
Radiological Control: *Radioactive Materials*

Course No: N02-005

Credit: 2 PDH

Gilbert Gedeon, P.E.



Continuing Education and Development, Inc.
22 Stonewall Court
Woodcliff Lake, NJ 07677

P: (877) 322-5800
info@cedengineering.com

CHAPTER 4 RADIOACTIVE MATERIALS

TABLE OF CONTENTS

Article	Page
PART 1 Radioactive Material Identification, Storage, and Control	
411 General.....	4-3
412 Radioactive Material Labeling.....	4-3
413 Radioactive Material Packaging.....	4-5
414 Radioactive Material Storage.....	4-6
PART 2 Release and Transportation of Radioactive Material	
421 Release to Controlled Areas.....	4-7
422 Release to Uncontrolled Areas.....	4-8
423 Transportation of Radioactive Material.....	4-9
PART 3 Sealed Radioactive Source Controls	
431 Sealed Radioactive Source Controls.....	4-11
PART 4 Solid Radioactive Waste Management	
441 Requirements.....	4-13
442 Waste Minimization.....	4-13
443 Mixed Waste.....	4-14
PART 5 Control of Radioactive Liquids and Airborne Radioactivity	
451 Minimization and Control of Radioactive Liquid Wastes.....	4-15
452 Control of Radioactive Drains.....	4-15
453 Control of Airborne Radioactivity.....	4-15
PART 6 Support Activities	
461 Control and Monitoring of Personal Protective Equipment and Clothing.....	4-16
462 Laundry.....	4-16
463 Decontamination.....	4-17
464 Vacuum Cleaners and Portable Air-Handling Equipment.....	4-17

Table

4-1 Radioactive Material Labeling4-4
4-2 Exceptions from Radioactive Material Labeling Requirements.....4-5

Last Page.....4-18

PART 1 Radioactive Material Identification, Storage, and Control

411 General

1. Materials in contamination, high contamination, or airborne radioactivity areas shall be considered contaminated until surveyed and released [see 835.1101(a)]. Any equipment or system component removed from a process that may have had contact with radioactive material should be considered contaminated until disassembled to the extent required to perform an adequate survey, surveyed, and shown to be free of contamination at levels exceeding the Table 2-2 values. These survey and release provisions do not apply to airborne radioactivity areas where only gaseous, short-lived (half-life of 1 hour or less) radionuclides are present. Detailed provisions for release of materials from radiological areas are provided in Article 421.
2. Radioactive material located within radiological areas does not require specific labeling or packaging if sufficient information is provided to allow individuals to take appropriate protective actions [see 835.606(a)]. The information may be provided by means of postings, pre-job briefings, training, or other appropriate means.
3. The site-specific radiological control manual should include response and notification requirements associated with a loss of radioactive material, including searches, internal investigations, documentation, and reporting. The radiological control organization should be notified in the event of a loss of radioactive material.

412 Radioactive Material Labeling

1. 10 CFR 835 requires labeling of individual containers of radioactive material and radioactive items except under certain specified conditions in which existing postings and control measures provide adequate warning [see 835.605 and 835.606(a)].
2. Postings and access control requirements for radiological areas generally provide sufficient personnel protection to negate the need for individual container or item labeling; however, items having removable contamination in excess of the Table 2-2 values should be labeled when used, handled, or stored in areas other than contamination, high contamination, or airborne radioactivity areas.
3. Required labels shall include the standard radiological warning trefoil and the words “Caution” or “Danger” and “Radioactive Material” [see 835.605]. The “Danger” heading should be used when an individual exposed to, using or handling the material could receive an equivalent dose exceeding any applicable administrative control level in one hour. The radiation warning trefoil shall be black or magenta and imposed upon a yellow background [see 835.601(a)]. Magenta is the preferred color for the trefoil and the lettering.
4. Required labels shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the labeled material to take appropriate actions to control exposures [see 835.605]. The following information should be included on radioactive material labels, to the extent appropriate to the radiological hazard created by the material and the education, training, and skills of the individuals who may be exposed to the hazards:
 - a. Radionuclide(s)
 - b. Radiological hazard information (e.g., radiation and contamination levels)
 - c. Total quantity of radioactive material (in subunits or multiple units of curies)
 - d. Date of survey
5. If an item is too small to be labeled with all of the desired information, the label should be applied to the device or storage location with sufficient information available to trace the item to the appropriate label.

6. If a label is applied to packaged radioactive material, the label should be applied to the outside of the package or be visible through the package.
7. Radioactive materials and containers should be labeled in accordance with Table 4-1.

Table 4-1: Radioactive Material Labeling

ITEM/MATERIAL	REQUIRED LABELING ¹	SUPPLEMENTAL LABELING ²
Equipment, components, and other items that are radioactive, potentially radioactive, or have been exposed to radioactive contamination or activation sources	Standard radiation warning trefoil, and "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL"	"CONTAMINATED" or "POTENTIALLY CONTAMINATED"
Sealed or other radioactive sources, or associated storage containers		
Equipment, components, and other items with actual or potential internal contamination		"INTERNAL CONTAMINATION" or "POTENTIAL INTERNAL CONTAMINATION"
Components, equipment, or other items with fixed contamination		"FIXED CONTAMINATION"

Footnotes:

- 1 Labeling required on item or container meets the criteria established in 10 CFR 835.605.
- 2 See items listed in Article 412.4.

8. Items and containers may be excepted from labeling in accordance with Table 4-2.

Table 4-2: Exceptions from Radioactive Material Labeling Requirements¹

Exception Criteria	Items Typically Included ²
Material is used, handled, or stored in radiological areas or radioactive material areas [see 835.606(a)(1)]	All radioactive material in radiological areas and radioactive material areas. This exception should not be applied to items that have removable contamination exceeding the Table 2-2 values that is stored outside of contamination, high contamination, or airborne radioactivity areas.
Material having a total quantity of radioactive material below one tenth of the values in Appendix E of 10 CFR 835 and less than 0.1 Ci. [See 835.606(a)(2)]	Items having extremely low levels of radioactive material content, such as low-activity sealed radioactive sources, laundered personal protective equipment and tools and equipment having low levels of fixed contamination
Material that has been packaged, labeled, and marked in accordance with the applicable (e.g., DOE or Department of Transportation) radioactive material transportation requirements [see 835.606(a)(3)]	Radioactive material packages awaiting shipment
Material that is inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity [see 835.606(a)(4)]	Material stored in locked areas or areas having strict physical and administrative entry controls that preclude unauthorized entry. Radioactive samples being handled or transported by authorized personnel.
Material that is installed in manufacturing, process, or other equipment [see 835.606(a)(5)]	Piping, tanks, valves, instrument sensors, test sources, etc., that are installed in immobile systems
Material that consists solely of nuclear weapons or their components [see 835.606(a)(6)]	Nuclear weapons components

Footnotes:

- 1 Caution should also be exercised to ensure that other applicable requirements (e.g., member of the public dose limits [Table 2-1], training requirements [Table 3-1], ALARA requirements [Article 117], controlled area dose expectation [Article 232]) will be met in the absence of radioactive material labels.
- 2 Caution must be exercised to ensure that the listed items actually meet the criteria established in the first column.

413 Radioactive Material Packaging

1. Radioactive material that is outside contamination, high contamination, or airborne radioactivity areas and is confirmed or suspected of having removable radioactive contamination levels greater than Table 2-2 values should be securely wrapped in plastic or placed in a closed container.
2. Radioactive material with sharp edges or projections should be taped or additionally protected to ensure package integrity.

3. Radioactive material with removable or potentially removable contamination levels in excess of 100 times Table 2-2 values should have additional packaging controls such as double-wrapping or the use of plastic bags inside containers.
4. Yellow plastic wrapping material (or clear plastic bags properly marked) should be used for packaging radioactive material and should not be used for non-radiological purposes.
5. The amount of combustible material used in packaging should be minimized.

414 Radioactive Material Storage

1. Radioactive material in quantities exceeding the applicable quantities shall be used, handled, and stored in a radioactive material area or other area posted in accordance with Article 234 or 235, as appropriate [see 835.2(a), radioactive material area, and 835.603].
2. Decontamination or disposal of radioactive material is the preferred alternative to long-term storage.
3. Each radioactive material area should be established consistent with guidelines in the site-specific radiological control manual. The radiological control manager or designee has the authority to defer the establishment of a radioactive material area.
4. A custodian should be assigned responsibility for each radioactive material area. A custodian may have responsibility for more than one storage area.
5. The custodian should conduct walk-throughs of radioactive material areas at least monthly to check integrity of containers and wrapping materials.
6. The custodian should conduct annual or more frequent reviews of each radioactive material area, with emphasis on treatment, decontamination, movement of material to long-term storage locations, and disposal of unneeded material.
7. Storage of non-radioactive material in a radioactive material area is discouraged.
8. Outdoor storage of radioactive material is discouraged. In cases where outdoor storage is necessary, the integrity of containers or wrapping materials used should be ensured to prevent degradation from weathering and subsequent release of radioactive material.
9. Radioactive material should be stored in a manner that reduces combustible loading. The use of cardboard containers for storage is discouraged.
10. Flammable or combustible materials should not be stored adjacent to radioactive material areas.
11. Fire protection measures, such as smoke detectors, water sprinklers, and fire extinguishers, should be considered when establishing a radioactive material area.

PART 2 Release and Transportation of Radioactive Material

421 Release to Controlled Areas

Once materials and equipment have entered radiological areas controlled for surface contamination or airborne radioactivity, comprehensive and time-consuming evaluations of the potential for contamination are required prior to releasing the material or equipment to controlled areas. Likewise, exposure of certain materials and equipment to a beam of neutrons or other particles produced in a nuclear reactor or particle accelerator may result in activation of that material or equipment, resulting in the creation of radioactive material requiring controlled use, storage, and disposal. The need for evaluation of the radiological characteristics of these materials and equipment and implementation of appropriate controls provides substantial impetus for implementation of measures to limit the amount of material and equipment that enters radiological areas and to prevent contamination or activation of materials and equipment that do enter these areas.

1. Accessible surfaces of material or equipment that has entered contamination, high contamination, or airborne radioactivity areas shall be surveyed prior to release from these areas to controlled areas [see 835.1101(a)]. Guidance for conducting these surveys is provided in the footnotes to Table 2-2.
2. If an assessment of the prior use of the material or equipment indicates that inaccessible surfaces are not likely to be contaminated in excess of applicable limits, a complete survey of accessible surfaces and documentation of the assessment may be an appropriate basis to release materials to the controlled area [see 835.1101(a)(2)].
3. If an assessment of the prior use of the material or equipment indicates that inaccessible surfaces are likely to be contaminated to levels in excess of the Table 2-2 values, then the material shall not be released from the radiological area, except as permitted under Article 421.5 or 421.6 [see 835.1101(a)(2)]. If it is necessary to release the material or equipment from the radiological area, the material or equipment should be disassembled to the extent necessary to perform adequate surveys.
4. Contamination levels shall be less than Table 2-2 values prior to releasing material and equipment for unconditional use in controlled areas [see 835.1101(a) & (b)].
5. Material and equipment with fixed contamination levels that exceed the total contamination values specified in Table 2-2, and removable contamination levels less than Table 2-2 values, may be released for conditional use in controlled areas outside of radiological areas [see 835.1101(c) & (c)(1)]. The material or equipment shall be routinely monitored and clearly marked or labeled to alert individuals to the contaminated status [see 835.1101(c)(2)]. Written procedures should be developed to establish requirements for monitoring of the material or equipment and surrounding areas, control of access to these areas, authorized uses of the material or equipment, and contingency plans for spread of radioactive contamination.
6. Material and equipment with total or removable contamination levels exceeding Table 2-2 values may be moved on site from one radiological area to another if appropriate monitoring is performed and appropriate controls are established and implemented [see 835.1101(b)]. These controls should include provisions for containment to the extent practicable, labeling in accordance with Article 412, monitoring and control of the transfer route and participating individuals, and control of spills.
7. The requirements of 10 CFR 835.1101 apply only to material and equipment that is radioactive due to the deposition of radioactive surface contamination. Although DOE has not established any specific controls over the release of other radioactive materials (e.g., activated materials or intrinsically-radioactive materials) to controlled areas, the release of these materials is subject to other requirements of 10 CFR 835. The following regulatory requirements and guidance are applicable to the control of this type of material and equipment.

- a. Controls shall be adequate to ensure compliance with the radiation safety training requirements of 10 CFR 835.901. The presence of the material and equipment may result in occupational or non-occupational exposure of individuals to radiation or may result in individuals handling radioactive material. Chapter 6 provides guidance for implementing an appropriate training program.
 - b. Controls shall be adequate to ensure compliance with the 100 millirem in a year controlled area maximum total effective dose expectation [see 10 CFR 835.602]. DOE sites should adopt site- or facility-specific criteria that will ensure that intrinsically-radioactive material and other equipment in the controlled area, will not result in any individual exceeding this dose expectation.
 - c. Controls shall be adequate to ensure the ALARA process is properly implemented [see 10 CFR 835.101 and 1001 - 1003]. Given the low levels of radioactivity that are likely to be present in material and equipment in controlled areas, the controls should not be burdensome. Options that should be considered include retention in radiological areas, placement in specified areas with appropriate access restrictions and usage controls, posting, labeling or color-coding, storage for decay, removal of radioactive components, and disposal as radioactive waste.
8. When radioactive materials are moved outside of radiological areas, controls should be established to ensure no unmonitored individual is likely to exceed an equivalent dose that would require monitoring in accordance with Article 511 or 521.
9. Records for release of materials should describe the property, date of last survey, identity of the individual who performed the survey, type and identification number of the survey instruments used, and survey results. For small items and packages of similar items (such as boxes of tools or boxes of fasteners), it is not necessary to create a separate survey record for each item. However, the survey record should provide traceability to the individual removing the item from the radiological area.
10. Per 10 CFR 835.1(b)(7), the requirements in 10 CFR 835 do not apply to radioactive material on or within material, equipment, and real property which is approved for release when the following conditions are met:
- a. The radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit and
 - b. The DOE authorized limit has been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer.

422 Release to Uncontrolled Areas

1. DOE O 458.1 and associated guidance documents describe the process for release/clearance of surface contaminated material, equipment or real property based on authorized limits.
 - a. Material, equipment or real property for which the authorized limit meet the pre-approved criteria in DOE O 458.1 may be released from DOE radiological controls without any restrictions on future use.
 - b. In addition, authorized limits may be approved for material, equipment or real property with surface contamination levels greater than the pre approved criteria.
2. DOE O 458.1 pre approved authorized limits for release of surface contaminated material, equipment or real property may differ from those limits established in this standard for release of surface contaminated material, equipment and real property.
3. DOE O 458.1 and associated guidance documents describe the process for obtaining approved authorized limit for releasing material, equipment or real property that has been contaminated in depth or volume, such as activated materials or smelted material.

4. Material, equipment or real property with radioactive material on its surface or within its volume is exempt from the provisions of 10 CFR 835 if it may be released in accordance with an authorized limit approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer [10 CFR 835.1(b)(6)].

423 Transportation of Radioactive Material

1. 49 CFR 170 through 180 establish requirements for inspecting and surveying packages, containers, and transport conveyances prior to transport via the public transportation system. These regulations apply to radioactive material transportation in commerce.
2. DOE Orders 460.1C, Packaging and Transportation Safety and 460.2A, Departmental Materials Transportation and Packaging Management provide requirements that are in conformance with 49 CFR 173 requirements for transportation and packaging of radioactive material using any conveyance. 10 CFR 835.1(b)(7) excludes radioactive material transportation not performed by DOE or DOE contractors from compliance with 10 CFR 835 regulations. However, radioactive material transportation (as defined in 10 CFR 835) does not include preparation of materials for shipment, packaging and labeling, or storage of material awaiting transportation for shipment. These activities shall be conducted in accordance with 10 CFR 835 [see 835.2(a), radioactive material transportation, and 835.1(b)] and should be conducted in accordance with this Standard.
3. Table 2-2 removable contamination values are more limiting than 49 CFR requirements and should be used as controlling limits for on-site and off-site transportation when using a conveyance that is owned by DOE or a DOE contractor [835.1(d)]. However, when a shipment is received from an off-site destination, by a non-DOE conveyance, the 49 CFR 173 transportation contamination values should be applied to all subsequent on-site transfers to the ultimate on-site destination.
4. On-site transfers over non-public thoroughfares or between facilities on the same site should be performed in accordance with written procedures utilizing pre-approved routes. The procedures or other measures should include requirements to ensure appropriate monitoring and control of the radioactive material and should be approved or concurred with by the radiological control organization.
5. On-site transfers over public thoroughfares by non-DOE conveyance shall be performed in accordance with Department of Transportation, state and local shipping requirements and pre-approved agreements. Onsite transfers over public thoroughfares by DOE conveyance shall be performed in accordance with applicable DOE Orders and should conform with state and local shipping requirements and pre-approved agreements [see DOE O 460.1C].
6. Before shipment and upon receipt of a radioactive material shipment, a visual inspection of packages should be performed to ensure that packages are not damaged. The inspection should identify dents, flaking paint, debris, package orientation, and any indication of leakage.
7. Before shipment and upon receipt of a radioactive material shipment, a comparison of package count to the shipping manifest should be made to ensure accountability.
8. Transport conveyances should be visually inspected prior to loading to ensure the trailers are acceptable for the intended use.
9. To the extent practicable, transport conveyances should be radiologically surveyed before loading, especially when using commercial carriers specializing in radioactive transport. The surveys should be adequate to identify any contamination remaining on the vehicle from previous radioactive material transport evolutions, such that DOE and its contractors would not be held liable.

10. Transport of large volumes of radioactive material by non-DOE motor vehicles should be "exclusive use" to prevent commingling of DOE and other commercial shipments.
11. The site emergency plan should describe provisions for response for those potential on-site radioactive material transportation accidents that would be categorized as an Operational Emergency
12. Specific arrangements shall be made for receiving packages containing radioactive material, regardless of the means of conveyance, in excess of Type A quantities (as defined in 10 CFR 71.4). These arrangements shall include making arrangements to receive packages upon delivery or to receive notification of delivery which leads to expeditious receipt of the package [see 835.405(a)].
13. Written procedures for safely opening packages should be developed and maintained. These procedures should include due consideration of the type of package and potential hazards present.

PART 3 Sealed Radioactive Source Controls

431 Sealed Radioactive Source Controls

Sealed radioactive sources, as defined in 10 CFR 835.2, having activities equal to or exceeding the values specified in 10 CFR 835 Appendix E are considered accountable sealed radioactive sources.

1. Written procedures shall be established and implemented to control accountable sealed radioactive sources. These procedures should establish requirements for source acquisition, receipt, storage, transfer, inventory, leak testing, and usage. These procedures shall include reporting to the DOE Radiological Source Registry and Tracking system [See DOE Order 231.1B].
2. Accountable sealed sources and all other sealed radioactive sources having activities exceeding one tenth of the values in Appendix E, 10 CFR 835, or their storage containers, shall be labeled with the radiation symbol and "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL" [see 835.605]. The label shall also provide sufficient information to control exposures [see 835.605]. Because of the wide variety of labels that are affixed to sealed radioactive sources by their manufacturers, these labels are excepted from the normal color scheme of magenta or black on yellow [see 835.606(b)]. If the size or configuration of the source precludes application of a suitable label, the label should be attached to the source container or mechanism.
3. Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months [see 835.1202(a)]. This inventory shall [see 835.1202(a)]:
 - a. Establish the physical location of each accountable sealed radioactive source.
 - b. Verify that the associated posting and labeling are adequate
 - c. Establish that storage locations, containers, and devices are adequate
4. Each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected and at intervals not to exceed six months [see 835.1202(b)]. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 μCi (as indicated by the presence of 0.005 μCi or more activity on the leak test sample) [see 835.1202(b)].
5. Periodic leak tests need not be performed if the source has been documented to have been removed from service. Such sources shall be stored in a controlled location and subject to periodic inventory in accordance with Article 431.3 and subject to leak testing prior to being returned to service [see 835.1202(c)].
6. If a source is located in an area that is unsafe for human entry or otherwise inaccessible, (such as due to operational or environmental constraints), then periodic inventories and leak tests need not be performed [see 835.1202(d)]. When the conditions that restrict access to the area have been terminated, the inventory and integrity test should be performed before allowing uncontrolled access to the area.
7. If an accountable sealed radioactive source is found to be leaking radioactive material, then controls shall be established to prevent the escape of radioactive material to the workplace [see 835.1202(e)]. These controls should include wrapping or containing the source, applying appropriate labels, and removing the source from service.
8. Both accountable and non-accountable sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with the operations involving the sources [see 835.1201].

9. The site-specific radiological control manual should specify controls for sealed radioactive sources having activities below one tenth of the accountability values in Appendix E, 10 CFR 835 to ensure their retention and proper use and storage.
10. Procurement of radioactive sources should be coordinated with the radiological control organization.
11. Receipt surveys of radioactive material shipments should be performed by the radiological control organization in accordance with Articles 552 and 554.
12. Sealed radioactive sources, including radiography sources, should not be brought on-site by external organizations without the prior knowledge and approval of the radiological control organization.
13. Accountable sealed radioactive sources without any documentation concerning origin and history of use should be evaluated with regard to their use and the need to upgrade associated radiological controls. The evaluation should consider:
 - a. Current source activity;
 - b. Chemical and physical form;
 - c. Estimated age and end-of-life expectations;
 - d. Use, including anticipated challenges to the source integrity during transportation; and
 - e. Potential hazards associated with failure of the source.
14. A custodian should be appointed to coordinate sealed radioactive source procurement, issue, inventory, leak testing, and other aspects of the sealed radioactive source control program. If justified by the scale of the program, sealed radioactive source user groups should appoint group-specific custodians to coordinate activities involving sealed radioactive sources within the group.
15. The sealed radioactive source control program should have in place procedures for controlling a sealed radioactive source that has exceeded its design life and is no longer in use. These procedures should address, at the least, sealed source integrity, leak testing, and disposal.

PART 4 Solid Radioactive Waste Management

441 Requirements

1. DOE O 435.1, Radioactive Waste Management, describes how solid radioactive waste is treated, packaged, stored, transported, and disposed.
2. Radiological operations generating radioactive waste should be designed and developed to promote minimization and permit segregation, monitoring, treatment, storage, and disposal [DOE O 435.1].
3. Radioactive waste minimization goals and practices should be developed and implemented [DOE O 435.1].

442 Waste Minimization

A radioactive waste minimization program should be in effect to reduce the generation of radioactive waste and spread of contamination from contamination, high contamination, or airborne radioactivity areas [see DOE O 435.1]. The following practices should be evaluated and instituted as appropriate to support waste minimization:

1. Restrict material entering radiological buffer areas and other areas surrounding contamination, high contamination and airborne radioactivity areas to that needed for performance of work.
2. Restrict quantities of hazardous materials, such as paints, solvents, chemicals, cleaners, and fuels, entering radiological buffer areas and other areas surrounding contamination, high contamination and airborne radioactivity areas and implement measures to prevent inadvertent radioactive contamination of these materials.
3. Substitute recyclable or burnable items in place of disposable ones and reuse equipment, chemicals, solvents, and cleaners when practical.
4. Select consumable materials such as protective coverings and clothing that are compatible with waste-processing systems, volume reduction, and waste form acceptance criteria.
5. Reserve an assortment of tools primarily for use in contamination, high contamination, or airborne radioactivity areas. Tools should be maintained in a designated storage or distribution area or a contaminated tool crib. Controls should be established for tool issuance and use.
6. Survey potentially contaminated material from contamination, high contamination and airborne radioactivity areas to separate uncontaminated from contaminated materials.
7. Segregate known uncontaminated from potentially contaminated waste.
8. Segregate reusable items, such as protective clothing, respirators, and tools, at the step-off pad.
9. Minimize the number and size of radioactive material areas.
10. Emphasize training in waste reduction philosophies, techniques, and improved methods.

443 Mixed Waste

Requirements specified in the Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) apply to waste that contains both radioactive and hazardous materials.

1. Technical and administrative controls should be established to minimize the volume of mixed waste generated and the amount of radioactivity in such waste. Volume reduction methods include process optimization, materials substitution, and new technology development.
2. Materials suspected of being mixed waste should be identified and segregated as soon as practical in the generating process to avoid combining mixed waste with other waste forms.

PART 5 Control of Radioactive Liquids and Airborne Radioactivity

451 Minimization and Control of Radioactive Liquid Wastes

DOE O 435.1 provides criteria for minimizing the generation of radioactive liquid waste.

452 Control of Radioactive Drains

Radioactive drain systems are designed to transport radioactive liquids. Improper use may cause an environmental release.

1. Radioactive drain systems should not discharge to the environment nor be used for the disposal of non-radioactive liquids.
2. Existing radioactive drains should be evaluated to ensure the following:
 - a. Verification of the existing radioactive drain piping configuration
 - b. Installation of flow-indicating devices in leak-off lines
 - c. Use of plugs to prevent non-radioactive input
 - d. Consideration of alternative work controls before systems are drained for maintenance
 - e. Controls prohibiting unauthorized use of drains.
3. Modifications to the design or operation of existing radioactive drain systems should be controlled to include:
 - a. Design considerations that prevent non-radioactive drain connections into radioactive drains
 - b. Procedural and design controls to prevent cross-connections of radioactive drains with non-radioactive systems
 - c. Management review of subsequent changes to the design of radioactive drain systems or radioactive drain controls
 - d. Management controls to restrict the introduction of hazardous wastes into radioactive drain systems.

453 Control of Airborne Radioactivity

1. The radiological control organization should be notified when engineered controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes, and glovebags, are compromised. An evaluation should be made of continuing operations with compromised engineered controls. The use of respiratory protection to continue activities under these conditions is discouraged. Implementation of short-term engineered modifications that provide a commensurate level of worker protection is the preferred alternative.
2. Preventive maintenance and surveillance procedures should be established to ensure equipment controls are maintained in an operable condition for containment of airborne radioactivity.

PART 6 Support Activities

461 Controls and Monitoring of Personal Protective Equipment and Clothing

1. Except for disposable, single use items, protective clothing designated for radiological control use should be specifically identified by color, symbol, or appropriate labeling.
2. Protective clothing designated for radiological control use should not be used for non-radiological work.
3. Personal protective equipment and clothing should not be stored with personal street clothing.
4. Cleaned personal protective equipment, such as face shields and respirators, that comes into contact with the wearer's face and company-issued clothing (other than protective clothing used for contamination control purposes) should be surveyed prior to reuse. Contamination levels should be below Table 2-2 total contamination values prior to reuse.
5. Laundered protective clothing should be surveyed and should meet the following criteria prior to reuse:
 - a. Beta-gamma radioactivity less than 10,000 dpm/100 cm²
 - b. Alpha radioactivity less than 1,000 dpm/100 cm² for transuranics and other alpha emitters in the same Table 2-2 category, and less than 10,000 dpm/100cm² for uranium.
6. Sites and facilities are encouraged to continue efforts to reduce contamination levels on reusable personal protective equipment and clothing.

462 Laundry

1. Clothing and equipment should be laundered according to facility, color, type, and level of contamination.
2. Laundry activities should be performed using processes that control worker dose and minimize the volume of waste generated.
3. Clothing and equipment should be screened before laundering to segregate those that are damaged, present special handling problems, or require disposal.
4. Waste streams that contain soaps, detergents, solvents, or other materials which could interfere with processing large-volume liquid waste streams should be segregated for separate processing.
5. Contracting for fully licensed laundry services should be considered.
6. Cleaned personal protective equipment and laundered protective clothing should be periodically inspected. Clothing should be free of tears, separated seams, deterioration, and damage, or repaired in a manner that provides the original level of protection.

463 Decontamination

1. Radiological work permits or technical work documents should include provisions to control contamination at the source to minimize the amount of decontamination needed.
2. Work preplanning should include consideration of the handling, temporary storage, and decontamination of materials, tools, and equipment.
3. Decontamination activities should be controlled to prevent the spread of contamination.
4. Water and steam are the preferred decontamination agents. Other cleaning agents should be selected based upon their effectiveness, hazardous properties, amount of waste generated, and ease of disposal.
5. Facility line management should be responsible for directing decontamination efforts.

464 Vacuum Cleaners and Portable Air-Handling Equipment

Improper use of vacuum cleaners and portable air-handling equipment may result in the generation of airborne radioactivity, removable contamination, or high dose rates.

1. Vacuum cleaners and portable air-handling equipment used in areas established to control removable surface contamination or airborne radioactivity (except areas where only tritium is present) should be equipped with High-Efficiency Particulate Air (HEPA) filters. If the material to be vacuumed is wet enough to preclude resuspension, then HEPA filters are not necessary.
2. HEPA filters used in vacuum cleaners and portable air-handling equipment should meet the applicable efficiency and construction requirements for the devices in which they are installed. The maximum flow rate of the device should not exceed the flow rate at which the HEPA filter was efficiency tested. In addition, the device should be leak tested prior to initial use, when units have undergone any type of service that may compromise the integrity of the HEPA filter or its sealing surfaces, and annually. Leak tests are conducted by injecting di-2-ethylhexyl phthalate (DOP) or equivalent aerosols into the inlet of the device and measuring the DOP concentration at the inlet and outlet of the device. Maintenance and testing should be conducted in accordance with the manufacturer's instructions or site-specific procedures that meet the manufacturer's minimum requirements.
3. Appropriate standards for system design, construction, maintenance, and testing are provided in ASME (American Society of Mechanical Engineers) N509, *Nuclear Power Plant Air- Cleaning Units and Components*, ASME N510, *Testing of Nuclear Air Treatment Systems*, and ASME AG-1, *Code on Nuclear Air and Gas Treatment*. DOE-STD-3020-2005 *Specification for HEPA Filters Used by DOE Contractors*, and DOE-STD-3025-2007, *Quality Assurance Inspection and Testing of HEPA Filters*, and 3026 provide additional information applicable to HEPA-filtered systems.
4. Vacuum cleaners used for radiological work should be:
 - a. Marked and labeled in accordance with Article 412
 - b. Controlled by written work authorizations
 - c. Controlled to prevent unauthorized use
 - d. Designed to ensure HEPA filter integrity under conditions of use
 - e. Constructed and controlled to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

5. Radiation and contamination surveys should be performed periodically for vacuum cleaners in use and labels on these units should be updated. The frequency of radiation surveys should depend on the specific use of the vacuum cleaner.
6. Airborne radioactivity levels should be monitored when a vacuum cleaner is used in a high contamination area.
7. A nuclear safety review should be performed and documented prior to the use of a vacuum cleaner for fissile material.