-903-4407 if you have any questions.

Sincerely,

Richard M. Stark
DNFSB 2005-1 Implementation Plan
Responsible Manager

Enclosure

cc:
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MANUAL

DRAFT
DOE M 441.1

Approved: XX-XX-XX
Expires: XX-XX-XX

NUCLEAR MATERIAL PACKAGING MANUAL

U.S. DEPARTMENT OF ENERGY
Office of Environment, Safety and Health

AVAILABLE ONLINE AT:
http://www.directives.doe.gov

INITIATED BY:
Office of Primary Interest

1. PURPOSE. This Manual describes the requirements for Nuclear Material packaging in interim storage in a manner that protects the worker. This Manual is not intended to conflict with or supersede accepted criteria established in other applicable Department directives such as DOE-STD-3013-2004, *Stabilization, Packaging, and Storage of Plutonium Bearing Materials*, DOE-STD-3028-2000, *Criteria for Packaging and Storing Uranium-233-Bearing Materials*, and DOE-HDBK-1129-99, *Tritium Handling and Safe Storage*.

2. CANCELLATIONS. This Manual supersedes Deputy Secretary of Energy Memorandum *Criteria for Interim Storage of Plutonium Bearing Materials* dated January 25, 1996.

3. APPLICABILITY.

   a. All Departmental Elements. Except for exclusions in paragraph 3c, this Manual applies to all departmental elements (see Attachment 1 for a complete list of all departmental elements). This Manual automatically applies to departmental elements created after it is issued.

      The Administrator of the National Nuclear Security Administration (NNSA) will require that NNSA employees and contractors comply with their respective responsibilities under this Manual.

   b. DOE Contractors.

      (1) The Contractor Requirements Document (CRD), Attachment 2, sets forth requirements of this Manual that will apply to site/facility management contracts that include the CRD.

      (2) The CRD must be included in all site/facility management contracts that involve nuclear materials and contain DOE Acquisition Regulation (DEAR) clause 48 CFR 970.5204-2, *Laws, Regulations, and DOE Directives*.

      (3) Departmental elements must notify contracting officers of affected site/facility management contracts to incorporate this Manual into those contracts.

      (4) Once notified, contracting officers are responsible for incorporating this directive into the affected contracts via the *Laws, Regulations, and DOE Directives* clause of the contracts.

      (5) As stated in DEAR clause 970.5204-2, regardless of the performer of the work, the site/facility contractors with the CRD incorporated into their contracts are responsible for compliance with the CRD. Affected site/facility management contractors are responsible for flowing down the requirements of the CRD to subcontracts at any tier to the extent necessary to ensure compliance with the requirements.

c. Exclusions. In accordance with Executive Order 12344, activities under the cognizance of the Deputy Administrator for Naval Reactors are exempt from this DOE Manual. Operations subject to the Nuclear Regulatory Commission (NRC) regulations are excluded from this Manual.

4. SUMMARY. This Manual is organized into three chapters. Chapter I, *General Requirements and Responsibilities*, contains requirements and responsibilities that are applicable to nuclear material interim storage and packaging, and delineates responsibilities for packaging and storage of nuclear materials at the complex-wide and Field Element levels. Chapter II and III contain those requirements that are applicable to high risk nuclear materials and low risk nuclear materials, respectively.

5. REFERENCES. References are located in Attachment 3 of this Manual

6. CONTACT. Questions concerning this Manual should be addressed to the Office of Environment, Safety, and Health at 301-903-4407.

SAMUEL W. BODMAN
Secretary of Energy

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CHAPTER I. GENERAL REQUIREMENTS AND RESPONSIBILITIES

1. REQUIREMENTS.

a. Nuclear Material Management. This Department of Energy (DOE) Manual is for use by all DOE organizations and their contractors holding inventories of nuclear material subject to Title 10 Code of Federal Regulations (CFR) Part 835 and in quantities that meet or exceed the thresholds established in the Scope of this document.

Title 10 Code of Federal Regulations Part 835 (10 CFR 835), *Occupational Radiation Protection*, is the regulation that establishes radiation safety requirements for DOE personnel and its contractors. To maintain the radiation safety of workers, requirements which relate to the handling and packaging of radioactive materials are listed in Attachment 5. This Manual is intended to implement and amplify 10 CFR 835 nuclear material packaging requirements.

b. Purpose. This document establishes and integrates DOE safety criteria to assure an adequate barrier between facility workers and the stored nuclear materials when the materials are removed from an approved engineered contamination barrier. Nuclear Material covered by this Manual shall be packaged to assure that no worker receives an internal exposure exceeding the limits in 10 CFR 835. This Manual addresses normal handling, packaging, and storage of selected radioisotopes. This Manual does not address accidents other than drops during normal handling.

c. Scope.

(1) Nuclear Materials in Scope. Nuclear Material, as defined, means any material that is "Special Nuclear Material," "by product material," or "source material" in the Atomic Energy Act of 1954 as amended. For the purpose of this document nuclear materials are those listed in Table 1.1. The table includes the nuclear materials, most prevalent in the DOE complex, where a hazard analysis for a breached package would identify an internal radiation exposure scenario as more limiting than an external radiation exposure scenario. These typically are the alpha emitting isotopes. In addition the scope is limited to nuclear material containing radionuclides where the total activity in the material exceeds the values specified in the table in 49 CFR 173.435, *Table of A_1 and A_2 Values for Radionuclides*, commonly referred to as the A_2 values. For mixtures of these isotopes, sites shall use 49 CFR 173.433, *Requirements for determining basic radionuclide values, and for the listing of radionuclides on shipping papers and labels*. The Manual requirements apply to

handling of nuclear material storage packages outside of an approved engineered contamination barrier (e.g. hot cell, glovebox line, ventilation hood, liquid transfer line) or a specifically analyzed and controlled radiological production or processing activity. The length of time that an item can be safely kept in storage is determined by the design life of the package and may vary with the type of material and packaging. The material forms included in the scope of this document are radioactive metals, compounds, and liquids.

Table 1.1 Applicable Isotopes is intended to identify nuclear materials that are subject to the requirements in this Manual. Combinations or mixtures of materials need to be addressed by Threshold Calculations (see 1.c. (2) below). Examples of mixed radionuclides are given in Attachment 4 of this Manual. In addition to the nuclear materials identified in the table, the material High Risk and Low Risk rem Committed Effective Dose Equivalent (CEDE) is given for each nuclide. High Risk materials are defined as those materials with values that are equal to or above the 100 rem CEDE, and Low Risk materials are those that are between 5 rem CEDE and 100 rem CEDE. Materials below 5 rem CEDE are below the A_2 values defined in 49 CFR 173.435 and are out of scope for this Manual.

Table 1.1 DOE M 441.1 Applicable Isotopes**

Nuclide	Specific Activity (Ci/g)	Low Risk 5 rem CEDE Quantity (g)	High Risk 100 rem CEDE Quantity (g)
U-232	$2.2x10^{1}$	$1.2x10^{-3}$	$2.5x10^{-2}$
U-233	$9.7x10^{-3}$	$1.6x10^{1}$	$3.3x10^{2}$
U-234	$6.2x10^{-3}$	2.6x101	5.2x102
U-235*	$2.2x10^{-6}$	Unlimited	Unlimited
U-236	$6.5x10^{-5}$	$2.5x10^{3}$	$4.9x10^{4}$
U-238*	$3.4x10^{-7}$	Unlimited	Unlimited
Pu-238	$1.7x10^{1}$	$106x10^{-3}$	$3.2x10^{-2}$
Pu-239	$6.2x10^{-2}$	$4.4x10^{-1}$	8.7
Pu-240	$2.3x10^{-1}$	$1.2x10^{-1}$	2.4
Pu-241	$1x10^{2}$	$1.6x10^{-2}$	$3.2x10^{-1}$
Pu-242	$3.9x10^{-3}$	6.9	$1.4x10^{2}$
Th-228	$8.2x10^{2}$	$3.3x10^{-5}$	$6.6x10^{-4}$
Th-229	$2.1x10^{-1}$	$6.7x10^{-2}$	1.3
Th-232*	$1.1x10^{-7}$	Unlimited	Unlimited
Np-237	$7.1x10^{-4}$	$7.6x10^{1}$	$1.5x10^{3}$
Am-241	3.4	$7.9x10^{-3}$	$1.6x10^{-1}$
Am-243	$2x10^{-1}$	$1.4x10^{-1}$	2.7
Bk-249	$1.6x10^{3}$	$5.1x10^{-3}$	$1.0x10^{-1}$
Cm-244	$8.1x10^{1}$	$6.7x10^{-4}$	$1.3x10^{-2}$
Cm-246	$3.1x10^{-1}$	$7.7x10^{-2}$	1.6
Cf-252	$5.4x10^{2}$	$1.5x10^{-4}$	$3.0x10^{-3}$

*The quantities for U-235, U-238, and Th-232 require an intake of more than 10 mg to result in the given threshold dose. Standards established by the IAEA assume an individual will inhale no more than 10 mg.
For uranium isotopes, nonradiological effects, such as chemical toxicity, may be limiting and require evaluation per 10 CFR 851 and DOE O 440.1A.
**Gram values are based on 49 CFR 173.435 dated October, 2005.
Isotopic mixtures vary and shall be calculated. Refer to 49 CFR 173.433.

(2) Threshold Calculations. The calculations below shall be used to determine whether a material is in or out of scope, and if in scope, if the material is low or high risk. Threshold Calculations shall use one of the following three methodologies.

(a) The quantity of material to be packaged shall be measured and compared to DOE M 441.1, Table 1.1. When obtaining Table 1.1 quantities, if no daughter nuclide has a half life greater than 10 days or longer than the parent nuclide, the quantity to be applied is the parent nuclide, otherwise the parent and daughter shall be considered. If the identities of the radionuclides in a mixture are in doubt, the lowest A_2 values with the total quantity of material shall be used for the mixture (49 CFR 173.433).

(b) The A_2 values of any radionuclide or mixture shall be determined using 49 CFR 173.433. Thresholds are defined as $1xA_2$ for low risk and $20xA_2$ or greater for high risk.

(c) Threshold values for rem CEDE shall be determined using the processes defined in Attachment four (4) of this Manual.

(3) Nuclear Materials Out of Scope. The materials not covered under these requirements include:

(a) Gases,

(b) Materials stored in approved packaging, such as described in DOE-STD-3013, DOE-STD-3028, and DOE-HDBK-1129,

(c) Materials designated as waste, which are transferred to appropriate waste containers in accordance with DOE O 435.1-1CN1, *Radioactive Waste Management*, and all applicable facility specific requirements,

(d) Fully clad nuclear reactor fuels (fresh or spent),

(e) Items packaged for shipment in approved shipping containers,

(f) Sealed sources as defined in 10 CFR 835.2, or the special form criteria in 49 CFR 173.469, *Tests for special form Class 7 (radioactive) materials*,

(g) Materials in weapons and fully encapsulated materials or components,

(h) Natural uranium (NU) and depleted uranium (DU),

(i) Medical isotopes, and

(j) Those isotopes that are defined as being below the A_2 limit using one of the methodologies described in Threshold Calculations of this Manual (I.1.c.(2)).

d. Basis for 49 CFR 173.435 Table A_2 Values. The values are the more limiting of a quantity that will give:

(1) External exposure: five (5) rem to an individual one meter from the package for 30 minutes.

(2) Internal exposure: five (5) rem whole body (CEDE) or 50 rem to any organ or tissue (CDE) from package disruption. Assumption for package disruption is that the package will release 10^{-3} of its contents and an individual will inhale 10^{-3} of the released material (total exposure 10^{-6} of contents). For some of the material in scope, the threshold values are based on the CDE to any organ or tissue. For simplicity, when referencing dose, this Manual will discuss dose in terms of whole body dose (CEDE).

Example (whole body):

Dose conversion factor (rem/Ci) x 10^{-6} x A_2 Value (Ci) = 5 rem

From DOT Table, 49 CFR 173.435, Table of A_1 and A_2 values for Radionuclides (use only the A_2 values, the A_1 values are for special forms). The DOT tables are based on IAEA, Safety Guide # TS-G-1.1 (ST-2), *Appendix 1 "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material.*

2. DEFINITIONS AND ACRONYMS.

a. Definitions.

(1) Approved Engineered Contamination Barrier. An enclosure which is designed with the intention of maintaining separation between nuclear materials and facility workers, and whose preventive function is a major contributor to worker safety as determined from safety analyses. Examples are hot cells, glovebox lines, ventilation hoods, process vessels, and liquid transfer lines.

(2) Committed Dose Equivalent (CDE). For purposes of this Manual CDE is the radiation dose to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the whole body. CDE is equivalent to the quantity, *committed equivalent dose*, as calculated, in accordance with International Commission on Radiological Protection (ICRP), *1990*

Recommendations of the ICRP, ICRP Publication 60, and uses the dose coefficients in ICRP, *Dose Coefficients for Intakes of Radionuclides by Workers*, ICRP Publication No. 68.

(3) Committed effective dose equivalent (CEDE). For purposes of this Manual CEDE is the sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate tissue weighting factor. CEDE is equivalent to the quantity, *committed effective dose*, as calculated, in accordance with International Commission on Radiological Protection (ICRP), *1990 Recommendations of the ICRP*, ICRP Publication 60, and uses the dose coefficients in ICRP, *Dose Coefficients for Intakes of Radionuclides by Workers*, ICRP Publication No. 68.

(4) Container. A can, drum jar, box, or similar object of rigid construction intended to retain its shape that is closed or sealed to contain nuclear materials.

(5) Design Leakage Rate Test. Verifies that a packaging design will contain radioactive material for normal handling, packaging and storage conditions. The design leakage rate test, for this Manual, is defined as a pre-drop test leak rate. (Methodologies to perform leak rate tests are discussed in ANSI N 14.5-97, *For Radioactive Materials – Leakage Tests on Packages for Shipment*, 7.2.1)

(6) Design Life. A period of time during which a component or product is expected by its designers to work within its specified parameters; i.e. the life expectancy of the item.

(7) Design Qualification Leak Test. Verifies that a packaging design will contain radioactive material for normal handling, packaging and storage conditions. The design qualification leak test, for this Manual, is defined as a post-drop test leak rate. (Methodologies to perform leak rate tests are discussed in ANSI N 14.5-97, *For Radioactive Materials – Leakage Tests on Packages for Shipment*, 6.2)

(8) Encapsulated. Material or component that is contained in a sealed capsule that can be opened only by destroying the capsule. The encapsulation retains reasonable resistance against impact, temperature, and corrosive species in the intended environments for storage, transportation, use, and disposition.

(9) Graded Approach (10 CFR Part 830.7). The process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement in a nuclear facility is commensurate with:

(a) The relative importance to safety, safeguards, and security (Level of Risk);

(b) The magnitude of any hazard involved;

(c) The life cycle stage of a facility (age, status, and condition of a facility or process);

(d) The programmatic mission of a facility (complexity of products or service involved);

(e) The particular characteristics of a facility;

(f) The relative importance of radiological and non-radiological hazards; and

(g) Any other relevant factor.

(10) Handling. Movement of the container as a result of picking up, transferring, or setting down except those covered under DOE O 460.1B, *Packaging and Transportation Safety*.

(11) Interim Storage. Interim Storage is on-site storage of materials outside of an approved engineered contamination barrier. Interim storage excludes materials that are stored in accordance with DOE-STD-3013, DOE-STD-3028, or DOE- HDBK-1129.

(12) Leak Rate or Leakage Rate. The volume of fluid passing through a containment system boundary per unit of time. For purposes of this Manual, leak rate is equivalent to the "Reference air leakage rate" defined in ANSI N 14.5-97. The reference air leakage rate is the allowable leakage rate (leak rate) converted to reference cubic centimeters per second (ref. cm^3/s).

(13) Material Form. Describes material in broad terms as falling into one of three physical states: gas, liquid, or solid. Solid materials are further broken down into elemental metals and compounds.

(14) Nuclear Material. Nuclear Material means any material that is "Special Nuclear Material," "by product material," or "source material" as defined in the Atomic Energy Act of 1954 as amended.

(15) Packaging/Packages. An assembly of one or more containers that meets a DOE Directive or standard.

(16) Packaging System. The assembly of packaging containers intended to retain the nuclear material during storage. [Adapted from 49 CFR 173.403]

(17) Pyrophoric Material. A pyrophoric material is a liquid or solid that, even in small quantities and without an external ignition source, can ignite or char filter paper within five (5) minutes after coming in contact with air when tested according to the United Nations Manual of Tests and Criteria (49 CFR 173.124, (b)(1)).

(18) Sealed Radioactive Sources. A radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed

radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material (10 CFR 835.2).

(19) Specifically Analyzed and Controlled Radiological Production or Processing Activity. Production or processing activities controlled by operational procedures where the hazards associated with packaging have been specifically analyzed in authorization basis.

(20) Spent nuclear fuel. Spent fuel includes fuel materials that have been irradiated and that require shielding for storage or processing (DOE M 470.4-7, *Safeguards and Security Program References*).

b. Acronyms.

(1) A_2. Values of allowable radionuclides from 10 CFR 173.435.

(2) CRD. Contractor Requirements Document.

(3) CFR. Code of Federal Regulations.

(4) DEAR. DOE Acquisition Regulation.

(5) DNFSB. Defense Nuclear Facilities Safety Board.

(6) DOE. United States Department of Energy.

(7) DU. Depleted uranium.

(8) ISSC. Interim Safe Storage Criteria.

(9) NNSA. National Nuclear Security Administration.

(10) NRC. Nuclear Regulatory Commission.

(11) NU. Natural uranium.

(12) RW. Radioactive Waste Management.

3. SURVEILLANCE PROGRAM.

a. General. A surveillance program shall evaluate appropriate attributes of stored containers to determine whether the container(s) can continue to be stored safely. Surveillance shall also validate the container design life.

b. As Low As Reasonably Achievable (ALARA). The surveillance program shall be structured to minimize the overall risk to the facility workers and maintain radiation doses ALARA. As a minimum, the following concepts shall be considered:

(1) Coordination of surveillance activities with MC&A measurements and inspections;

(2) Coordination of surveillance activities with container movements;

(3) Using MC&A and routine radiological survey data in the surveillance program;

(4) Performing surveillance on containers as they are being opened for material use; and

(5) Remote surveillance (e.g., camera, load cell, etc.) for items generating high radiation fields.

c. Objectives and Techniques. The objective of the surveillance program is to identify early indications of container degradation in order to remediate the degraded package and identify similar containers and materials. Surveillance techniques shall be specified to provide early indications of container degradation. Any signs of degradation should be used for comparison with similar containers. As a minimum, the following techniques shall be considered:

(1) Visual inspection of the container for indications of corrosion or pressurization including examining the container for signs of degradation (e.g., corrosion, pressurization, etc.) prior to routine handling of the container or opening for material use;

(2) Mass measurement for indications of mass change which could indicate loss of container seal and possible oxidation, and resulting expansion, of metal contents;

(3) Contamination surveys which could indicate loss of container seal;

(4) Radiography which could indicate pressurization or degradation of inner containers; and

(5) Opening container for examination of interior and contents.

d. Frequency. Surveillance frequencies shall be specified for each container design and content combination. The frequency should be based on the potential failure mechanism, failure consequence, and container design life. Statistical sampling of containers for surveillance may be used for large, uniform populations of containers and/or contents.

e. Procedures. Surveillance procedures shall specify the surveillance techniques to be used and shall have defined acceptance criteria. Procedures shall be established to safely handle anomalous containers until they are repackaged.

f. Evaluation. Surveillance data shall be evaluated at least annually. Results of the surveillance program shall be used to improve packaging design and modify the surveillance program, when appropriate. Sites should consider sharing data with other sites.

4. DOCUMENTATION.

a. Records Retention. Packaging and surveillance records shall be maintained in accordance with site records management requirements.

b. Content Elements.

(1) Material Information. The records shall include, as a minimum, available information on the following material characteristics:

(a) Chemical and physical form;

(b) Best available isotopic content, and the effective dates(s) of analysis;

(c) Mass of material contents; and

(d) Description of container contents.

(2) Package Information. The records shall include identification of the following package characteristics:

(a) Package configuration – quantity and type of containers in a package;

(b) Date of packaging for each container;

(c) Baseline package gross weight;

(d) The unique identification number associated with each container; and

(e) The TID or other security designation.

(3) Surveillance Information. As a minimum, the records shall include the following records from surveillance and inspections:

(a) The unique identification number associated with each container;

(b) Surveillance and radioactive survey results and dates;

(c) Dates and results of inspections; and

(d) Name and site qualifications of individuals performing inspections.

c. Data Base. An electronic data base should be maintained as a source of relevant information about stored materials and packages. Data bases should also include surveillance results. Use of a database simplifies the scheduling of surveillances and repackaging of containers as well as the evaluation of surveillance data. This data base may consist of several files (which, in themselves, may be data bases), some of which may be classified. For completeness, the data base should be coordinated and generally compatible with the MC&A data base(s).

5. REQUIREMENTS OF OTHER REGULATIONS AND DOE DIRECTIVES. The following requirements and DOE directives are required for all DOE nuclear material management facilities, operations, and activities as applicable. Any of the requirements for the following Departmental directives may be waived or modified through application of a DOE-approved requirements tailoring process, such as the "Necessary and Sufficient Closure Process" in DOE P 450.3, *Authorizing Use of the Necessary and Sufficient Process for Standards-Based Environment, Safety and Health Management*, and DOE M 450.3-1, *DOE Closure Process for Necessary and Sufficient Sets of Standards*, and DOE P 450.4, *Safety Management System Policy,* or by an exemption processed in accordance with the requirements of that directive or DOE M 251.1-1A, *Directives System Manual.*

a. Classified Materials. Nuclear material to which access has been limited for national security reasons and which cannot be declassified shall be managed in accordance with the requirements of DOE O 470.4 *Safeguards and Security Program.*

b. Conduct of Operations. Nuclear material management facilities, operations, and activities shall be conducted in a manner based on consideration of the associated hazards. Nuclear material management facilities, operations, and activities shall meet the requirements of DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities.*

c. Criticality Safety. Nuclear material management facilities, operations, and activities shall be covered by a criticality safety program in accordance with DOE O 420.1 *Facility Safety.*

d. Emergency Management Program. Nuclear material management facilities, operations, and activities shall maintain an emergency management program in accordance with DOE O 151.1C, *Comprehensive Emergency Management.*

e. Environmental and Occurrence Reporting. Nuclear material management facilities, operations, and activities shall meet the reporting requirements of DOE O 231.1A, *Environment, Safety and Health Reporting.*

f. Hazard Analysis Documentation and Authorization Basis. Nuclear material management facilities, operations, and activities shall implement DOE Rule 10 CFR 830 Subpart B, *Nuclear Safety Management.*

g. Real Property Asset Management. Planning, acquisition, operation, maintenance, and disposition of nuclear material management facilities, operations, and activities shall be in accordance with DOE O 430.1B, *Real Property Asset Management.*

h. Packaging and Transportation. Nuclear material shall be packaged and transported in accordance with DOE O 460.1B, *Packaging and Transportation Safety,* DOE O 460.2A, *Departmental Materials Transportation and Packaging Management,* and DOE O 461.1A, *Packaging and Transfer or Transportation of Materials of National Security Interest.*

i. Quality Assurance Program. Nuclear material management facilities, operations, and activities shall develop and maintain a quality assurance program that meets the requirements of 10 CFR 830, Subpart A, *Quality Assurance Requirements,* and DOE O 414.1C, *Quality Assurance,* as applicable.

j. Radiation Protection. Nuclear material management facilities, operations, and activities shall meet the requirements of DOE 5400.5, *Radiation Protection of the Public and the Environment.*

k. Radiation Protection Standards. Individuals responsible for nuclear material management facilities, operations, and activities should consider the following DOE standards when operating their facilities: DOE-STD-1136-2004, *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities;* DOE-STD-1128-98, Change Notice 1, February 2005, *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities;* DOE-STD-1121-98, Reaffirmed May 2003, *Internal Dosimetry;* and DOE-STD-1098-99, Reaffirmed December 2004, *Radiological Control.*

l. Records Management. Nuclear material management facilities, operations, and activities shall develop and maintain a record-keeping system, as required by DOE O 200.1, *Information Management Program.*

m. Safeguards and Security. Appropriate features shall be incorporated into the design and operation of nuclear material management facilities, operations, and activities to prevent unauthorized access and operations, and for purpose of nuclear materials control and accountability shall be consistent with DOE P 470.1, *Integrated Safeguards and Security Management Policy.*

n. Safety Management System. Nuclear material management facilities, operations, and activities shall incorporate the principles of integrated safety management as described in DOE P 450.4, *Safety Management System Policy,* and meet the requirements of the safety management systems sections of: 48 CFR Chapter 9, *Federal Acquisition Regulations System;* and DOE M 411.1-1C, *Safety Management Functions, Responsibilities, and Authorities Manual.*

o. Training and Qualification. A training and qualification program shall be implemented for nuclear material management program personnel and shall meet the requirements of DOE O 360.1B, *Federal Employee Training.* In developing the training and qualification program, sites should consider the following training standards: DOE HDBK-1145-2001, *Radiological Safety Training for Plutonium Facilities;* DOE HDBK 1110-97, *ALARA Training for Technical Support Personnel,* Change Notice 1, November 2004; and DOE HDBK-1113-98, *Radiological Safety Training for Uranium Facilities,* Reaffirmation April 2005.

6. RESPONSIBILITIES.

a. Program Secretarial Officers. Program Secretarial Officers with Nuclear Material Packaging facilities, operations, or activities are responsible within their respective programs for ensuring that the Field Element Managers meet the requirements 10 CFR 835 and this Manual.

b. Assistant Secretary for Environment, Safety and Health. The Assistant Secretary for Environment, Safety and Health is responsible for:

(1) Safe Packaging for Nuclear Materials Storage

(a) Advising the Secretary of the status of Departmental compliance with the requirements of 10 CFR 835, this Manual, and applicable provisions of other DOE Orders.

(b) Providing guidance and manual interpretation of packaging and storage.

(c) Reviewing and approving any requested exceptions to this Manual.

(2) Changes to Regulations and DOE Directives. Ensuring changes to regulations and DOE directives are reviewed and, when necessary, incorporated into revisions of this Manual to ensure the basis for safe storage of nuclear materials is maintained.

c. Field Element Managers. Field Element Managers are responsible for:

(1) Nuclear Material Packaging Technical Basis. Developing a technically justified basis for packaging systems that describe how they are meeting the requirements established in this Manual. Reviewing and approving the technical basis for packaging per this Manual.

(2) Oversight. Ensuring oversight of nuclear material packaging for storage facilities, operations, and activities is conducted in accordance with 10 CFR 835 and this Manual.

(3) Corrective Actions. Ensuring a process exists for proposing, reviewing, approving, and implementing site corrective actions when necessary to ensure that the requirements of 10 CFR 835 and this Manual are met and to address conditions that are not protective of the public, workers, or the environment. The process shall allow workers, through the appropriate level of management, to stop work when they discover conditions that pose an imminent danger or other serious hazard to workers or the public, or are not protective of the environment.

d. Contractors. Contractors are responsible for implementing DOE M 441.1, implementing the CRD, and for:

(1) Training and Qualification. Ensuring the site training and qualification program is implemented for designated nuclear material storage and handling personnel, and the training is commensurate with job duties and responsibilities.

(2) ALARA. Ensuring ALARA principles for radiation protection are incorporated when reviewing and approving storage and handling activities.

(3) Storage. Ensuring that all nuclear materials are stored in a manner that protects the public, workers, and the environment in accordance with 10 CFR 835 and this Manual.

CHAPTER II. HIGH RISK REQUIREMENTS

1. DEFINITION OF HIGH RISK MATERIALS. High Risk Nuclear Materials are those isotopes listed on Table 1.1, or mixtures thereof, which in sufficient quantities have a dose calculation, when performed in accordance with this Manual, of 100 rem or greater committed effective dose equivalent (CEDE). Information to calculate the CEDE for a particular material is include in Attachment 4. High Risk materials that are in-process must meet the requirements defined in this Manual after being removed from an engineered contamination barrier for greater than 5 days.

2. MATERIAL CRITERIA. Material characteristics determine the material risk level for specific radioactive metals or nonmetals, solids and liquids. Material characteristics must address potential attributes which could negatively impact storage and handling by a facility worker (e.g. gas pressurization). Note that material criteria shall be used in developing surveillance requirements.

   a. Explosion Sensitive and/or Flammable Materials. Explosion sensitive and/or flammable materials are not acceptable storage forms. In addition, these materials should not be stored adjacent to radioactive material areas. (DOE-STD-1098-99)

   b. Gas Generation. Gas generation rate and composition shall be evaluated. Measures shall be taken to minimize the formation or accumulation of gases inside the storage package. Minimization measures include placing limitations on contents of containers, stabilizing materials, or venting and filtering containers.

   c. Incompatible Materials. Materials whose interaction could lead to failure of one or more of the containment barriers shall not be packaged together (e.g., oxidizers and nitrated ion exchange resins).

   d. Physical and Chemical Form. The physical and chemical form of material shall be considered to ensure proper packaging and surveillance requirements. For example, a Pu metal should not be stored in a vented container while a Pu oxide, depending on specific activity and particle size, could be. A gas generating oxide might be stored in a vented container to ensure no buildup of pressure but should be surveilled more frequently than a metal containing sealed package.

   e. Moisture Content. Moisture content of materials to be packaged and stored shall be evaluated to determine if safe storage can be achieved or if stabilization is necessary. Stabilization shall be considered for materials that can absorb/adsorb significant quantities of moisture when in contact with air.

   f. Pyrophoricity. Pyrophoricity of materials to be packaged and stored shall be evaluated to determine if safe storage can be achieved or if stabilization is necessary. Mixtures of pyrophoric materials and non-pyrophoric materials shall be considered to be pyrophoric if they demonstrate pyrophoricity as defined by 49 CFR 173.124.

g. Radiation/Decay Heat. Radiation or decay heat of the stored materials shall not raise the storage temperature to a level that could cause failure of one or more of the containment barriers. Radiation levels shall be evaluated and considered in developing a packaging and surveillance plan. Package designers shall include a maximum heat load in the design specifications.

h. Solutions. Solution composition and its effect on the selection of packaging type, storage duration, and surveillance must be evaluated as part of the criteria.

3. PACKAGING CRITERIA.

a. General. The properties of single or multiple containers and contamination barriers constitute the system and combine to create an acceptable system. The package design must address concerns with corrosion, radiolytic and thermal degradation, oxidative expansion, pressurization, usage (handling), and incompatible materials that may result in container failure. Failure of an inner container shall not challenge the integrity of the outermost container. The package design shall be tested for impact resistance when dropped from the designated drop test height (49 CFR 173.465). A package shall not be stored at a height that exceeds the design basis storage height. Package surveillance requirements shall be detailed in the surveillance program. The surveillance program shall be structured to minimize the overall risk to the facility workers and maintain radiation doses ALARA.

b. Container Design Concept.

(1) Container. The package provides the boundary to prevent release of radioactive materials during anticipated normal handling or storage. Criteria for container design should consider both sealed and filter vented containers. Additional sealed or unsealed inner containers may be used. Contamination levels shall be ALARA. The exterior surface of the outermost container should be designed to facilitate decontamination.

The storage container shall be securely closed in a way that precludes accidental opening or breaching during postulated accidental dropping and/or normal operational conditions. Seals incorporated to provide effective closure must undergo useful-life determinations and must maintain their integrity for approved contents. For surveillance purposes, the design life of the seal must be specified.

(2) Sealed Containers. Values for burst pressure and maximum design pressure requirements must be established for the container design life.

The types of materials that a container can accommodate shall be determined by the design leakage rate test. In qualifying any given design, the package must be pressure-tested to the design leakage rate test and pass the design qualification leak test (ANSI N 14.5). Seals incorporated to provide effective closure must undergo useful-life determinations and must maintain their integrity for approved contents. The seals must function effectively, including opening and closing cycles, for the container design life or be replaced on a formal surveillance and/or maintenance schedule. The design life of elastomer or metal seals shall be specified.

(3) Filter Vented Containers. In qualifying any given design,packages must be pressure and leak tested (ANSI N 14.5). The seals must function effectively for the container design life or be replaced on a formal surveillance and/or maintenance schedule. The design life of the seal shall be specified and documented. The venting and filter capacity must be adequate to accommodate expected gas generation rates.

(4) Other Containers. Plastic bags and slip-lid cans may be used inside the package but may not be counted as one of the storage containment barriers. Plastic containers shall not be in direct contact with alpha emitting materials with a specific activity greater than one curie per gram. Processes and procedures that use plastic bags, bottles, or slip-lid cans must be documented in site documentation prior to the usage of these materials as contamination barriers.

c. Containers for Liquid Storage. Containers for liquid storage must be compatible with the stored material. Criteria for the use of either vented or non-vented plastic bottles shall be evaluated. Consideration should be given to the effect of solution composition and permitted storage time for this type of packaging. Surveillance of liquid storage containers should be more frequent than normal surveillance of metals and/or oxides.

d. Corrosion Effects. The container and filter vent shall be constructed entirely of materials that are resistant to corrosion or chemical degradation by the contained materials as well as the ambient storage environment. Details on resistance to corrosion shall be evaluated. Material type may be limited in order to inhibit corrosion processes.

e. Drop Test Criteria. The storage package design shall be tested for impact resistance and material containment when dropped from the heights defined in Package Configuration (see Chapter II, 4). Containers must be oriented as to suffer maximum damage to the safety features being tested. Surrogate contents must be representative of the actual mass and the dispersible contents. (Modified from 49 CFR 173.465)

f. Filter Performance. Use of filtered vents on storage packages to prevent pressure buildup is acceptable. However, criteria must be established and documented for the use of filtered vents. Filters must be compatible with the material being stored, the storage container, and the surrounding environment including any product of reaction between the environment and the material, e.g., salts adsorbing moisture and corroding the can. Container designs incorporating filters require useful-life determinations and performance verification measurements at the rated filtration efficiency. The filter(s) shall be capable of venting the maximum credible gas flow rate, be resistant to plugging, and allow for testing for plugging during surveillance. Filter venting shall not have a material specific gas flow rate that exceeds the 5 rem CEDE A_2 limit established for this manual.

g. Heat Resistance. Container design shall address thermal loading and decay heat. The heat generation of the contents must not degrade the container for the design life of the container. (49 CFR 172.442(a))

h. Pressure Effects. Sealed containers shall be designed to be capable of withstanding pressure due to gas generated during the storage period with an acceptable safety margin. Measures should be taken to minimize the formation or accumulation of gases inside the storage package. Such measures include placing limitations on the contents of containers and permitted length of storage time, or providing mechanisms in the storage package design, such as venting. Container design shall address concerns with container pressurization potentially caused by material oxidation, volume expansion, release of volatiles, or gas pressurization. If a container shows evidence of abnormal pressurization the gas shall be treated as potentially explosive and corrective action shall be taken (i.e. repackaging, relieving the pressure).

i. Pyrophoric Materials. Materials defined as being pyrophoric shall be packaged in an inert environment with double sealed contamination barriers to prevent a pyrophoric reaction. Sites are encouraged to stabilize pyrophoric materials prior to storage (DOE-HDBK-1081).

j. Radiation Resistance. Container design shall address degradation from radiation effects. Radiation must not challenge the integrity of the package for its design life.

4. PACKAGING CONFIGURATION.

High risk materials, as defined above, have two options for storage configuration.

a. Option One.

(1) Single Container. The package assembly shall consist of a single container to isolate stored materials from the environment (10 CFR 71.63). The container provides the physical boundary to prevent release of the contents. The use of additional inner containers, sometimes referred to as material or convenience containers is optional. Transfer of the bagged-out convenience container to the final package configuration outside the

engineered containment boundary is acceptable for short durations, if performed in accordance with approved radiological controls.

(2) Design Leakage Rate Test. The following leak/release rate tests described in (2) and (3) are intended to show equivalency to ANSI N 14.5-1997. For qualification of a design, the package shall pass one of the following tests: a) a design leakage rate test of ten times "leaktight" (1×10^{-6} cm^3/s); b) values calculated for a leak rate corresponding to ten times release limits (1×10^{-5} A_2/hr); or c) an actual (directly measured) release of 1×10^{-5} A_2/hr, under normal conditions, of handling and storage. Only surrogate materials shall be used for leak or release testing.

(3) Drop Test and Design Qualification Leak Rate. For qualification of a design, the package shall pass a drop test from 1.5 times the maximum working or storage height but not less than four feet; and a post drop package design qualification leak rate test using one of the following tests: a) an accidental drop leak rate (1×10^{-3} cm^3/s); b) a leak rate corresponding to 0.1 A_2/hr; or c) an actual (directly measured) release of 0.1 $A_2/$ hr. Only surrogate materials shall be used for leak or release testing.

(4) Venting. The container shall be either sealed or filter vented.

(5) Liquids. Liquids shall not be stored in a single containment configuration.

(6) Surveillance. The package configuration should allow for non-destructive contents verification, inspection, and surveillance such as by radiography and weighing.

(7) Fabrication. The container shall be fabricated of materials resistant to corrosion from the contents and storage environment. Any additional material or convenience containers shall be made of materials compatible with the outer container and stored material.

(8) Design Life. The design life of the container construction materials shall be calculated and the container will be examined under a regular documented maintenance and surveillance program. The impact of organic materials used in the construction must be accounted for in these calculations and maintenance and surveillance plans.

(9) Labeling. Each storage container or package of radioactive material shall have a unique permanent identification marking or bear a durable, clearly visible label for identification and documentation purposes.

(10) Contamination Levels. The contamination levels on the exterior surface of the assembled package shall be maintained ALARA, but shall not exceed the limits in the site approved DSA for the contamination area. Exterior

contamination shall not exceed limits in 10 CFR 835, Appendix D values for the radiological classification of the container storage and handling areas.

b. Option Two.

(1) Double Containment. The package assembly shall consist of a minimum of two nested containers to isolate stored materials from the environment. The outer container provides the physical boundary to prevent release of the contents. The inner container provides an additional isolation boundary and can function as an internal pressure indicator. The use of additional inner containers, sometimes referred to as material or convenience containers is optional. Transfer of the bagged-out convenience container to the final package configuration is acceptable for short durations outside the engineered containment boundary in accordance with approved area radiological controls.

(2) Design Leakage Rate Test. The following leak/release rate tests described in (2) and (3) are intended to show equivalency to ANSI N 14.5-1997. For qualification of a design, the package shall pass one of the following tests: a) a design leakage rate test of ten times "leaktight" ($1x10^{-6}$ cm^3/s) for the package; b) values calculated for a leak rate corresponding to ten times release limits ($1x10^{-5}$ A_2/hr); or c) an actual (directly measured) release of $1x10^{-5}$ A_2/hr, under normal conditions, of handling and storage. Only surrogate materials shall be used for leak or release testing.

(3) Drop Test and Design Qualification Leak Rate. For qualification of a design, the package shall pass a drop test from 1.2 times the maximum working or storage height but not less than four feet; and a post drop package design qualification leak rate test using one of the following tests: a) an accidental drop leak rate ($1x10^{-3}$ cm^3/s); b) a leak rate corresponding to 0.1 A_2/hr; or c) an actual (directly measured) release of 0.1 A_2/ hr. Only surrogate materials shall be used for leak or release testing.

(4) Venting. Containers shall be either sealed or filter vented.

(5) Liquids. Liquids are only allowed to be stored in double containment.

(6) Surveillance. The package configuration should allow for non-destructive contents verification, inspection, and surveillance such as by radiography and/or weighing.

(7) Fabrication. Both the primary and secondary containers shall be fabricated of a material that is corrosion resistant such as stainless steel or other material of comparable or better performance (strength, corrosion resistance, etc.). Any additional material or convenience containers shall

be made of materials compatible with the inner and outer containers and stored materials.

(8) Design Life. The design life of the container construction materials shall be calculated and the container will be examined under a regular documented maintenance and surveillance program. The impact of organic materials used in the construction must be accounted for in these calculations and maintenance and surveillance plans.

(9) Labeling. Each storage container or package of radioactive material shall have a unique permanent identification marking or bear a durable, clearly visible label for identification and documentation purposes.

(10) Contamination on Exterior of Inner Container. Containers must be configured such that contamination is less than the 49 CFR 173.435 Table A_2 limits on the exterior of the inner container and shall maintain ALARA before the final contamination barrier is put into place.

(11) Contamination Levels. The contamination levels on the exterior surface of the assembled package shall be maintained ALARA, but shall not exceed the limits in the site approved DSA for the contamination area. Exterior contamination shall not exceed limits in 10 CFR 835, Appendix D values for the radiological classification of the container storage and handling areas.

CHAPTER III. LOW RISK REQUIREMENTS

1. DEFINITION OF LOW RISK MATERIALS. Low Risk Nuclear Materials are those isotopes listed on Table 1.1, or mixtures thereof, which in sufficient quantities have a dose calculation, when performed in accordance with this Manual, between five (5) rem and 100 rem committed effective dose equivalent (CEDE). Information to calculate the CEDE for a particular material is included in Attachment 4. For Low Risk materials that are in-process, materials must meet the requirements defined in this Manual after being removed from an engineered contamination barrier for greater than 60 days.

2. MATERIAL CRITERIA. Material characteristics must be considered when determining appropriate packaging requirements. Material characteristics could negatively impact the integrity of the container during storage and handling by a facility worker (e.g. gas pressurization). Note that material characteristics shall be considered when developing container surveillance requirements.

   a. Explosion Sensitive and/or Flammable Materials. Explosion sensitive and/or flammable materials are not acceptable storage forms. In addition, these materials should not be stored adjacent to radioactive material areas. (DOE-STD-1098-99)

   b. Gas Generation. Gas generation rate and composition shall be evaluated. Measures shall be taken to minimize the formation or accumulation of gases inside the storage package. Minimization measures include placing limitations on contents of containers, stabilizing materials, or venting and filtering containers.

   c. Incompatible Materials. Materials whose interaction could lead to failure of the containment barrier shall not be packaged together (e.g., oxidizers and nitrated ion exchange resins).

   d. Physical and Chemical Form. The physical and chemical form of the material shall be considered to ensure proper confinement, e.g. purity, stability, etc., for both packaging and surveillance requirements.

   e. Moisture Content. Moisture content of materials to be packaged and stored shall be evaluated to determine if safe storage can be achieved or if stabilization is necessary. Stabilization shall be considered for materials that can absorb/adsorb significant quantities of moisture when in contact with air.

   f. Pyrophoricity. Pyrophoricity of materials to be packaged and stored shall be evaluated to determine if safe storage can be achieved or if stabilization is necessary. Mixtures of pyrophoric materials and non-pyrophoric materials shall be considered to be pyrophoric if they demonstrate pyrophoricity as defined by 49 CFR 173.124.

g. Radiation/Decay Heat. Radiation or decay heat of the stored materials shall not raise the storage temperature to a level that could cause failure of the containment barrier. Radiation levels shall be evaluated and considered in developing a packaging and surveillance plan.

h. Solutions. Solution composition and its effect on the selection of packaging type, storage duration, and surveillance must be evaluated as part of the criteria.

3. PACKAGE CRITERIA.

a. General. The container design must address concerns with corrosion, radiolytic and thermal degradation, oxidative expansion, pressurization, usage (handling), and incompatible materials that may result in container failure. The package design shall be evaluated structurally and tested for impact resistance when dropped from the designated drop test height (49 CFR 173.465). A package shall not be stored at a height that exceeds the design basis storage height. Package surveillance requirements shall be detailed in the surveillance program. The surveillance program shall be structured to minimize the overall risk to the facility workers and maintain radiation doses ALARA.

b. Container Design Concept.

(1) Containers. The package provides the boundary to prevent release of the radioactive materials during anticipated normal handling or storage. Criteria for container design should consider both sealed and filter vented containers. Additional sealed or unsealed inner containers may be used. Contamination levels shall be ALARA. The exterior surface of the outermost container should be designed to facilitate decontamination.

The storage container shall be securely closed in a way that precludes accidental opening or breaching during postulated accidental dropping and/or normal operational conditions. Seals incorporated to provide effective closure must undergo useful-life determinations and must maintain their integrity for approved contents. For surveillance purposes, the design life of the seal must be specified.

(2) Sealed containers. Values for burst pressure and maximum design pressure requirements must be established for the container design life. The types of materials that a container can accommodate shall be determined by the design leakage rate test. Seals incorporated to provide effective closure must undergo useful-life determinations and must maintain their integrity for approved contents. The seals must function effectively, including opening and closing cycles, for the container design life or be replaced on a formal surveillance and/or maintenance schedule.

The design life of elastomer or metal seals shall be specified and documented.

(3) Filter Vented containers. In qualifying any given design, containers must be pressure and leak tested in accordance with this Manual. The seals must function effectively for the container design life or be replaced on a formal surveillance and/or maintenance schedule. The design life of the seal shall be specified and documented. The venting and filter capacity must be adequate to accommodate expected gas generation rates. Failure of an inner container shall not challenge the integrity of the outermost container.

(4) Other Containers. Other container types may be considered, but must meet the confinement requirements of the contained material to prevent facility worker exposures in excess of the five (5) rem annual limits. Plastic containers shall not be in direct contact with alpha emitting materials with a specific activity greater than one curie per gram. Processes and procedures that use plastic bags, bottles, or slip-lid cans must be documented in site documentation prior to the usage of these materials as contamination barriers.

c. Containers for Liquid Storage. Containers for liquid storage must be compatible with the stored material. Criteria for the use of either vented or non-vented plastic bottles shall be evaluated. Consideration should be given to the effect of solution composition and permitted storage time for this type of packaging. Surveillance of liquid storage containers should be more frequent than normal surveillance of metals and/or oxides.

d. Corrosion Effects. The container and filter/vent shall be constructed entirely of materials that are resistant to corrosion or chemical degradation by the contained materials as well as the ambient storage environment. Details on resistance to corrosion shall be evaluated. Material type may be limited in order to inhibit corrosion processes.

e. Drop Test Criteria. The storage package design shall be evaluated structurally and/or tested for impact resistance and material containment when dropped from the maximum storage or handling height, whichever is greater, but not less than four feet. Containers must be oriented as to suffer maximum damage to the safety features being tested. Surrogate contents must be representative of the actual mass and the dispersible contents. (Modified from 49 CFR 173.465)

f. Filter Performance. Use of filtered vents on storage packages to prevent pressure buildup is acceptable. However, criteria must be established and documented for the use of filtered vents. Filters must be compatible with the material being stored, the storage container, the surrounding environment, and any product of reaction between the environment and the material, e.g. salts picking up moisture and corroding the container. Container designs incorporating filters require useful-life determinations and performance verification measurements at the rated filtration efficiency. The filter(s) shall be capable of venting the maximum credible gas flow rate, be resistant to plugging, and allow for testing for plugging during surveillance.

g. Heating Resistance. Container design shall address thermal loading and decay heat. The heat generation of the contents must not degrade the container for the design life of the container (49 CFR 172.442(a)).

h. Pressure Effects. Sealed containers shall be designed to be capable of withstanding pressure due to gas generated during the storage period with an acceptable safety margin. Measures should be taken to minimize the formation or accumulation of gases inside the storage package. Such measures include placing limitations on the contents of containers and permitted length of storage time, or providing mechanisms in the storage package design, such as venting. Container design shall address concerns with container pressurization potentially caused by material oxidation, volume expansion, release of volatiles, or gas pressurization. If a container shows evidence of abnormal pressurization the gas shall be treated as potentially explosive and corrective actions shall be taken (repackaging, relieving the pressure, etc.).

i. Pyrophoric Materials. Materials defined as being pyrophoric shall be packaged in an inert environment with a single sealed contamination barrier to prevent reaction with air. Sites are encouraged to stabilize pyrophoric materials prior to storage (DOE-HDBK-1081).

j. Radiation Resistance. Container design shall address degradation from radiation effects. Radiation must not challenge the integrity of the package for its design life.

4. PACKAGE CONFIGURATION.

a. Single Containment. The package assembly shall consist of at least a single container to isolate stored materials from the environment (equivalent to 10 CFR 71.63). The container provides the physical boundary to prevent release of the contents. The use of additional inner containers, sometimes referred to as material or convenience containers, is optional. Transfer of the bagged-out convenience container to the final package configuration outside the engineered containment boundary is acceptable for short durations, if performed in accordance with approved radiological controls.

b. Design Leakage Rate Test. The following leak/release rate tests described in b and c are intended to show equivalency to ANSI N 14.5-1997. For qualification of a design, the package shall pass one of the following tests: a) a design leakage rate test of ten times "leaktight" ($1x10^{-6}$ cm^3/s); b) values calculated for a leak rate corresponding to ten times release limits ($1x10^{-5}$ A_2/hr); c) an actual (directly measured) release of $1x10^{-5}$ A_2/hr, under normal conditions, of handling and storage. Only surrogate materials shall be used for leak or release testing.

c. Drop Test and Design Qualification Leak Rate. For qualification of a design, the package shall pass a drop test from 1.0 times the maximum working or storage height but not less than four feet; and a post drop package design qualification leak rate test using one of the following tests: a) an accidental drop leak rate ($1x10^{-3}$ cm^3/s) or b); a leak rate corresponding to 0.1 A_2/hr; or c) an actual (directly measured) release of 0.1 $A_2/$ hr. Only surrogate materials shall be used for leak or release testing.

d. Surveillance. The container should allow for non-destructive contents verification, inspection, and surveillance (such as by radiography and weighing).

e. Fabrication. The container shall be fabricated of corrosion resistant materials or materials of comparable or better performance (for contamination control, etc.) and may include plastics. Any additional material or convenience containers shall be made of materials compatible with the outer container and stored materials.

f. Design Life. The design life of the container construction materials shall be calculated and the container will be examined under a regular documented maintenance and surveillance program. The impact of organic materials used in the construction must be accounted for in these calculations and maintenance and surveillance plans.

g. Labeling. Each storage container or package of radioactive material shall have a unique permanent identification marking or bear a durable, clearly visible label for identification and documentation purposes.

h. Contamination Levels. The contamination levels on the exterior surface of the assembled package shall be maintained ALARA, but shall not exceed the limits in the site approved DSA for the contamination area. Exterior contamination shall not exceed limits in 10 CFR 835, Appendix D values for the radiological classification of the container storage and handling areas.

Attachment 1

ALL DEPARTMENT ELEMENTS TO WHICH DOE M 441.1 IS APPLICABLE

Office of Civilian Radioactive Waste Management*

Office of Electricity Delivery and Energy Reliability

Office of Energy Efficiency and Renewable Energy

Office of Environment, Safety and Health

Office of Environmental Management

Office of Fossil Energy

Office of Independent Oversight and Performance Assurance

Office of Intelligence

Office of Legacy Management

National Nuclear Security Administration

Office of Nuclear Energy, Science and Technology

Office of Science

Office of Security and Safety Performance Assurance

Note: Applicability to a field entity is assumed when its lead program Secretarial Officer organization is listed.

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* This Manual only applies to DOE materials at the Office of Radioactive Waste Management. NRC licensed materials are exempt from this Manual.

Attachment 2

CONTRACTOR REQUIREMENTS DOCUMENT

This is a place holder. The CDR will be developed from this Manual after is it further developed.

Attachment 3

REFERENCES

<u>Government Documents.</u> **DOE Technical Standards, Handbooks, Orders, Manuals, Policies, and Technical Standards Lists (TSLs)**

(1) DOE-HDBK-1081-94, Primer on Spontaneous Heating and Pyrophoricity, December 1994

(2) DOE-HDBK-1129-99, Tritium Handling and Safe Storage, March 1999

(3) DOE-STD-1098-99, Radiological Control, July 1999

(4) DOE-STD-3009-94, Change Notice No. 1, Preparation Guide for US Department of Energy Non-Reactor Nuclear Facility Documented Safety Analyses January 2000

(5) DOE-STD-3013-2004, Stabilization, Packaging, and Storage of Plutonium Bearing Materials, April 2004

(6) DOE-STD-3028-2000, Criteria for Packaging and Storing Uranium-233-Bearing Materials, July 2000

(7) DOE Acquisition Regulation (DEAR) clause 48 CFR 970.5204-2, Laws, Regulations, and DOE Directives, 10/01/05

(8) DOE O 151.1C, Comprehensive Emergency Management, 11/02/05

(9) DOE O 200.1, Information Management Program, 9/30/96

(10) DOE O 231.1A Chg 1, Environment, Safety and Health Reporting, 6/03/04

(11) DOE M 251.1-1A, Directives System Manual, 01/30/98

(12) DOE O 360.1B, Federal Employee Training, 10/11/01

(13) DOE M 411.1-1C, Safety Management Functions, Responsibilities, and Authorities Manual, 12/31/03

(14) DOE O 414.1C, Quality Assurance, 6/17/05

(15) DOE O 420.1B, Facility Safety, 12/22/05

(16) DOE O 430.1B, Real Property Asset Management, 9/24/03

(17) DOE O 435.1-1C, Radioactive Waste Management, 8/28/01

(18) DOE P 450.3, Authorizing Use of the Necessary and Sufficient Process for Standards-Based Environment, Safety and Health Management, 1/25/96

(19) DOE M 450.3-1, DOE Closure Process for Necessary and Sufficient Sets of Standards, 1/25/96

(20) DOE P 450.4, Safety Management System Policy, 10/15/96

(21) DOE O 460.1B, Packaging and Transportation Safety, 04/04/03

(22) DOE O 460.2A, Departmental Materials Transportation and Packaging Management, 12/22/04

(23) DOE O 461.1A, Packaging and Transfer or Transportation of Materials of National Security Interest, April 26, 2004

(24) DOE M 470.4-7, Safeguards and Security Program References, 8/26/05

(25) DOE P 470.1, Integrated Safeguards and Security Management Policy, 5/08/01

(26) DOE O 470.4 Safeguards and Security Program, 8/26/05

(27) DOE Order 5400.5, Radiation Protection of the Public and the Environment, 1/07/93

(28) DOE 5480.19, Conduct of Operations Requirements for DOE Facilities, 10/23/01

(29) CH-TRAMPAC, Rev. 2, May, 2005, Table 2.5-1,

Other Government documents, drawings, and publications.

(1) 10 CFR 36, Licenses and Radiation Safety Requirements for Irradiators, January 1, 2006

(2) 10 CFR 36.21, Performance Criteria for Sealed Sources, January 1, 2006

(3) 10 CFR 830, Nuclear Safety Management, January 1, 2006

(4) 10 CFR 835, Occupational Radiation Protection, January 1, 2006

(5) 48 CFR 9, Contractor Qualifications, October 1, 2005

(6) 49 CFR 173, Shippers – General Requirements for Shipments and Packaging, October 1, 2005

(7) 49 CFR 173.124, Class 4, Divisions 4.1, 4.2 and 4.3—Definitions, October 1,2005

(8) 49 CFR 173.433, Requirements for determining basic radionuclide values, and for the listing of radionuclides on shipping papers and labels, October 1, 2005

(9) 49 CFR 173.435, Table of A_1 and A_2 Values for Radionuclides, October 1, 2005

(10) 49 CFR 173.465, Type A Package Tests, October 1, 2005

(11) 49 CFR 173.469, Tests for special form Class 7 (radioactive) materials, October 1, 2005

(12) Executive Order 12344, February 1, 1982

(13) "Criteria for Interim Storage of Plutonium Bearing Materials," memo to field from Charles B. Curtis, 1/25/96

(14) Recommendation 2005-1 to the Secretary of Energy, DNFSB, March 2005

RADIATION PROTECTION STANDARDS.

(1) Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities, DOE-STD-1136-2004, December 2004

(2) Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities, DOE-STD-1128, Change Notice 1, February 2005

(3) Internal Dosimetry Technical Standard, DOE-STD-1121, Reaffirmed May 2003

RADIATION PROTECTION TRAINING STANDARDS.

(1) DOE HDBK-1145-2001, Radiological Safety Training for Plutonium Facilities, August 2001

(2) DOE HDBK-1110-97, ALARA Training for Technical Support Personnel, Change Notice 1, November 2004

(3) DOE HDBK-1113-98, Radiological Safety Training for Uranium Facilities, Reaffirmation April 2005

OTHER REFERENCES.

(1) ANSI N 14.5-1997, For Radioactive Materials – Leakage Tests on Packages for Shipment

(2) Safety Guide No. TS-G-1-1 (ST-2), Appendix 1 "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material" January 14, 2005 (DRAFT)

Attachment 4

CALCULATING THE MAR FOR THE 5 REM AND 100 REM THRESHOLDS

In calculating the Material at Risk, MAR, that will generate a respirable fraction that would expose a worker to 5 rem or 100 rem, one of two methods can be used. The first is founded on the 49 CFR 173.435 A_2 limits (herein referred to as the DOT methodology); the second is derived from the DOE-HDBK-3010.

For the DOT methodology, 49 CFR 173 A_2 limit method:

Dose (rem CEDE) = MAR (g) * f * DCF (rem CEDE/g)

Where MAR is the total quantity of material in a package (in grams), f is the fraction available for uptake—and for the 49 CFR 173 method it set to a constant 1×10^{-6}—and DCF is the Dose Conversion Factor.

For the DOE-HDBK-3010-derived method:

Dose (rem CEDE) = MAR (g) * RRF * DF * DCF (rem CEDE/g)

Where MAR and DCF have the same definitions as the above method, and

RRF = DR * ARF * RF * LPF

DR – Damage Ratio, the fraction of the MAR contributing to the release

ARF – Airborne Release Fraction, the amount of the MAR*DR aerosolized by the event

RF – Respirable Fraction, the fraction of aerosolized (ARF) that is respirable

RRF – Respirable Release Fraction

LPF- Leak Path Factor, the fraction of the container that is spilled (assumed = 1)

DF – Dilution Factor, see explanation below.

Note the similarity between the two equations. The real comparison between the two methods lies in the comparison of f ($=1\times10^{-6}$) and the product of DF and RRF (RRF can reasonably vary from 1×10^{-3} to 1×10^{-6}). The Dilution Factor (DF) is a value that is derived from modeling and experimental measurements that take into account the atmospheric transport of the aerosolized material. It assumes that the material, liberated from a container, expands in a hemispherically expanding aerosol and reaches the worker in 10 seconds, and the worker leaves the location after 60 seconds of normal breathing; it has been calculated at Los Alamos to be equal to 7.7×10^{-4}.

1. CONSEQUENCE MODEL.

The consequence to the worker from the release of radioactive material resulting from the failure of a package is highly dependent on circumstances. In order to risk-rank packages, however, it is sufficient to assume a particular accident scenario and to apply that scenario to each package. The scenario chosen here assumes a spill of total package contents from a height of three meters. Choosing any other (low energy) mechanical release scenario and applying that scenario consistently to all packages would yield a different worker consequence, but should not change the consequence ranking of the packages.

In our case, we assume $LPF = 1$, that is, no holdup occurs in the package, by definition of the release scenario. *DR* is the fraction of the material that is finely enough dispersed to contribute to the airborne release, that is, essentially the fine powder fraction of the contents of a package. It is assumed that the spill event is insufficiently energetic to comminute material. *ARF* and *RF* are as defined – applied to the fine powder fraction. Given these definitions, it is useful to group *DR*, *ARF*, and *RF* as the respirable release fraction $RRF = DR \times ARF \times RF$ that is applied directly to the *MAR* to yield the airborne respirable source term. In the following discussion we develop this respirable release fraction for packaged materials.

2. CONSEQUENCE MODEL INPUT.

Nuclear material is stored in a variety of packages. Each item (one of possibly several per package) is labeled by an Item Description (IDES) code, mass of nuclear material, (nuclear) Material Type, and is entered into a material accountability database. Each IDES has a short description of the physic-chemical nature of the material to which it is assigned. More detailed physical characterization was obtained by consultation with subject matter experts to assess the *RRF* of a given IDES.

Similar to, and expanding on, the data given in DOE Handbook 3010, one approach is to give RRF values for a manageable list of items based on their item description (see the following table). Broadly, all of the material descriptions of concern can reasonably be assigned to the following 7 groups, characterized by physical characteristic and a given *RRF*:

a. Non-Dispersible Material.

This group includes encapsulated radiation sources, ceramic pellets, cemented material, and resin beads. All of these are expected to suffer no significant release during a 3 m spill. Hence $RRF = DR \times ARF \times RF = 0$.

b. Gas.

In a "spill" from container, all of the gas is assumed to escape. Therefore $RRF = DR \times ARF \times RF = 1$

c. Liquid.

When a liquid spills from a container, a certain fraction of the spilled liquid is dispersed as aerosol (droplets that may or may not dry in transport). Since all of the liquid contributes to the generation of this aerosol, *DR* =1. For liquid spills (aqueous solution) from 3 m, the DOE Handbook (P. 3-4)[9] suggest *ARF* = 2E-4, and *RF* = 0.5 as bounding values.

RRF = DR X ARF x RF = 1.0E-04

RRF = 1 x 0.0002 x 0.5 = 0.0001 or 1.0E-04

d. Contamination on Flexible Substrate

Contamination on rags or other flexible substrates is generally tightly bound, but some is released on impact with the floor. The DOE Handbook (P. 5-4)[9] provides *ARF* = 1E-3 and *RF* = 1 as bounding values. For this case, *DR* = 1 since all of the contamination is subject to such release. If the contamination consists of ^{238}Pu oxide, it is possible that it originated in the ball-mill grinding process which produces very fine powder with particle diameters around 1 μm. In this case we assumed *RF* = 1.

RRF = DR X ARF x RF = 1.0E-04

RRF = 1 x 0.001 x 0.1 = 0.0001 or 1.0E-04

RRF = 1 x .001 x 1 = .001 or 1.0E-03 for ^{238}Pu

e. Large Pieces, < 10% Fines.

Items in this group, such as large pieces of metal, were generally characterized qualitatively by subject matter experts as having less than 10% powder in the bottom of the container. Since this was also their qualitative impression of the category *Small Chunks and Powder*, which contains some bulk powder from the start, rather than just powder that presumably abraded from large pieces during handling, we assigned 1% powder to this category in order to distinguish it from the latter. It was assumed that only the 1% powder would be affected by the spill, and that therefore *DR* = 0.01. For fine powder spilling from 3 m, the DOE handbook (P. 4-9)[9] gives as bounding values *ARF* = 2E-3, *RF* = 0.3. If the powder fraction is suspected of consisting entirely of ^{238}Pu oxide, it was again assumed (see *Contamination on Flexible Substrates*) that *RF* = 1.

RRF = DR X ARF x RF = 1.0E-04

RRF = 0.01 x 0.002 x 0.3 = 0.000006 or 6.0E-06

f. Small Chunks and Powder.

For items in this group the subject matter experts estimated a 10% powder fraction. By the arguments made for the previous category (*Large Pieces, < 10% Fines*), we assigned *DR* = 0.1, *ARF* = 2E-3 and *RF* = 0.3. Again, if the powder material exists exclusively of MT-83 oxide, incinerator ash or filter residue, *RF* = 1. For ^{238}Pu calcium salt and hydroxide precipitate, the particle size is expected to be larger than ball-milled oxide and *RF* = 0.3.

RRF = DR X ARF x RF = 6.0E-05

RRF = 0.1 x 0.002 x 0.3 = 0.00006 or 6.0E-05

g. Loose, Free-Flowing Powder.

For these items, by the above arguments, *DR* = 1, *ARF* = 2E-3 and *RF* = 0.3. Again, for MT-83 oxide and sweepings, *RF* = 1. For ^{238}Pu hydride, *RF* = 0.3.

RRF = DR X ARF x RF = 6.0E-04

RRF = 1 x 0.002 x 0.3 = 0.0006 or 6.0E-04

The following table (Table 4-1) gives a list of RRF's based on the item description (derived from the LANL assessment1).

Table 4-1

Description	Physical Characteristic	*DR*	*ARF*	*RF*	*RRF*
Solid metal	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Non-Weap Nitrate Assembly	large pieces, < 10% fines in bottom	0.1	2.0E-03	0.3	6.0E-05
Acetate	small chunks/powder	0.1	2.0E-03	0.3	6.0E-05
Carbide	non-disp. mat. (ceramic pellet)	0	0	0	0
Chloride	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Dioxide	loose, free-flowing powder	1	2.0E-03	0.3	6.0E-04
Fluoride	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Hydride	loose, free-flowing powder	1	2.0E-03	0.3	6.0E-04
Nitrate	small chunks/powder	0.1	2.0E-03	0.3	6.0E-05
Nitride	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Phosphate/Phosphoric	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Sulfate	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Tetrafluoride	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Trichloride	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Trioxide	loose, free-flowing powder	1	2.0E-03	0.3	6.0E-04
U308	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Nitride - Reactor Element	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Non-Specific Gas	gas	1	1	1	1
Cellulose Rags	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Wooden HEPA Filter	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Paper/Wood	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Solution (non-specific)	liquid	1	2.0E-04	0.5	1.0E-04
Non-spec. Noncombustibles	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Asbestos	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Filter Media	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Fire Brick	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Glass	contamination on flexible substrate	0.01	2.0E-03	0.3	6.0E-06
Graphite	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Heating Mantles	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
HEPA Filters	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Leaded Gloves	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
MgO	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Plastic / Kim Wipes / Rubber	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Resin	non-disp. mat. (large resin beads)	0	0	0	0
Unleaded Gloves	contamination on flexible substrate	1	1.0E-03	0.1	1.0E-04
Hydrogenous Salt	small chunks/powder	0.1	2.0E-03	0.3	6.0E-05
Al_2O_3 crucible pieces	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Calcium Salt	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
CaO	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Calcium Metal	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06

Description	Physical Characteristic	*DR*	*ARF*	*RF*	*RRF*
Cemented Residue	non-disp. mat. (cemented piece)	0	0	0	0
Evaporator Bottom	liquid	1	2.0E-04	0.5	1.0E-04
Filter Residue	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Hydroxide Precip.	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
DOR Salt	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Incinerator Ash	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Oxalate Precip.	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
ER Salt	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Misc. Salt	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Silica	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Sweepings	loose, free-flowing powder	1	2.0E-03	0.3	6.0E-04
MSE Salt	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Pu-238 ITEMS					
Solid Metal - ^{238}Pu	large pieces, < 10% fines in bottom	0.01	2.0E-03	0.3	6.0E-06
Dioxide - ^{238}Pu	loose, free-flowing powder	1	2.0E-03	1	2.0E-03
Hydride - ^{238}Pu	loose, free-flowing powder	1	2.0E-03	0.3	6.0E-04
Non-Specific Gas - ^{238}Pu	gas	1	1	1	1
Hexafluoride - ^{238}Pu	gas	1	1	1	1
Cellulose Rags - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Paper / Wood - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Non-spec. Non-comb. - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Filter Media - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Glass - ^{238}Pu	contamination on flexible substrate	0.01	2.0E-03	1	2.0E-05
HEPA Filters - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Leaded Gloves - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Plastic/Kim Wipes - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Unleaded Gloves - ^{238}Pu	contamination on flexible substrate	1	1.0E-03	1	1.0E-03
Calcium Salt - ^{238}Pu	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Filter Residue - ^{238}Pu	small chunks and powder	0.1	2.0E-03	1	2.0E-04
Hydroxide Precip - ^{238}Pu	small chunks and powder	0.1	2.0E-03	0.3	6.0E-05
Incinerator Ash - ^{238}Pu	small chunks and powder	0.1	2.0E-03	1	2.0E-04
Sweepings - ^{238}Pu	loose, free-flowing powder	1	2.0E-03	1	2.0E-03

Examples

The MAR is calculated as follows:

$$\text{DOT}\ MAR(g) = \frac{Dose}{f_{DOT} * DCF}$$

$$3010\ MAR(g) = \frac{Dose}{RRF * DF * DCF}$$

Where Dose is either 100 rem (defining the boundary between high and low packaging requirements) or 5 rem (defining the boundary between low packaging requirements and quantities which are out of scope).

Example 1. For a loose, free-flowing dioxide powder of typical actinides, above what quantity of material (i.e., the MAR) would require the high package requirement?

- The Dose is 100 rem (high packaging requirements)
- $f_{DOT} = 1 \times 10^{-6}$
- Loose, free-flowing oxide powder
    - o DR = 1
    - o ARF = 2×10^{-3}
    - o RF = 0.3
    - o RRF = $1 \times (2 \times 10^{-3}) \times 0.3 = 6 \times 10^{-4}$
    - o DF = 7.7×10^{-4}

Table 4-2 Dose = 100 rem CEDE

Isotope or Material	Dose (rem CEDE)	Dose Conversion Factor (rem CEDE/g)	f_{DOT}	RRF_{3010}	MAR_{DOT} (g)	MAR_{3010} (g)
^{233}U	100	3.1×10^{5}	1.0×10^{-6}	6.0×10^{-4}	320	690
WG U	100	2.0×10^{3}	1.0×10^{-6}	6.0×10^{-4}	50,000	108,000
^{239}Pu	100	1.1×10^{7}	1.0×10^{-6}	6.0×10^{-4}	9.2	20
WG Pu	100	1.5×10^{7}	1.0×10^{-6}	6.0×10^{-4}	6.6	14
FG Pu	100	2.2×10^{7}	1.0×10^{-6}	6.0×10^{-4}	4.6	10
^{238}Pu	100	2.8×10^{9}	1.0×10^{-6}	6.0×10^{-4}	0.036	0.080
^{241}Am	100	5.0×10^{8}	1.0×10^{-6}	6.0×10^{-4}	0.20	0.43

Example 2. For a loose, free-flowing dioxide powder of typical actinides, below what quantity (i.e., MAR in grams) would be out of scope of this manual?

- The Dose is 5 rem (threshold between low packaging and out-of-scope)
- $f_{DOT} = 1 \times 10^{-6}$
- Loose, free-flowing oxide powder
  - DR = 1
  - $ARF = 2 \times 10^{-3}$
  - RF = 0.3
  - $RRF = 1 \times (2 \times 10^{-3}) \times 0.3 = 6 \times 10^{-4}$
  - $DF = 7.7 \times 10^{-4}$

Table 4-3 Dose = 5 rem CEDE

Isotope or Material	Dose (rem CEDE)	Dose Conversion Factor (rem CEDE/g)	f_{DOT}	RRF_{3010}	MAR_{DOT} (g)	MAR_{3010} (g)
^{233}U	5	3.1×10^{5}	1.0×10^{-6}	6.0×10^{-4}	16	35
WG U	5	2.0×10^{3}	1.0×10^{-6}	6.0×10^{-4}	2,500	5,400
^{239}Pu	5	1.1×10^{7}	1.0×10^{-6}	6.0×10^{-4}	0.46	1.0
WG Pu	5	1.5×10^{7}	1.0×10^{-6}	6.0×10^{-4}	0.33	0.71
FG Pu	5	2.2×10^{7}	1.0×10^{-6}	6.0×10^{-4}	0.23	0.50
^{238}Pu	5	2.8×10^{9}	1.0×10^{-6}	6.0×10^{-4}	0.0018	0.0039
^{241}Am	5	5.0×10^{8}	1.0×10^{-6}	6.0×10^{-4}	0.010	0.022

Attachment 5

10 CFR 835 Requirements Applicable to Packaging of Radioactive Material

1.0 10 CFR 835 Sections that apply to this Manual

§ 835.1 Scope.

(a) General. The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

§ 835.101 Radiation Protection Programs.

(a) A DOE activity shall be conducted in compliance with a documented radiation protection program (RPP) as approved by the DOE.
(b) The DOE may direct or make modifications to a RPP.

§ 835.401 General Requirements.

(a) Monitoring of individuals and areas shall be performed to:
 (5) Verify the effectiveness of engineering and process features and administrative controls in containing radioactive material and reducing radiation exposure.

§ 835.603 Radiological areas and radioactive material areas.

Each access point to radiological areas and radioactive material areas (as defined at § 835.2) shall be posted with conspicuous signs bearing the wording provided in this section.
(g) Radioactive Material Area. The words "Caution, Radioactive Material(s)" shall be posted at each radioactive material area.

§ 835.605 Labeling items and containers.

Except as provided in § 835.606, each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material." The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers, to take precautions to avoid or control exposures.

§ 835.606 Exceptions to labeling requirements.

(a) Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:

 (2) The quantity of radioactive material is less than one tenth of the values specified in appendix E of this part.