Designation: E1760 – 16

# Standard Guide for Unrestricted Disposition of Bulk Materials Containing Residual Amounts of Radioactivity[1]

This standard is issued under the fixed designation E1760; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

The feasibility of recycling bulk material containing trace amounts of radioactive contamination depends on the dose to the public that could occur as a result. However, the assessment of this dose depends not only on the measurements of contaminants present, but also on the future use of the material and the pathways by which persons can be exposed. This guide provides a recommended approach to support a petition (to a regulatory agency) seeking approval for the recycle or disposal of the material outside of the radioactive materials regulatory control.

Since dose rate limits to the public have been established by regulation for decommissioning by NRC (25 mRem/y) and remediation sites by EPA (15 mRem/y), this guide provides an approach to demonstrate compliance with those regulations.

This guide describes the steps needed to implement recommendations for the development of a data package to support the petition and to serve as a permanent record.

## 1. Scope

1.1 This guide provides an approach for developing a basis for obtaining approval for release of bulk materials to be removed from a decontamination and decommissioning (D&D) or environmental remediation site from regulatory control. This would be addressed in the decommissioning plan (Guide E1281). Fig. 1 follows the logic described in the MARSAME for determining the materials that could be considered for release. Materials that negotiate this logic tree are referred to as "candidate for release based on dose."

1.2 For purposes of this guide, bulk materials shall consist of, for example, building materials, concrete rubble, soils, and internally contaminated or activated equipment and facility components.

1.3 This guide is intended to apply to those equipment and materials to be removed from the site for their disposition as opposed to real property (buildings and grounds) that are to remain.

1.4 **Warning—**Breathing of asbestos dust is hazardous. Asbestos and asbestos products present demonstrated health risks for users and for those with whom they come into contact. In addition to other precautions, when working with asbestos products, minimize the dust that results. For information on the safe use of chrysoltile asbestos, refer to "Safe Use of Chrysotile Asbestos: A Manual on Preventive and Control Measures."

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard see 1.4.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2216 Guide for Evaluating Disposal Options for Concrete from Nuclear Facility Decommissioning

E1892 Guide for Preparing Characterization Plans for Decommissioning Nuclear Facilities

E1893 Guide for Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments to Support Unrestricted Release from Further Regulatory Controls

E1281 Guide for Nuclear Facility Decommissioning Plans

[1] This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.03 on Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components.

Current edition approved July 1, 2016. Published August 2016. Originally approved in 1996. Last previous edition approved in 2009 as E1760-09. DOI: 10.1520/E1760-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

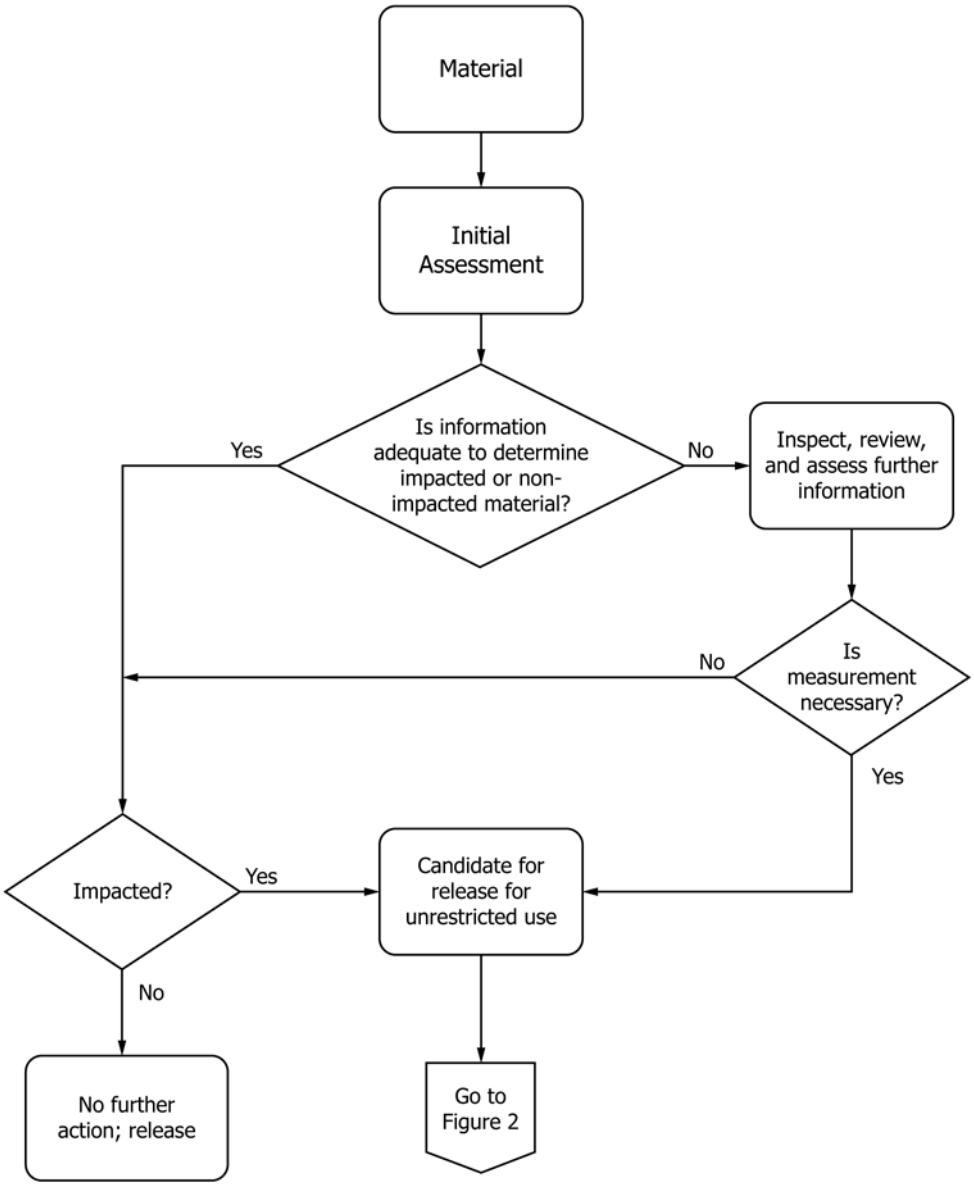


**FIG. 1 Prerequisites for Material To Be Candidate For Release**

2.2 *ANSI Standards:*[3]

ANSI N13.12 Surface and Volume Radioactivity Standards for Clearance

2.3 *DOE Documents:*

DOE Order 458.1 Radiation Protection of the Public and the Environment[4]

RESRAD RESidual RADioactivity Family of Computer Codes Developed for DOE by the Argonne National Laboratory[5]

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from Department of Energy, National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161.

[5] C. Yu, et al., "Users Manual for RESRAD, ANL/EAD-4,"; "Users Manual for RESRAD-BUILD," ANL/EAD-03-1,"; "Users Manual for RESRAD-OFFSITE," NUREG/CR-6937 and "RESRAD-RECYCLE, A Computer Model for Analyzing the Radiological Dose and Risks Resulting from the Recycle of Scrap Metal and the Reuse of Surface Contaminated Material and Equipment," ANL/EAD-3. Available online at www.ead.anl.gov.

2.4 *International Atomic Energy Agency Document:*[6]
Application of Exemption Principles to the Recycle and Reuse of Materials from Nuclear Facilities
IAEA TECDOC-855 Clearance Levels for Radionuclides in Solid Materials

2.5 *Nuclear Regulatory Commission Documents:*[7]
NUREG/CR-5512, Residual Radioactive Contamination from Decommissioning
NUREG-1575, Rev. 1 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)
NUREG-1576 Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP)
NUREG-1575 Supplement 1, Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME)
Regulatory Guide 1.86 Termination of Operating Licenses for Nuclear Reactors
NRC Inspection and Enforcement (IE) Circular 81-07 Control of Radioactively Contaminated Material

2.6 *U.S. Government Documents:*[7]
10 CFR 20 , Standards for Protection Against Radiation, Subpart E, Radiological Criteria for License Termination
10 CFR 20 , Standards for Protection Against Radiation, Subpart K, Waste Disposal
40 CFR 192 , Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings
10 CFR 60 , Disposal of High-Level Radioactive Wastes in Geological Repositories
10 CFR 61 , Licensing Requirements for Land Disposal of Radioactive Waste
40 CFR 117 , Determination of Reportable Quantities for Hazardous Substances
40 CFR 261 , Identification and Listing of Hazardous Waste
40 CFR 268 , Land Disposal Restrictions
40 CFR 712 , Chemical Information Rules
40 CFR 716 , Health and Safety Data Reporting

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *credible, adj*—offering reasonable grounds for being believed.

3.1.2 *intended use, n*—the first use planned for the material proposed to be released from radiological controls.

3.1.3 *primary dose limit, n*—the limit for exposures that could occur via the intended use scenario.

3.1.4 *secondary dose limit, n*—the limit for exposure that could occur via the unplanned use scenario.

3.1.5 *unplanned use, n*—any use other than the planned use that may occur after the intended use or by accident.

3.1.6 *TRU, transuranic, n*—those elements above uranium in the periodic table.

3.1.7 *initial assessment, n*—the first step in the investigation of material and equipment, similar to the historical site assessment in MARSSIM.

3.1.8 *non-impacted, adj*—term that applies to material and equipment where there is no reasonable potential to contain radionuclide concentration(s) or radioactivity above background.

3.1.9 *impacted, adj*—term that applies to material and equipment that is not classified as non-impacted.

## 4. Objective

4.1 The objective of this guide is to provide a methodology for distinguishing between material that must be carefully isolated to prevent human contact from that which can be recycled or otherwise disposed of. It applies to material in which the radioactivity is dispersed more or less uniformly throughout the volume of the material (termed residual in bulk form) as opposed to surface contaminated objects.

4.2 Surface contaminated objects are materials externally contaminated with radioactive material. Provisions already exist for their release for recycle if it can be shown that they meet applicable federal and state regulatory requirements for surface contamination. NRC IE Circular 81–07, Regulatory Guide 1.86 and DOE Order 458.1 provide guidance on radioactive surface contamination levels on material to be released for unrestricted use.

4.3 The release of bulk material containing residual radioactive material (except for $^{226}$Ra), such as soil, equipment and building rubble or slightly activated metal, is based on the demonstration that the dose to a member of the public will be lower than a specified value (proposed by the petitioner or defined by regulation) for its intended use *and* lower than a second specified value via the most restrictive plausible scenario. The first proposed value should be lower than the second since the dose to any member of the public (via the intended use scenario) will almost certainly be realized, whereas the dose from the alternate scenario will only accrue if an unintended (and presumably less probable) circumstance arises. Federal regulation already exists for the release of $^{226}$Ra contaminated soils (40 CFR 192).

## 5. Summary of Guide

5.1 The owner of the material must first determine if the material is candidate for release. To do this one must take representative samples of the bulk material and identify the radioactive contaminants and concentrations. The MARLAP document presents laboratory protocols that provide assurances for the quality and accuracy of the sample analysis. Sampling should be done using standard statistical inspection methods. The MARSSIM document provides guidance for design of sampling protocols in accordance with accepted statistical standards. For bulk materials contaminated on the exposed surfaces only, Guide E1893 provides guidance for measurement and assessment of this radioactivity. The kinds of analyses shall be appropriate for the potential contaminant expected, and performed using standard techniques (E1892). For some of these analyses, for example, $^{3}$H or $^{14}$C in activated

[6] International Atomic Energy Agency, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria.

[7] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

concrete or $^{55}$Fe in steel, the standard techniques are beyond the capabilities of many laboratories. Material that passes the logic diagram shown in Fig. 1 is candidate for release. The sampling, analysis, and determination of candidacy must be documented and included in the record package. The RESRAD family of computer codes, particularly RESRAD-RECYCLE, provide a methodology for correlating unrestricted disposition criteria with the measurable radiological quantities contained within the bulk materials. For example, end-point receptor dose may be correlated to radioactive concentration through site-specific pathways.

5.2 Fig. 2 diagrammatically shows how a material that is candidate for release should be treated to justify its release from radiological restriction use. Section 8 describes the methodology shown.

## 6. Significance and Use

6.1 Materials encountered during D&D may contain residual radioactivity varying in amounts from that in irradiated fuel to barely detectable quantities in or on building materials. It is clear that highly radioactive materials have to be disposed as radioactive waste pursuant to 10 CFR 60 and 10 CFR 61. Conversely, it is not reasonable to expend a disproportionate amount of resources to isolate materials that contain minute quantities of radioactive materials that will not cause even statistically measurable health effects.

6.2 This guide provides a rationale and methodology for distinguishing between materials that contain sufficient radioactivity to warrant isolation of some type (such as storage awaiting decay, near-surface disposal, disposal with intruder protection, or placement in a deep repository) from materials with insignificant radioactive content. Materials with insignificant radioactive content can be recycled in the economy or disposed of in conventional (landfill) facilities without adverse health effects. Materials that meet the criteria identified in this guide are not simply excluded from regulation because they do not fall precisely in the regulatory scope. They are sufficiently free of radioactive material so that no further efforts at control are justified for radiation protection purposes. Therefore, the release of materials for unrestricted use in accordance with this guide meets the criteria for being an “as low as reasonably achievable” (ALARA) activity.

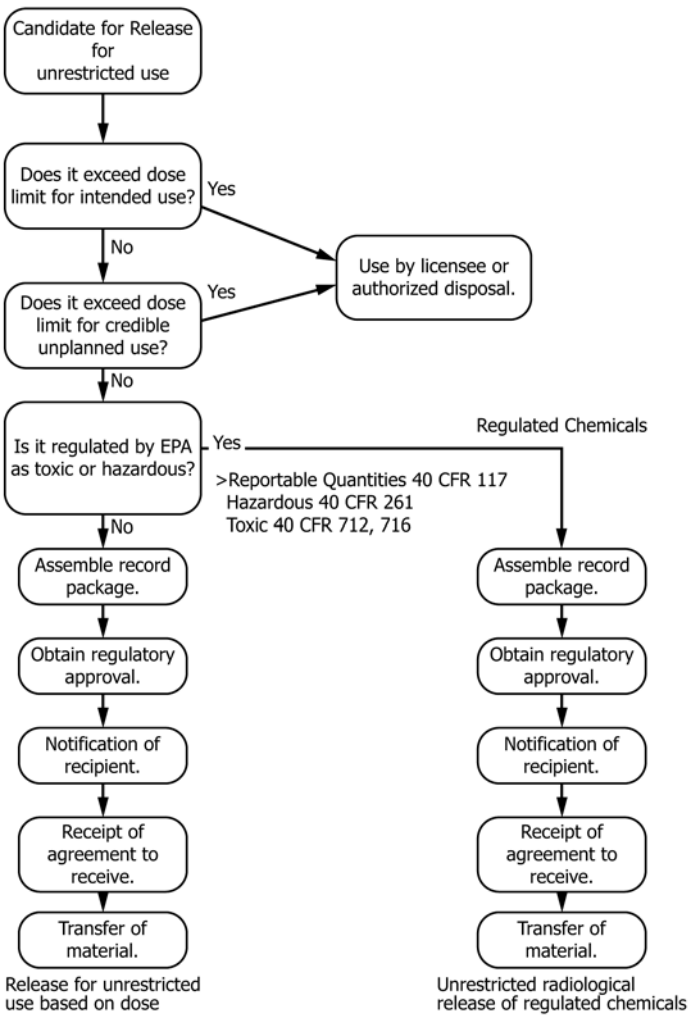


**FIG. 2 Methodology for Approving Candidate Material for Unrestricted Release**

6.3 For the purpose of this guide, the return of materials containing residual radioactivity to society without regulatory restrictions is referred to as "unrestricted release based on the absence of the credible potential for adverse health effects." This guide asserts that materials recycled this way will have no statistically measurable health effects regardless of use. It does not guarantee that the materials are suitable for use in every possible application, for example, trace amounts of radionuclides in materials may not be acceptable for certain photographic and electronic applications.

6.4 This guide also asserts that the owner of the materials is responsible for ensuring that society's criteria for "no measurable health effects" is met before release, and that the responsibility for providing materials with the purity required for a special application rests not with the owner, but with the developer of that application.

## 7. Criteria for Unrestricted Release

7.1 There are three criteria for the release of bulk materials that are candidates for release (that is, that have negotiated the logic diagram shown in Fig. 1). First, the material must not be expected to cause more than the intended use dose limit when used for the intended purpose. Second, the material must not be expected to cause more than the unplanned use dose limit when used for the most restrictive credible unplanned purpose. Finally, the materials must maneuver the procedural gates described in this guide successfully. The RESRAD computer code system and NUREG/CR-5512 provide pathway computer code methodologies for supporting the logic determinations. ANSI N13.12 provides dose consequences for a variety of assumed pathways. Regulatory limits that must be addressed are found in the CFRs referenced in Section 2.

7.2 The Multi-Agency Radiation Survey and Assessment of Materials and Equipment manual (MARSAME) is a supplement to the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) providing information on planning, conducting, evaluating, and documenting radiological disposition surveys for the assessment of materials and equipment. MARSAME is a multi-agency consensus document that was developed collaboratively by four federal agencies having authority and control over radioactive materials: Department of Defence (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC). The objective of MARSAME is to provide a multi-agency approach for planning and assessing disposition surveys of materials and equipment, while at the same time encouraging an effective use of resources.

## 8. Candidate Materials for Unrestricted Release

8.1 There are two groups of materials encountered in decontamination and decommissioning that are likely to be candidates for release for unrestricted use. The first group includes basic building materials that were used originally in the construction of a nuclear facility but were not exposed to significant amounts of activating radiation or radioactive contamination. The second group is materials that were contaminated but have been subjected to a decontamination treatment. Some types of building material from both groups that could be cost effectively released are described in 8.1.1 – 8.1.6.

NOTE 1—In the following sections, references to "release criteria" refer to criteria approved by the regulatory approval for unrestricted release.

8.1.1 Miscellaneous and structural steel that is not intended for use "as is" (on the basis of surface contamination) would be smelted. Contaminant levels in the melt would be minimized by avoiding the selection of steel from highly contaminated areas or surface cleaning the steel before smelting. In addition, the slagging process also generally reduces the concentration of contaminants in the melt. If the metal ingot met applicable release criteria it would not have to be disposed of as radioactive waste. At worst it would be disposed of in a sanitary landfill. Preferably it would be recycled.

8.1.2 Asbestos insulation is a porous bulk material that is not amenable to surface surveys. Economical decontamination methods for asbestos insulation have not been demonstrated. Ordinarily, most of the asbestos in a facility is not contaminated or is very slightly contaminated, but cannot be shown to be absolutely free of radioactivity. Asbestos could be disposed of in a permitted landfill instead of a licensed radioactive materials disposal site if shown to meet applicable release criteria.

8.1.3 Miscellaneous building materials such as wood, non-asbestos insulation, built-up roofing, and sheet rock are not amenable to surface survey for release. Although these materials are not ordinarily useful for recycle they could be disposed of in a sanitary landfill rather than at a licensed disposal facility if they met applicable release criteria.

8.1.4 Granular materials such as soil, concrete, or masonry rubble cannot be surveyed against surface criteria. However, they could be disposed of in a sanitary landfill or used as clean fill if shown to meet release criteria.

8.1.5 Neutron-activated material has radioactivity distributed within the solid mass because of the neutron transmutation of atoms within the material itself. Surface measurements generally are not appropriate for the release of such material. However, a metal could be smelted and the resulting ingot released if it met the applicable release criteria. Alternately, if the metal met that release criteria in the irradiated form, it could be reused as is.

8.1.6 Spent solvents and other hazardous materials that contain radioactive materials could be treated to reduce the concentration of radioactivity. Until now, there have not been standards for the cleanliness required before they could be considered to be released from regulatory control of the radionuclides. Therefore, no matter how much cleaning is done the materials have to be considered to be mixed waste. This guide would permit hazardous materials with trace radioactivity to be reused or disposed of as "hazardous-only" wastes if they could be shown to be compliant with criteria for unrestricted release. In this case the release for unrestricted use is termed "unrestricted radiological release of regulated chemicals" because non-radiological health effects must be considered in the future use or disposal of this material. Actions to be taken in consideration of non-radiological health effects are not addressed in this guide.

## 9. Implementation

9.1 This guide requires two logical steps. First, the material being considered for release must not explicitly be subject to regulatory control because of its radioactivity. The second step is to show that the dose by planned and unplanned scenarios is acceptably small (E2216, Safety Series No. 111-P-1.1). Fig. 1 shows diagrammatically how the first step is accomplished, and Fig. 2 outlines the process for the second step. The processes shown in the figures are described in 9.1.1 – 9.1.13.

9.1.1 A prerequisite to the first step in releasing material for unrestricted use is to identify and characterize the material (see 3.1). One needs to know or determine what radio-nuclides are present, their average concentration, and the amount of variation. This information is used to determine if a material should be candidate for release, and later to do the pathways analysis. Fig. 1 shows the methodology for determining a material's candidacy. By proceeding through these gates, materials that are subject to the regulations shown (because of the presence of radionuclides) are excluded one by one. Materials remaining are considered to be candidates for release. Subsequent steps are then taken to show that credible doses that may result are acceptable, and if so, the material may be released.

9.1.2 Dose limits for intended use and unplanned use must be established by future regulation. In lieu of such regulation, intended use and unplanned use dose limits should be proposed by the petitioner as noted in 9.1.4.

9.1.3 The intended use of the material shall be specified, and the person likely to have the highest risk (receptor) and the scenario for exposure shall be identified. These determinations shall be included in the documentation package described in 9.1.8. Appendix X1 gives some typical examples of material, intended use scenarios, and receptors.

9.1.4 Compute the annual dose to the receptor by way of the identified scenario. NUREG/CR-5512 and the RESRAD codes may be used for such calculations. Additional guidance is given in IAEA's "Application of Exemption Principles to the Recycle and Reuse of Materials from Nuclear Facilities." All applicable pathways shall be considered. For example, if material were to be disposed of in a landfill, a future resident might farm the area and be exposed through the food chain and by ingestion of well water. If the material were used to make structural steel, direct exposure would be assessed by determining the expected worst case geometry and occupancy. The computed annual dose is then compared with the dose limit for intended use. If the computed annual dose is less than the established dose limit, continue with the logic flow diagram. Otherwise, do not consider the material any further for unrestricted release. The results of the calculation and comparison shall be included in the record package described in 9.1.8.

9.1.5 The unplanned use scenario for the candidate material also shall be defined. This scenario must be for an unplanned event that would produce the greatest credible exposure to a person who could be justified as a reasonable receptor. Appendix X2 gives some examples of unplanned use scenarios. Include this determination of the unplanned use scenario in the record package.

9.1.6 Compute the annual dose to the receptor by way of the unplanned use scenario using all the applicable pathways. Use the same techniques that would be required in 9.1.4. Compare the result with the dose limit for unplanned use and continue if the annual dose is lower than the limit. If not, the material should not be considered further for release from radiologically restricted use. Include this calculation and comparison in the record package.

9.1.7 Determine whether the material (which has been shown to meet the dose based standards for release from radiological restrictions) is otherwise regulated because of chemical or toxic hazards. If the material is subject to regulation because of its chemical properties, the further steps in the radiological release process must be qualified. This is necessary to ensure that the release from radiological restrictions will not imply that the released material can be used for any and all purposes. This is emphasized in Fig. 2 by showing parallel paths for the remaining steps of the radiological release process for (*1*) materials regulated only because of radioactivity, and (*2*) materials regulated because of both radioactivity and hazardous or toxic properties.

9.1.8 Assemble the record package documenting 9.1.1 – 9.1.6 and submit it to the responsible regulatory agency (for example, NRC, DOE, or Agreement State) for approval. The following items should be included:

9.1.8.1 Plan for identification and quantification of radionuclides,

9.1.8.2 Concentrations and types of radioactive materials present,

9.1.8.3 Specification of intended use,

9.1.8.4 Identification of intended use scenario, pathways analysis, and receptor considered,

9.1.8.5 Calculation of dose from intended use scenario and comparison with primary dose limits,

9.1.8.6 Identification of unplanned use scenario, pathways analysis, and receptor,

9.1.8.7 Calculation of dose via the unplanned use scenario and comparison with the secondary dose limit, and

9.1.8.8 Sampling and analytical quality assurance associated with the determination.

9.1.8.9 For the radiological release of regulated chemicals the record package should also include sufficient chemical and physical data to characterize the material and indicate its relationship to the applicable regulations. The regulatory agency may require independent confirmatory analyses of the bulk material prior to granting approval for the requested disposition.

9.1.9 Proceed after obtaining approval from the responsible regulatory agency (for example, NRC, DOE, or Agreement State). If regulated chemicals are involved, additional permits or approvals may be required.

9.1.10 Identify the recipient who will receive the material from the owner for treatment or use. This recipient should not be a broker who merely transfers the material or ownership to it. If the intended release is to be the "unrestricted radiological release of regulated chemicals," this factor must be considered in selection of a recipient. The following information should be provided to the identified recipient:

9.1.10.1 A description of the material,

9.1.10.2 The intended use scenario considered,

9.1.10.3 A report giving the type and concentrations of residual radioactive material present, and

9.1.10.4 A statement asserting that the intended use dose limit will not be exceeded through the intended use of the material.

9.1.11 Obtain from the intended recipient (*1*) acknowledgement that the notification made in 9.1.10 was received, and (*2*) his agreement to receive the material for use as intended.

9.1.12 Deliver or ship the material to the intended recipient after receipt of the acknowledgement and agreement referenced in 9.1.11. For regulated chemicals the shipment may have to comply with special requirements of the Department of Transportation, the Environmental Protection Agency, and the states involved for the type of materials being shipped.

9.1.13 Ensure the indefinite and permanent retention of all documentation referenced in 9.1.1 – 9.1.11.

## 10. Keywords

10.1 decontamination and decommissioning; radiologically contaminated materials; release of materials

# APPENDIXES

**(Nonmandatory Information)**

## X1. TYPICAL INTENDED USES, EXPOSURE SCENARIOS, AND RECEPTORS FOR BULK MATERIAL RELEASE

X1.1 The intended use of a material is defined by the owner/petitioner based on the nature of the material and the plans of the intended recipient. The first column below lists common types of bulk materials encountered during decommissioning, as well as a common use for each. For example, concrete rubble could be used for clean fill, or disposed of in a sanitary landfill. Slightly contaminated asbestos, in contrast, has no reuse but can be disposed of in a permitted sanitary landfill if the dose to the public is sufficiently small. The second column identifies the way (scenario) that members of the public would receive the highest dose because of the intended use. For materials that are to be disposed of in a sanitary landfill, or used as fill, the greatest credible dose usually would occur if the land were later occupied by a resident farmer. The analysis to determine the magnitude of the resulting dose would include all of the usual pathways applicable in the area where the material is to be placed, that is, direct exposure, resuspension, meat, milk, vegetables, aquatic foods, and drinking water. A possible intended use scenario for ferrous metal that is to be melted and reused as structural steel would be the exposure to persons who dwell in an apartment constructed from that steel, and the applicable pathway would be by direct exposure. The third column lists the person who would receive the highest dose.

| Material Type/Use | Intended Use Scenario | Receptor |
|---|---|---|
| Building rubble/landfill | Residential | Farmer |
| Asbestos/landfill | Residential | Farmer |
| Granular material/landfill | Residential | Farmer |
| Granular material/clean fill | Residential | Farmer |
| Metal ingot/structural | Apartment Occupancy | Lessee |
| Hazardous waste/permitted disposal | Residential | Farmer |

## X2. TYPICAL UNPLANNED USES, EXPOSURE SCENARIOS, AND RECEPTORS FOR BULK MATERIAL RELEASE

X2.1 The unplanned use of a material would occur if by mistake the material were not used for its intended purpose, but in some other way. The unplanned use scenario is the credible alternative to the intended use that gives the highest dose. For example, material to be disposed of in a sanitary landfill may instead be dumped on the surface, or steel planned for structural purposes may instead be used in the manufacture of dishwashers or stoves. The residential farmer scenario is usually the most conservative for material placed in or on the ground, but pathways may differ. One suggested for granular fill is a residential scenario that includes as one pathway the ingestion by a child. Another pathway would apply if a resident farmer would dig up a hazardous waste disposal site and be exposed to the trace radionuclides present.

| Material Type/Use | Secondary Scenario | Receptor |
|---|---|---|
| Building rubble/landfill excavation | Residential | Farmer |
| Asbestos/landfill excavation | Residential | Farmer |
| Granular material/landfill excavation | Residential | Farmer |
| Granular material/clean fill | Consumption | Resident child |
| Metal ingot/structural | Home use | Domestic |
| Hazardous waste/permitted landfill excavation | Residential | Farmer |