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NUCLEAR FACILITY RADIOLOGICAL CONTORL - VOL 2 OF 2

Main Category:	Nuclear Engineering
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NUC-117 EXAM PREVIEW

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Exam Preview:

1. Management should request termination bioassay monitoring when an individual who participated in the bioassay program terminates employment or concludes work involving the potential for internal exposure.
    a. True
    b. False
2. DOE encourages the use of electronic dosimeters for entry into high radiation areas or when planned doses greater than ___ millirem in 1 work day are expected. An electronic dosimeter provides an early warning of elevated exposure through the use of alarm set points at specified dose rates or integrated doses.
    a. 25
    b. 50
    c. 80
    d. 100
3. Red plastic wrapping material should be used for packaging radioactive material and should not be used for non-radiological purposes.
    a. True
    b. False
4. According to the Nuclear Accident Dosimeters section of the refence material, fixed dosimeters should a. Be capable of determining the neutron dose from 10 rads to approximately 10,000 rads with an accuracy of ± ___%
    a. 10
    b. 15
    c. 25
    d. 30

5. Heat stress may result from working in areas of high heat, humidity, and radiant heat. Heat stress has occurred at ambient temperatures less than __°F when multiple sets of anti-contamination clothing or plastic suits were in use or strenuous work was required.
    a. 70
    b. 75
    c. 80
    d. 90
6. According to the reference material, due to the limited protection afforded by half-face respirators, DOE discourages the use of half-face respirators for emergency evacuation purposes.
    a. True
    b. False
7. According to the reference material, 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 __ month(s).
    a. 12
    b. 18
    c. 3
    d. 6
8. According to the reference material, 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 _____.
    a. 30 minutes
    b. 1 hour
    c. 5 hours
    d. 1 day
9. Individuals should wear their primary dosimeters on the chest area, on or between the waist and the neck, or in the manner prescribed by radiological control procedures or work authorizations.
    a. True
    b. False
10. According to the reference material, non-uniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the primary dosimeter by more than __ percent and the anticipated whole body dose is greater than 100 millirem.
    a. 30
    b. 40
    c. 50
    d. 60

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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 Requirements*[1]**

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 835and 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 cm^2
   b. Alpha radioactivity less than 1,000 dpm/100 cm^2 for transuranics and other alpha emitters in the same Table 2-2 category, and less than 10,000 dpm/100cm^2 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.

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PART 1 External Dosimetry

511 General Provisions

1. Personnel dosimetry shall be provided to and used by individuals as follows:

    a. Radiological workers who are expected to receive from external sources an effective dose of 100 millirem or more in a year or an equivalent dose to the extremities, lens of the eye, or skin of 10 percent or more of the corresponding limits specified in Table 2-1 [see 835.402(a)(1)]
    b. Declared pregnant workers who are expected to receive from external sources an equivalent dose of 50 millirem (ten per cent of dose limit [see 835.206]) or more to the embryo/fetus during the gestation period [see 835.402(a)(2)]
    c. Occupationally exposed minors likely to receive from external sources an effective dose in excess of 50 millirem [see 835.402(a)(3)]
    d. Members of the public who enter the controlled area and are likely to receive from external sources an effective dose of 50 millirem or more in a year [see 835.402((a)(4)]
    e. Individuals entering a high or very high radiation area [see 835.402(a)(5)].

2. Neutron dosimetry shall be provided when an individual is likely to exceed any of the criteria provided in Article 511.1 from neutrons [see 835.401(b)(2) and 835.402(a and b)].

3. Dosimeters should be issued only to individuals knowledgeable of their proper use and worn only by those to whom the dosimeters were issued.

4. To minimize the number of individuals in the dosimetry program, DOE discourages the issuance of dosimeters to individuals other than those entering areas where there is a likelihood of external exposure in excess of the monitoring thresholds established in Article 511.1. Implementation of an unnecessarily broad dosimetry program is not an acceptable substitute for development of a comprehensive workplace monitoring program.

5. Individuals should return dosimeters for processing as scheduled or upon request, and should be restricted by line management from continued radiological work until dosimeters are returned.

6. Individuals should wear their primary dosimeters on the chest area, on or between the waist and the neck, or in the manner prescribed by radiological control procedures or work authorizations.

7. DOE discourages the practice of taking personnel dosimeters off-site.

8. Individuals should not wear dosimeters issued by their resident facilities while being monitored by a dosimeter at another facility unless authorized by the radiological control manager or designee. Individuals should not expose their dosimeters to excessive heat, or medical sources of radiation, and, unless required, to security X-ray devices.

9. An individual whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, immediately exit the area, and report the occurrence to the radiological control organization. The individual should be restricted from entry into radiological areas until a review has been conducted to verify that dose limits have not been exceeded.

512 Technical Provisions for External Dosimetry

1. External dosimetry programs shall be adequate to demonstrate compliance with the Table 2-1 limits [see 10 CFR 835.402(b)]. External dosimetry programs implemented to meet the requirements of Article 511.1 shall be:

   a. Accredited by the DOE Laboratory Accreditation Program for Personnel Dosimetry (DOELAP) [see 835.402(b)(1)]; or
   b. Excepted from accreditation by the DOELAP Program [see 835.402(b)(1)]; or
   c. Otherwise approved by a Secretarial Officer responsible for environment, safety and health matters [see 835.402(b)(2)].

   DOE-STD-1095-2011 *Department of Energy Laboratory Accreditation Program for External Dosimetry* specifies the requirements for accreditation of personnel external dosimetry monitoring programs by DOELAP. A technical basis document should be developed and maintained for the external dosimetry program. Personnel external dosimeters include, but are not limited to, thermoluminent dosimeters (TLDs), track etch dosimeters, and optically stimulated luminescence (OSL) dosimeters.

2. The technical basis document should also address dosimeters monitoring radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators or electronic dosimeters.

3. Facilities are encouraged to participate in inter-comparison studies for external dosimetry programs.

4. Multiple dosimeters should be issued to individuals to assess effective dose in non-uniform radiation fields. Non-uniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the primary dosimeter by more than 50 percent and the anticipated whole body dose is greater than 100 millirem. When the radiation field is well characterized and the worker's orientation is known, relocation of the primary dosimeter is permitted in lieu of issuance of multiple dosimeters. Under such conditions, the individual's dosimeter should be relocated to the portion of the whole body likely to receive the highest dose. Dosimeter relocation should be conducted in conformance with facility procedures or specific work authorizations, such as RWPs. The technical basis document should describe the methodology used in determining the dose of record when multiple dosimeters are used and when dosimeters are relocated.

5. A dose assessment should be performed for each instance of a lost, damaged, or contaminated personnel dosimeter.

6. A monitoring program implemented at the discretion of the contractor (i.e., personnel monitoring that is not required by Article 511.1) should either utilize the contractor’s existing DOELAP-accredited program or establish a program that is excepted from DOELAP accreditation.

7. External dose measurements should be based on the operational quantities specified in Appendix 5A.

513 Pocket and Electronic Dosimeters

Pocket and electronic dosimeters are supplemental dosimeters that provide real-time indication of exposure to radiation and assist in maintaining personnel doses less than administrative control levels.

1. Individuals entering a high radiation or very high radiation area shall be monitored by a supplemental dosimeter or other means of determining the individual’s effective dose during the entry (see Article 334 for entry requirements) [see 835.502(a)(2)]. Supplemental dosimeters should also be issued when planned activities could cause an individual to exceed 50 millirem or 10 percent of a facility administrative control level from external

gamma radiation in 1 work day, whichever is greater, or when required by a radiological work permit. Pocket dosimeters should be selected with the lowest range applicable (typically 0-200 mR) for anticipated personnel exposures.

2. Supplemental dosimeters should be worn simultaneously with the primary dosimeter and located in accordance with Article 511.6.

3. Supplemental dosimeters should be read periodically while in use and should not be allowed to exceed 75 percent of full scale.

4. Work authorized by written authorization should be stopped when supplemental dosimeter readings indicate dose rates or integrated dose greater than limiting radiological conditions specified in Appendix 3F, or substantially greater than planned. The radiological control organization should be consulted prior to restart of work.

5. The energy dependence and radiation sensitivity of supplemental dosimeters, particularly to low-energy beta and neutron radiation, should be considered in determining their applicability.

6. DOE encourages the use of electronic dosimeters for entry into high radiation areas or when planned doses greater than 100 millirem in 1 work day are expected. An electronic dosimeter provides an early warning of elevated exposure through the use of alarm set points at specified dose rates or integrated doses.

7. When the dose results from the pocket or electronic dosimeters differ by more than 50 percent from the primary dosimeter result and the primary dosimeter result is greater than 100 millirem, an investigation should be initiated to explain the difference.

514 Area Monitoring Dosimeters

Establishment and maintenance of a comprehensive area monitoring program can minimize the number of areas requiring the issuance of personnel dosimeters and demonstrate that doses outside radiological areas are negligible. Minimizing the number of personnel dosimeters issued reduces the costs of operating the dosimetry program and reduces costs associated with maintaining personnel with enhanced training and qualifications.

1. Area monitoring dosimeters may be used to record and document radiation levels in routinely occupied areas adjacent to areas where radiation or operations with radiation exist. This monitoring provision does not apply when the radiation arises solely from low-energy beta sources (e.g., carbon-14 or tritium).

2. Area monitoring dosimeter results may be used to support dosimetry investigations where individuals express concerns about their work environments and exposure to ionizing radiation.

3. Area monitoring dosimeters may be used in controlled areas to supplement existing monitoring programs and to provide data in the event of an emergency.

515 Nuclear Accident Dosimeters

1. Facilities that possess fissile materials in sufficient quantities to create a critical mass such that the potential exists for excessive exposure of individuals in an accident shall provide nuclear accident dosimetry to affected individuals [see 835.1304(a)].

2. The nuclear accident dosimetry system shall include the following:

    a. A method to conduct initial screening of potentially exposed individuals to identify those who have received significant doses [see 835.1304(b)(1)]
    b. Equipment and methods sufficient to analyze appropriate biological samples [see 835.1304(b)(2)] and dosimeters
    c. A system of fixed nuclear accident dosimeter units [see 835.1304(b)(3)] capable of measuring the estimated neutron dose and approximate neutron spectrum
    d. Personnel nuclear accident dosimeters [see 835.1304(b)(4)].

3. The fixed dosimeters discussed above should:

    a. Be capable of determining the neutron dose from 10 rads to approximately 10,000 rads with an accuracy of ± 25%
    b. Be capable of measuring fission gamma radiation from 10 rads to approximately 10,000 rads in the presence of neutron radiation with an accuracy of approximately ± 20%.

4. Personnel nuclear accident dosimeters should be capable of measuring an absorbed dose in or on a phantom from 10 rads to approximately 1,000 rads with an accuracy of ± 20% for gamma radiation and ± 30% from neutron radiation.

5. An analysis of the fixed dosimetry system needs should be documented and should consider such factors as the nature of operations, structural design of the facility, area accessibility, number of dosimeters and their location, and the effect of intervening shielding. The analysis should be reevaluated as necessary to ensure facility modifications do not impair the capabilities of the fixed dosimetry system.

PART 2 Internal Dosimetry

521 General Provisions

1. The following individuals shall participate in an internal dosimetry program:

    a. Radiological workers who are likely to receive a committed effective dose of 100 millirem or more from all radionuclide intakes in a year [see 835.402(c)(1)]
    b. Declared pregnant workers likely to receive intakes resulting in an equivalent dose to the embryo/fetus of 50 millirem or more during the gestation period [see 835.402(c)(2)]
    c. Occupationally exposed minors likely to receive a committed effective dose in excess of 50 millirem from all radionuclide intakes in a year [see 835.402(c)(3)].
    d. Members of the public who enter a controlled area and are likely to receive an intake resulting in a committed effective dose exceeding 50 millirem in a year [see 835.402(c)(4)].

2. The estimation of internal dose shall be based on bioassay data rather than air concentration values unless one of the following conditions exists [see 835.209(b)]:

    a. bioassay data are unavailable
    b. bioassay data are inadequate
    c. internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate.

3. Individuals should participate in follow-up bioassay monitoring when their routine bioassay results indicate an intake in the current year with a committed effective dose of 100 millirem or more.

4. Individuals whose routine duties may involve exposure to surface or airborne contamination or to radionuclides readily absorbed through the skin, such as tritium, should be considered for participation in the bioassay program.

5. The bioassay program should establish appropriate frequencies for the collection of bioassay samples, such as urine or fecal samples, and for participation in bioassay monitoring, such as whole body or lung counting. Individuals should participate at the frequency required by the bioassay program.

6. Individuals should be notified promptly of positive bioassay results and the results of dose assessments and subsequent refinements. Dose assessment results shall be provided in terms of rem or millirem [see 835.2(b), dose term definitions, and 835.4].

522 Technical Provisions for Internal Dosimetry

1. All bioassay programs implemented to demonstrate compliance with Article 521.1 shall be:

    a. Accredited by the DOE Laboratory Accreditation Program for Radiobioassay (DOE-STD-1112-98) [see 835.402(d)]; or
    b. Excepted from accreditation by the DOELAP Program [see 835.402(d)(1)]; or
    c. Otherwise approved by a Secretarial Officer responsible for environment, safety and health matters [see 835.402(d)(2)].

2. A technical basis document should be developed for the internal dosimetry program.

3. Baseline bioassay monitoring of individuals who are likely to receive intakes resulting in a committed effective dose greater than 100 millirem in a year should be conducted before they begin work that may expose them to internal radiation exposure.

4. Routine bioassay monitoring methods and frequencies should be established for individuals who are likely to receive intakes resulting in a committed effective dose greater than 100 millirem in a year. The technical basis for the methods and frequency of bioassay monitoring should be documented.

5. Confirmatory bioassay monitoring should be performed as described in DOE-STD-1121-2008, *Internal Dosimetry*, section 5.7, *Confirmatory Bioassay Program*.

6. Management should request termination bioassay monitoring when an individual who participated in the bioassay program terminates employment or concludes work involving the potential for internal exposure.

7. Bioassay analyses should also be performed when any of the following occurs:

   a. Facial or nasal contamination is detected that indicates a potential for internal contamination exceeding any monitoring threshold established in Article 521.1
   b. Airborne monitoring indicates the potential for intakes exceeding 100 millirem committed effective dose
   c. Upon direction of the radiological control organization when an intake is suspected.

8 Levels of intakes that warrant the consideration of medical intervention should be established for site-specific radionuclides. The effectiveness of medical intervention, such as blocking or chelating agents, should be documented using bioassay results.

9. A preliminary assessment of intakes detected should be conducted prior to permitting an employee to return to radiological work.

10. Internal dosimetry program personnel should use radionuclide standards from or traceable to the National Institute of Standards and Technology (NIST).

11. Internal dosimetry program personnel are encouraged to participate in inter-comparison studies and to use the "DOE Phantom Library." Information on the DOE Phantom Library may obtained from the DOE's DOELAP Program Administrator or the Phantom Library Administrator at the Radiological and Environmental Sciences Laboratory.

12. Internal dose measurements should be based on the operational quantities specified in Appendix 5A.

13. A site radiobioassay program implemented at the discretion of the contractor (i.e., for personnel monitoring that is not required by Article 521.1) should either utilize the contractor's existing DOELAP-accredited program or establish a program that is excepted from DOELAP accreditation..

523 Technical Provisions for Dose Assessment

Interpretations of bioassay results and subsequent dose assessments should be documented. Detailed technical guidance for performing and documenting dose assessments is contained in DOE Standard 1121-2008, *Internal Dosimetry*.

PART 3 Respiratory Protection Program

Respiratory protection equipment includes respirators with particulate or gas-filtering cartridges, supplied-air respirators, self-contained breathing apparatus, and airline supplied-air suits and hoods.

531 General Provisions

1. Use of respiratory protection shall be reduced to the minimum practicable by implementing engineered controls and work practices to contain radioactivity at the source [see 29 CFR 1910.134, *Respiratory Protection*].

2. 10 CFR 851, *Worker Safety and Health Program*, requires DOE contractors to comply with 29 CFR 1910.134, *Respiratory Protection*, and ANSI Z88.2, *Practices for Respiratory Protection*. 29 CFR 1910.134 establishes requirements for a respiratory protection program that are applicable to most DOE facilities. ANSI Z88.2 provides requirements and guidance for implementation of the respiratory protection program and associated training of personnel. In addition, both 10 CFR 851 and DOE Order 440.1B Chg. 1, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*, require the "use of respiratory protection equipment tested under the DOE Respirator Acceptance Program for Supplied-Air Suits (DOE Technical Standard 1167-2003) when National Institute for Occupational Safety and Health-approved respiratory protection does not exist for DOE tasks that require such equipment."

3. Respirators shall be issued only to individuals who are trained, fitted, and medically qualified to wear the specific type of respirator. Training and qualification testing shall be performed annually [see 29 CFR 1910.134 and ANSI Z88.2].

4. Positive controls should be maintained for the issue, use, and return of respirators to ensure that only qualified individuals wear respirators.

5. 29 CFR 1910.134 mandates that breathing air meet the specifications of ANSI/CGA G-7.1 *Grade D Breathing Air*. Compressed air supplied to respirators shall be tested quarterly. Compressors shall be of the breathing air type and shall not allow oil or other chemicals and fumes to enter the breathing air supply. Special attention shall be focused on the location of compressor air supply intakes and on cross-connections to other compressed gas systems to prevent contamination [see 29 CFR 1910.134].

6. Facility safety analyses should not take credit for the use of respiratory protection for routine work involving potential exposure to airborne radioactive materials.

532 Medical Assessments

Each prospective respirator wearer shall have a medical assessment prior to being fit-tested. The medical assessment shall determine if an employee's medical condition precludes the use of respirators and should follow the guidance in ANSI Z88.6, *Physical Qualifications for Respiratory Use*, on frequency and content of the examination [see 29 CFR 1910.134 and ANSI Z88.2]. The ability of an employee to accommodate the additional stress placed on the body when working in a respirator is part of this assessment.

533 Use of Respiratory Protection

The use of respiratory protection devices may impair worker communication, mobility and vision and cause the worker discomfort and stress. For these reasons, the issuance and use of respiratory protective devices must be controlled.

1. Individuals using respiratory protection shall:

    a. Perform fit checks of close-fitting respirators to ensure a proper seal before entering areas requiring respirator use
    b. Be clean shaven in the area of the facial seal, if applicable
    c. Use corrective lenses, if needed, that are approved for respirators
    d. Be trained to leave the work area when experiencing respirator failure
    e. Be trained to remove their respirators to avoid life-threatening situations when exiting an area after a respirator failure such as the loss of supplied air [see 29 CFR 1910.134 and ANSI Z88.2].

534 Heat Stress

Heat stress may result from working in areas of high heat, humidity, and radiant heat; working in protective clothing; and using respirators, particularly where other protective equipment is required. Heat stress has occurred at ambient temperatures less than 70°F when multiple sets of anti-contamination clothing or plastic suits were in use or strenuous work was required.

1. The planning stages for work in hot environments should address heat stress controls, as applicable.

2. Job supervisors should inform their personnel of heat stress precautions prior to work on job assignments in hot environments. Precautions that should be considered during work that includes a high probability of heat stress include:

    a. Engineered controls to moderate airborne or surface contamination in the work area environment;
    b. Appropriate work time limits;
    c. Use of protective clothing made of materials that wick perspiration away from the body;
    d. Use of body cooling devices;
    e. Provision of beverages at or near the work site, using appropriate contamination controls;
    f. Relaxation of protective clothing requirements.

3. If an individual begins to feel symptoms of heat illness, the individual should immediately notify the nearest co-worker, exit the area, remove personal protective equipment, notify the supervisor, and rest in a cool area. In such cases, medical assistance should be provided.

535 Half-Face Respirators

Half-face respirators have limited applications because of the design of the facial seal area. As a result, their permitted protection factor is low. Full-face respirators are generally preferred over half-face respirators because of the significant increase in protection offered with minimal loss of worker comfort.

1. The use of half-face respirators is permitted in situations where intakes of radioactive material will be low, such as those resulting in a few millirem, and where industrial and safety considerations warrant, such as during the operation of heavy equipment.

2. Due to the limited protection afforded by half-face respirators, DOE discourages the use of half-face respirators for emergency evacuation purposes.

PART 4 Handling Radiologically Contaminated Personnel

541 Skin Contamination

1. Survey techniques should be established to determine the extent of skin contamination.

2. When personnel detect skin contamination, they should notify the radiological control organization.

3. The extent of skin contamination should be determined prior to initiating decontamination procedures.

4. Skin decontamination methods should be established for site-specific radionuclides. Skin abrasion should be avoided during the decontamination process. Intrusive decontamination methods, such as tissue removal, require medical assistance.

5. Levels of skin contamination that trigger the need for dose assessments should be established for site-specific radionuclides. These trigger levels should not exceed 100 millirem.

6. Individuals with skin contamination that triggers the need for dose assessment should be informed of the initial dose estimate to their skin as soon as practicable, preferably prior to the end of their work day.

7. Individuals with skin contamination for which dose assessment was not performed should be informed of the nature of the contamination and an upper estimate on the potential dose (such as less than 10 millirem) as soon as practicable, preferably prior to the end of their work day.

8. An assessment of skin exposure requires time to conduct a detailed evaluation. Requirements for assessments are provided in Appendix 2D. Promptly after completion, the results should be explained to the persons affected.

542 Contaminated Wounds

1. Emergency medical care should be administered immediately for injuries involving radioactive materials. National Council on Radiation Protection and Measurements Report Number 161, *Management of Persons Contaminated with Radionuclides: Handbook*, contains applicable information. Medical treatment of injuries takes precedence over radiological control considerations.

2. The treatment of contaminated injuries should include the following:

    a. Treatment of contaminated wounds by medically qualified personnel
    b. Monitoring of wounds and associated bandages for contamination, including alpha emitters if applicable
    c. Identification of the radionuclides involved
    d. Medical determination of the need to lower internal dose through therapeutic intervention such as surgery or administration of chelating or other decorporation agents
    e. Initiation of appropriate bioassay monitoring
    f. Determination of need for work restrictions.

3. An injured individual should be counseled promptly on the medical and radiological implications resulting from contaminated wounds that are likely to result in internal doses greater than 2 percent of the Table 2-1 limits. The counseling should be performed by senior radiological control and medical professionals.

543 Handling Individuals Exposed to Airborne Radioactivity

Potential intakes of radioactive material are indicated when individuals without respiratory protection are exposed to airborne radioactivity or when respiratory protection has been compromised. If intakes of radioactive material are indicated which could result in an individual receiving a committed effective dose greater than 100 millirem, the following actions should be taken:

1. Identify individuals potentially exposed to airborne radioactivity.

2. Analyze air samples to determine airborne concentrations where appropriate.

3. Determine duration of potential exposure to airborne radioactivity.

4. Perform bioassay appropriate for the type and quantity of radionuclides involved.

5. Determine the need to lower internal dose through medical intervention such as administration of chelating or other decorporation agents for intakes greater than 2000 millirem ED. This action should performed by the site medical organization in consultation with the site radiological protection organizations. National Council on Radiation Protection and Measurements Report Number 161, *Management of Persons Contaminated with Radionuclides: Handbook*, contains applicable information.

6. Evaluate dose prior to permitting the worker to return to radiological work.

PART 5 Radiological Monitoring

551 General Provisions

Workplace monitoring provides a basis for posting and labeling, development of RWPs and other work authorizations, implementation of ALARA measures, issuance of individual monitoring devices, and verification of the efficacy of design measures and engineered controls. Development of a workplace monitoring program sufficient to meet the provisions of this chapter should include consideration of these factors to ensure the adequacy of the program.

1. Radiological monitoring of radiation exposure levels, contamination, and airborne radioactivity shall be conducted to:

    a. Characterize workplace conditions and detect changes in those conditions [see 835.401(a)(2) & (3)]
    b. Verify the effectiveness of engineered and administrative controls [see 835.401(a)(5)]
    c. Demonstrate regulatory compliance [see 835.401(a)(1)]
    d. Detect the gradual buildup of radioactive material in the workplace [see 835.401(a)(4)]
    e. Identify and control potential sources of personnel exposure [see 835.401(a)(6)]
    f. Determine exposure rates during each entry to a high or very high radiation area [see 835.502(a)(1)].

2. Monitoring shall be performed only by individuals who have the appropriate education, training, and skills [see 835.103]. The instruments used shall be [see 835.401(b)]:

    a. Periodically maintained and calibrated
    b. Appropriate for the types, levels, and energies of radiation to be detected
    c. Appropriate for existing environmental conditions
    d. Routinely tested for operability.

3. Monitoring for radiation, contamination, and airborne radioactive materials should be performed as specified in technical work documents and radiological work permits.

4. The radiological control organization should perform and document a review of the adequacy of sampling and monitoring programs as part of any facility or operational changes affecting radiological control. In the absence of such changes, a review should be conducted annually.

5. Instruments used to perform radiation monitoring should be performance-checked daily or, if not checked within the past 24 hours, prior to operation. Ambient background radiation should not be used for performance checks. When performance checks are not within ±20 percent of the expected value, the instrument should be taken out of service. When performance checks are not feasible, such as with instruments used to measure neutrons or tritium, compensatory actions should be established to ensure proper instrument performance.

6. Monitoring of radiological conditions should include a sufficient number of survey points to characterize the radiation present and to verify boundaries.

7. Monitoring should be performed before, during, and at the completion of work that has the potential for causing changes in levels of radiation and radioactivity.

8. Monitoring frequencies should be established based on potential radiological conditions, probability of change in conditions, and area occupancy factors.

9. Monitoring results should be reviewed by the cognizant radiological control supervisor to ensure that all required surveys have been performed and that the documentation is accurate and complete.

10. Results of current surveys or survey maps should be conspicuously posted or available at access points to the surveyed area to inform personnel of the radiological conditions.

11. Survey results should be made available to line management and used in support of pre- and post-job evaluations, preparation or selection of appropriate radiological work permits, ALARA preplanning, contamination control, and management of radiological control operations.

12. Monitoring data in each building or area should be compiled and reviewed at least quarterly. Changes or trends should be noted and corrective actions assigned.

552 Radiation Exposure Monitoring

1. In addition to the requirements of Article 551, routine radiation monitoring programs should be established to ensure that surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. The following survey frequencies are suggested and should be modified as necessary to ensure area hazards are adequately characterized, based upon facility-specific experience:

    a. Daily, in office space located in radiological buffer areas and other areas surrounding radiological areas where the potential exists for external radiation exposure
    b. Weekly, in routinely occupied radiological buffer areas and radiation areas
    c. Weekly, for operating HEPA-filtered ventilation units
    d. Weekly, for temporary radiation area boundaries to ensure that radiation areas do not extend beyond posted boundaries
    e. Monthly, or upon entry, if entries are less frequent than monthly, for radioactive material areas
    f. Monthly, for potentially contaminated ducts, piping, and hoses in use outside of radiological facilities.

2. Radiation monitoring should include dose rate measurements of the general area, dose rates at a distance of 30 centimeters from a source or surface of interest to evaluate potential whole body exposures, and dose rates on contact with potential sources of radiation where there is a potential for hands-on work or other direct contact.

3. Monitoring should be conducted whenever operations are being performed that might result in individuals being exposed to small intense beams of radiation, such as those generated by shielded X-ray devices or due to removal or alteration of shielding, modification of shielding penetrations, or relocation of significant radiation sources within shielded enclosures.

4. When radioactive material exceeding a Type A quantity (as defined in 10 CFR 71) is received, radiation monitoring of the received packages shall performed if:

    a. The package is labeled in accordance with the applicable transportation requirements (e.g., Radioactive White I or Yellow II or III label) [see 835.405(b)(1)]; or
    b. The package has been transported as low specific activity (LSA) material on an exclusive vehicle [see 835.405(b)(2)].

    The external surfaces of all packages received from transportation should be monitored to determine the external radiation level, unless the packaged materials are not capable of creating an external radiation hazard (i.e., the packages contains only materials that emit radiation of low penetrating ability). These surveys are used to ensure compliance with Department of Transportation regulations and applicable DOE Orders and to identify

appropriate postings and access control measures. These measures should be established as soon as practicable after receipt.

5. Monitoring shall also be performed when a received package containing greater than a Type A quantity of radioactive material shows evidence of degradation, such as packages that are crushed, wet, or damaged [see 835.405(b)(3)].

6. Monitoring of received packages of radioactive material shall be performed as soon as practicable following receipt, but not later than eight hours following the beginning of the working day following the receipt of the package [see 835.405(d)].

7. Monitoring is not required for packages transported on a DOE site which have remained under the continuous observation and control of a DOE employee or DOE contractor employee who is knowledgeable of and implements required exposure control measures [see 835.405(e)].

8. See Articles 554 for additional provisions for radioactive material receipt.

553 Area Radiation Monitors

1. In addition to the requirements and recommendations of Article 551, area radiation monitors (not to include area monitoring dosimeters discussed in Article 514) should be installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates prior to personnel entry.

2. Area radiation monitors should not be substituted for radiation exposure surveys in characterizing a workplace.

3. The need for and placement of area radiation monitors should be documented and assessed when changes to facilities, systems, or equipment occur.

4. In addition to the requirements of Article 562, area radiation monitors should be tested periodically (e.g., quarterly) to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms when so equipped.

5. If installed instrumentation is removed from service for maintenance or calibration, temporarily, a radiation monitoring program providing similar detection capability should be provided, consistent with the potential for unexpected increases in radiation dose rates.

6. Where an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor either prevents entry into the area or prevents operation of the radiation producing device. If the circuitry is required to ensure compliance with the high radiation area access control requirements of 10 CFR 835.502, then the circuitry shall be fail-safe [see 835.502(b)].

554 Contamination Monitoring

1. In addition to the requirements of Article 551, contamination monitoring programs should be established to ensure that surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. The following survey frequencies are suggested and should be modified as necessary to ensure area hazards are adequately characterized, based upon facility-specific experience:

    a. Prior to transfer of equipment and material from one radiological buffer area established for contamination control to another - unless the material was monitored immediately prior to this transfer, such as upon removal from a contamination area
    b. Prior to transfer of equipment and material from high contamination areas within radiological buffer areas - unless precautions such as bagging or wrapping are taken prior to transfer
    c. Daily, at contamination area control points, change areas, or step-off pads when in use, or per shift in high use situations
    d. Daily, in office space located in radiological buffer areas
    e. Daily, in lunch rooms or eating areas near radiological buffer areas
    f. Daily in accessible areas where operations likely to produce hot particles are under way
    g. Weekly, in routinely occupied radiological buffer areas
    h. Weekly, or upon entry if entries are less frequent, in contamination areas and other areas where materials having removable contamination exceeding the Table 2-2 values are handled or stored
    i. Weekly, or upon entry if entries are less frequent, where contamination area boundaries or postings are located
    j. During initial entry into a known or suspected contamination area
    k. Monthly, in and around areas of fixed contamination
    l Periodically during work in a contamination area or, at completion of job, or as specified in a radiological work permit
    m. After a leak or spill of radioactive materials.

2. Articles 421 and 422 provide requirements and guidance for material release surveys.

3. When radioactive material is received (other than gaseous or special form materials), contamination monitoring of the received packages shall be performed if:

    a. The package is labeled in accordance with the applicable transportation requirements (e.g., Radioactive White I or Yellow II or III label) [see 835.405(b)(1)]; or
    b. The package has been transported as low specific activity material on an exclusive vehicle [see 835.405(b)(2)].

    The external surfaces of all packages received from transportation should be monitored to determine the external contamination level, unless the packaged materials are not capable of creating a contamination hazard (i.e., the packages contain only gaseous or special form materials). These surveys are used to ensure compliance with Department of Transportation regulations and applicable DOE Orders and to identify appropriate postings and access control measures. These measures should be established as soon as practicable after receipt.

4. Monitoring shall also be performed when a received package of radioactive material shows evidence of degradation, such as packages that are crushed, wet, or damaged [see 835.405(b)(3)], unless the packages contain only special form or gaseous radioactive material.

5. When monitoring of received packages is required (as specified in Article 554.3)**,** monitoring shall be performed as soon as practicable following receipt, but not later than eight hours following the beginning of the working day following the receipt of the package [see 835.405(d) and 835.405(e)].

6. Contamination surveys should incorporate techniques to detect both removable and fixed contamination.

7. Swipe surveys for removable contamination should be recorded in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2). For swipe surveys of small items covering less than 100 cm^2, the results should be recorded in units of dpm per area swiped. If contamination levels exceed the range of the available count rate meters, the swipes should be analyzed by holding an appropriate exposure rate meter within one half inch and the results should be recorded in units of millirad or rad per hour.

8. Large area wipes are encouraged and should be used to supplement standard swipe techniques in areas generally assumed not to be contaminated, such as entrances to radiological areas. If an evaluation indicates that an area wiped is contaminated, a thorough contamination swipe survey should be performed.

9. Areas identified as either contaminated with, or having the potential for being contaminated with, highly radioactive particles ("hot particles") should be surveyed using special swipe techniques to collect hot particles, such as tape and large area wipes.

555 Airborne Radioactivity Monitoring

1. In addition to the requirements of Article 551, air monitoring programs should be established to ensure that airborne radioactivity monitoring is performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. Selection of air monitoring equipment should be based on the specific job being monitored. Air monitoring equipment includes portable and fixed air sampling equipment and continuous air monitors.

2. Air sampling equipment shall be used where an individual is likely to receive an annual exposure of 40 or more Derived Air Concentration (DAC) hours [see 835.403(a)(1)]. This intake generally represents a committed effective dose to an individual of approximately 100 millirem. Samples shall also be taken as necessary to characterize the hazard in areas where respiratory protection devices have been prescribed for protection against airborne radionuclides [see 835.403(a)(2)]. Air samples should be adequate to evaluate the concentrations of airborne radioactive materials at the individual's work locations.

3. Real-time air monitors, such as continuous air monitors (CAMs) are used to provide early warning to individuals of events that could lead to substantial unplanned exposures to airborne radioactivity. Such exposures could result from a breakdown of engineered controls or improper establishment of boundaries during work that creates airborne radioactivity. Real-time air monitoring shall be conducted as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material [see 835.403(b)].

4. Air sampling equipment should be positioned to measure air concentrations to which individuals are exposed. If this cannot be achieved, a program of personal breathing-zone air sampling should be initiated. The Nuclear Regulatory Commission's NUREG-1400, *Air Sampling in the Workplace*, Chapter 3, *Demonstration that Air Sampling is Representative of Inhaled Air*, provides information on breathing-zone air sampling.

5. Air monitoring equipment shall be routinely calibrated and maintained on an established frequency [see 835.401(b)]. Air monitoring equipment should be calibrated at least once each year. CAMs should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.

6. Real-time air monitoring equipment required by Article 555.3 should have alarm capability and sufficient sensitivity to alert individuals that immediate action is necessary to minimize or terminate inhalation exposures.

7. A technical basis document should be developed for the airborne radioactivity monitoring program. The technical basis document should provide the basis for air monitor selection, placement, and operation.

8. The proper operation of real time air monitoring equipment should be verified daily (e.g., by performing an operational check, or verifying the CAM is operating normally as indicated by 'power on', 'normal count-rate reading', and no 'trouble' or 'failure' alarms). Operational checks typically include positive air-flow indication, non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. Real-time air monitoring equipment detector operation should be verified weekly by checking for instrument response with a check source or with ambient levels of radon and thoron daughters.

9. Preliminary assessments of air samples utilizing field survey techniques should be performed promptly upon removal. In situations where background levels of radon and thoron daughters interfere with evaluation of alpha air samples, prompt field assessments may not be possible.

10. Air sample results should be evaluated as quickly as practicable for evaluation of the need for respiratory protection, area evacuation (if necessary), worker intake, and worker relief from respirator use.

11. Site-specific temporal and spatial averaging techniques may be used in determining the requirements for air monitoring. Justification for these techniques should be documented and retained and the results of these analyses used in documentation of the RPP.

12. Approved respirator protection factors may be considered in specifying application of CAMs if all individuals in the affected area will be wearing respiratory protection devices. This provision supplements the Department's reliance upon engineered and administrative controls for airborne radioactivity control and does not diminish the need to perform workplace monitoring as required by 10 CFR 835.401(a). In addition, the accompanying provision regarding the need to alert individuals to unexpected transients remains in effect and must be considered. Criteria requiring the use of CAMs should be fully described in the RPP.

13. Any of the various available air sampling methods (high or low flow rate grab samples, CAMs, lapel samples, etc.) may be used to demonstrate compliance with 10 CFR 835.403(a)(1). Specific guidance should be developed and provided to individuals performing the sampling (such as in site procedures) to ensure proper application of the specified method.

14. Air monitoring results may be used for determination of internal doses but only under the conditions specified in 10 CFR 835.209(c). Efforts should be made to acquire and analyze air samples using the most representative and accurate techniques that are available, considering site-specific factors such as available resources and potential for missed dose.

15. When performing air monitoring to demonstrate compliance with either 10 CFR 835.403(a)(1) or (2), the method used must be appropriate for the existing environmental conditions, consistent with 10 CFR 835.401(c)(3). Any conflicts between this requirement and the specific monitoring requirements of 10 CFR 835.403(a) should be considered in development of the RPP.

PART 6 Instrumentation and Calibration

561 Standardization

DOE encourages standardization on the use of commercially-available radiological instrumentation.

562 Inspection, Calibration, and Performance Tests

1. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid [see 835.401(b)(2)]. ANSI N323A, *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* provides appropriate comprehensive guidance for establishing and operating a radiological instrumentation calibration program. Calibrations should use NIST traceable sources.

2. Calibration procedures should be developed for each radiological instrument type and should include frequency of calibration, pre-calibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements.

3. All radiological monitoring instruments, including pocket and electronic dosimeters and area radiation monitors, shall be maintained and calibrated on an established frequency [see 835.401(b)(1)]. Calibration frequencies should be determined in accordance with National Conference of Standards Laboratories Recommended Practice RP-1, *Establishment and Adjustment of Calibration Intervals*.

4. The effects of environmental conditions, including interfering radiation, on an instrument shall be known prior to use [see 835.401(b)(3)].

5. Operational tests should be used to assess instrumentation designs that include alarms or that involve a process control. An operational test should be developed to test all components involved in an alarm or trip function and performed at least annually.

6. In unusual and limited situations it may be necessary to use an instrument in an application other than that envisioned by the manufacturer. Special calibrations should be performed for use of instrumentation outside manufacturer's specifications. The instrument should be adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

7. Measures should be implemented to ensure that individuals using an instrument can verify its calibration status.

8. Instruments whose "as found" readings indicate that the instrument may have been used while out of calibration should be reported to the radiological control organization. The radiological control organization should review surveys performed with the instrument while it was out of calibration and consider the need for additional surveys.

563 Maintenance

1. A program for preventive and corrective maintenance of radiological instrumentation should be established and documented.

2. Preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the manufacturer of the instrument.

3. Radiological instruments should undergo calibration prior to use following any preventive or corrective maintenance or any adjustment that voids the previous calibration. A battery change is not normally considered maintenance.

564 Calibration Facilities

1. Radiological monitoring instrument inspections, calibrations, performance tests, calibration equipment selection, and quality assurance should be performed using documented protocols/procedures. ANSI N323A provides detailed technical guidance for the establishment of calibration programs.

2. For organizations that do not possess or use their own calibration facilities, contracted calibration services should be performed in accordance with the referenced standards.

Appendix 5A

Protection and Operational Quantities

Protection Quantities

The ICRP Publication 60 dosimetric quantities adopted in 10 CFR 835 and reflected in Table 2-1 of this standard have been designated by ICRP as "protection quantities" that are intended for defining and calculating the numerical limits and action levels used in radiation protection standards such as 10 CFR 835. Protection quantities provide a way to relate the magnitude of a radiation exposure to the risk of a health effect that is applicable to an individual and that is largely independent of the type and source (internal or external) of the radiation. In addition the protection quantities can be easily calculated for use in planning radiological work.

These goals are achieved using a combination of theoretical and practical considerations. For example, absorbed dose is assumed to be averaged over a tissue or organ. Radiation weighting factors are used to account for the biological effectiveness of various types and energies of radiation and tissue weighting factors are used to account for the sensitivity of various tissues to radiation induced cancer. See Appendices 2B and 2C of Chapter 2 of this standard for listings of values. The tissue and radiation weighting factors are based on both biological and epidemiological studies and have been updated as new research became available. Nevertheless, the values of these weighting factors are approximations that account for both uncertainty in the underlying data and the need to ensure that the protection quantities do not underestimate the true dose and hence the risk. Protection quantities used in 10 CFR 835 include: equivalent dose, effective dose, committed equivalent dose, committed effective dose, total effective dose, and cumulative total effective dose.

Operational Quantities

Because protection quantities were developed to provide an index of the risk resulting from energy imparted to tissue by radiation, they are theoretical and not measurable. Fortunately, it is possible to use the measurable properties of radiation fields and radioactive materials associated with exposure to external radiation sources or intake of radioactive materials to estimate and demonstrate compliance with the protection quantities. These measurable quantities are called operational quantities.

Although many types of operational quantities are possible, a well characterized set of operational quantities for assessing doses received from external exposure have been selected by the International Commission on Radiation Units and Measurements (ICRU) in Report 51, *Quantities and Units in Radiation Protection Dosimetry*. These operational quantities have been adopted in recommendations of the ICRP and in the standards implementing the ICRP recommendations written by the International Atomic Energy Agency (IAEA) and the European Union (EU). In addition, the ICRP, in Publication 74, *Conversion Coefficients for Use in Radiological Protection against External Radiation*, compared and contrasted doses determined using the ICRP system of protection quantities with doses determined using the ICRU based operational quantities. For almost all situations considered, doses determined with the operational quantities were greater or equal to the doses determined using protection quantities. These operational quantities and their relation to the protection quantities listed in DOE G 441.1-1C are contained in the tables below.

Appendix 5A (continued)

Relation between protection quantities and operational quantities for individual monitoring of doses from external exposure

Protection quantity	Operational quantity (depth [d] in tissue [mm])
Equivalent dose to the whole body from external sources*	$H_p(10)$
Equivalent dose to the lens of the eye from external sources	$H_p(3)$
Equivalent dose to the extremity or skin from external sources	$H_p(0.07)$

Where:

$H_p(d)$ is the personal equivalent dose at depth d in tissue
See ICRU Report 51 for the definition of $H_p(d)$
* Same as effective dose from external sources.

Relation between protection quantities and operational quantities for individual monitoring of doses from intakes of radioactive material

Protection quantity	Operational quantity
Committed effective dose	$\sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$
Committed equivalent dose	$\sum_j h_{j,T,50,inh} I_{j,inh} + \sum_j h_{j,T,50,ing} I_{j,ing}$
Total effective dose (Equivalent dose to the whole body from external sources + Committed effective dose)	$H_p(10) + \sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$

Where:

$h_{j,eff,50,inh}$ is the committed effective dose per unit of radioactivity intake by inhalation (*inh*)
$h_{j,eff,50,ing}$ is the committed effective dose per unit of radioactivity intake by ingestion (*ing*)
$h_{j,T,50,inh}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by inhalation
$h_{j,T,50,ing}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by ingestion
$I_{j,inh}$ is an intake by inhalation
$I_{j,ing}$ is an intake by ingestion
j is a radionuclide

Appendix 5A (continued)

In addition to the operational quantities used for individual monitoring, the following table contains operational quantities that may be measured to characterize certain aspects of radiation fields in the workplace.

Operational quantities for use in characterizing workplace radiation fields

Workplace measurement	Suggested operational quantity
Control of effective dose	$H^*(10)$
Control of dose to the skin, the extremities and the lens of the eye	$H'(0.07, \Omega)$
Control of dose to the lens of the eye	$H'(3, \Omega)$

Where: $H^*(10)$ is the ambient equivalent dose at a depth of 10 mm in tissue
$H'(0.007, \Omega)$ is the directional equivalent dose at a depth of 0.07mm in the ICRU sphere
$H'(3, \Omega)$ is the directional equivalent dose at a depth of 3 mm in the ICRU sphere
Ω defines the direction of the radiation field
See ICRU Report 51 for the definitions of ambient equivalent dose and directional equivalent dose

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CHAPTER 6 TRAINING AND QUALIFICATION

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PART 6 Training For Special Applications

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PART 1 Radiological Control Training and Qualification

611 Purpose

The provisions of this chapter ensure that individuals are trained to work safely in and around radiological hazards and to maintain their individual radiation exposure and the radiation exposures of others ALARA. Training provisions in this chapter apply to individuals entering controlled areas at DOE sites and other individuals who are responsible for developing and implementing radiological control measures.

612 Standardization

10 CFR 835.901 establishes requirements for radiation safety training programs for two classes of individuals: 1) individuals who are permitted unescorted access to controlled areas or are occupationally exposed to radiation in a controlled area; and 2) individuals who are permitted unescorted access to radiological areas or perform unsupervised assignments as a radiological worker. Within this Standard, these training programs are referred to as General Employee Radiological Training and Radiological Worker Training (I and II), respectively. In addition, 10 CFR 835.103 establishes requirements for the education, training, and skills of individuals who are responsible for developing and implementing measures necessary for ensuring compliance with 10 CFR 835. DOE sponsored the development of core courses and training materials to achieve consistency in the level and quality of Department-wide training. In establishing local training programs, DOE's core-courses should be utilized to the extent practicable and should be supplemented with site-specific information. Core-course training material is developed and maintained by DOE Headquarters (AU) and consists of lesson plans, viewgraphs, student handbooks, qualification standards, question banks, and Program Management Guides.

1. Radiation safety training programs are necessary to ensure compliance with 10 CFR 835.901. Training programs for members of the public, general employees, and radiological workers should be developed consistent with Parts 2, 3, and 6 of this Chapter to ensure compliance with these requirements. Additional training programs consistent with those discussed in Parts 4,5 and 6 of this Chapter may be necessary to ensure compliance with the education, training, and skills requirements of 10 CFR 835.103. Affected individuals may include, but not be limited to, managers, supervisors, radiological control technicians, technical specialists, researchers, clerks, and engineers.

2. DOE's core course training material, supplemented by site-specific training materials, should be used to the extent practicable to satisfy the training requirements of both 10 CFR 835.901 and 10 CFR 835.103. DOE has sponsored the development of standardized courses for:

    a. General Employee Radiological Training
    b. Radiological Worker Training
    c. Radiological Control Technician Training
    d. Radiological Safety Training for Plutonium Facilities
    e. Radiological Training for Tritium Facilities
    f. Radiological Safety Training for Accelerator Facilities
    g. Radiological Safety Training for Uranium Facilities
    h. ALARA Training for Technical Support Personnel

3. Successful completion of the entire core academic component of a DOE core course at one DOE site within the past two years may be recognized by other DOE sites. Allowances may also be made for individuals who have successfully completed other types of radiological control training. Documentation of previous training should include the individual's name, date of training, topics covered, and name of the certifying official. However, under these circumstances, any additional radiological control training necessary for the individuals to perform

radiological work or to enter specific areas, including site-specific aspects of the radiation safety training, shall be completed [see 835.901(c)]. Site-specific training for General Employee Radiological Training and Radiological Worker I and II training may be included with other site orientation training.

4. At sites where there are multiple facilities, the training may be facility-specific if personnel access is limited to those facilities for which training has been completed.

613 General Provisions

1. Radiation safety training shall include the following topics, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards:

    a. Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure [see 835.901(c)(1)]
    b. Basic radiological fundamentals and radiation protection concepts [see 835.901(c)(2)]
    c. Controls, limits, policies, procedures, alarms, and other measures implemented at the facility to control doses, including both routine and emergency actions [see 835.901(c)(3)]
    d. Individual rights and responsibilities as related to implementation of the facility radiation protection program [see 835.901(c)(4)]
    e. Individual responsibilities for implementing ALARA measures [see 835.901(c)(5)]
    f. Individual exposure reports that may be requested [see 835.901(c)(6)].

2. Prior to permitting an individual to enter a radiological area unescorted or perform unescorted/unsupervised radiological work, successful completion of training commensurate with the hazard in the area and required controls shall be demonstrated [see 835.901(b)]. Chapter 3 provides guidance regarding the level of training appropriate for each defined area. Examinations and performance demonstrations shall be used to demonstrate satisfactory completion of initial Radiological Worker Training [see 835.901(b)]. Examinations shall be used to demonstrate satisfactory completion of biennial Radiological Worker Training and Radiological Worker Training provided for significant changes to the radiological control program [see 835.901(e)]. Examinations should be written; however, the radiological control manager may approve alternatives to accommodate special needs. Alternative examinations should be equivalent in content to written examinations. The RCO should consider the following when developing the examination process:

    a. Minimizing the number of true/false questions and not allow open-book examinations
    b. Use of questions randomly selected from the question bank
    c. Acknowledgment by signature that the student participated in a post-examination review
    d. That competence in required skills be measured using performance-based examinationse. Remedial actions for failure to meet the minimum score
    f. Maximizing the question bank questions that test what the student is expected to remember months after the training rather than to test short term memory of theoretical material.

3. Training should address both normal and abnormal situations in radiological control.

4. General Employee Radiological Training and Radiological Worker training shall be completed at intervals not to exceed 24 months [see 835.901(e)]. This biennial training should not be limited to subjects with which the students are already familiar, but should focus on applicable lessons learned and topics that will increase the students' knowledge of radiological hazards and controls. Training shall also be provided to affected individuals when there is a significant change to the radiological control program [see 835.901(e)]. Changes to the radiological control program should be incorporated into the training program on a periodic basis.

5. Measures should be implemented to ensure that each individual's current training status can be assessed as necessary to ensure appropriate job assignments and to permit effective entry control. Appropriate measures include electronic databases or wallet-sized training certificates that identify current training status.

6. Site-specific training and refresher training should include changes in requirements and applicable updates of lessons learned from operations and maintenance experience and occurrence reporting, for the site and across the DOE complex.

7. Verification of the effectiveness of radiation safety training should be accomplished by surveying a limited subset of former students in the workplace. This verification is in addition to performance evaluations routinely performed by training departments. This evaluation should include observation of practical applications and discussions of the course material and may include written examinations. The survey should be performed by radiological control managers and supervisors, quality assurance personnel, or senior instructors after the former student has had the opportunity to perform work for several months. The results should be documented and may be used to identify the need for remedial training.

8. Training programs developed for radiation safety should meet the requirements for performance-based training.

9. Reading and comprehension skills in the English language are generally necessary for radiation safety training. The radiological control manager is authorized to approve alternative measures for those lacking reading and comprehension skills in the English language until adequate English language skills can be achieved. Training in an alternate language should be equivalent to training in English. The alternative measures should be sufficient to ensure that the affected individuals can respond appropriately to any audible or visible warnings that they may encounter in the facility. Orientation and the use of trained escorts provide an alternate to training with the concurrence of the radiological control manager.

10. Additional requirements for personnel training are established in DOE O 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*.

11. The site radiological control manager or designee should concur in radiation safety training material.

12. Requirements and guidance for training records and course documentation are provided in Article 725.

614 Instructor Training and Qualifications

1. All instructors should be qualified in accordance with the contractor's site Instructor Qualification Program or possess equivalent qualifications.

2. Instructors should have the technical knowledge, experience, and instructional skills required to fulfill their assigned duties.

3. Instructors-in-training should be monitored by a qualified instructor.

4. Subject matter experts without instructor qualification may provide training in their areas of expertise. However, these subject matter experts should be trained as instructors when this occurs routinely.

PART 2 General Employee Radiological Training

Table 3-1 specifies those individuals who should receive General Employee Radiological Training.

621 Site Personnel

1. Individuals shall complete radiation safety training prior to receiving occupational radiation exposure during access to controlled areas and prior to unescorted access to controlled areas [see 835.901(a)]. This training shall address the radiation safety training topics in Article 613.1 to the extent appropriate for the degree of exposure to radiological hazards that may be encountered and the required controls [see 835.901(a)].

   General Employee Radiological Training should include DOE's core course training materials (DOE-HDBK-1131-2007), as applicable, and should be expanded to include site-specific information, such as site-specific radiation types, alarm responses, and policies. This site-specific information may be included in GERT, or in facility orientations.

   For purposes of determining the need for training, occupational radiation exposure is considered to commence at the start of a job assignment that involves work with radiation producing devices or radioactive materials, or of a job assignment located within a controlled area where radiation levels, resulting from DOE activities, are expected to be distinguishable from background.

2. Workers may challenge General Employee Radiological Training core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire General Employee Radiological Training standardized core training should be completed. Challenges should not apply to the site-specific portions.

3. Additional training beyond General Employee Radiological Training should be required for unescorted entry into:

   a. Radiological buffer areas,
   b. Radioactive material areas (where the expected dose is likely to exceed > 0.1 rem in a year),
   c. Underground radioactive material areas (where the expected dose is likely to exceed > 0.1 rem in a year), or
   d. Soil contamination areas to perform work that does not disturb the soil (see table 3-1)

4. Information may be communicated by classroom lecture, videotape, or other appropriate methods. An examination is not required.

5. In the alternate year when full training is not completed, the latest General Employee Radiological Training Handbook (Student Guide) should be available for self-study.

6. If an escort is used in lieu of training, then the escort shall have completed the level of training required for the areas to be entered and the work to be performed and shall ensure that the escorted individual complies with the radiation protection program [see 835.901(d)]. In addition, the untrained individual, if occupationally exposed in a controlled area at a DOE site or facility, shall complete at least those portions of the training related to the risks of exposure to radiation and radioactive materials, including prenatal radiation exposure and individual exposure reports that may be requested [10 CFR 835.901(a)]. In this situation, such training may be provided by a use of a brochure or a poster.

622 Radiological Safety Training and Orientation for Members of the Public

1. Members of the public shall receive radiation safety training prior to being permitted unescorted access to controlled areas [see 835.901(b)]. This training shall address the radiation safety training topics in Article 613.1 to the extent appropriate for the degree of exposure to radiological hazards that may be encountered and the required controls [see 835.901(a)].

2. DOE encourages its operating entities to continuously escort members of the public in the controlled area. However, when members of the public are trained in accordance with Article 622.1, the following additional criteria should be met prior to permitting unescorted access to controlled areas:

    a. Prior approval by the radiological control manager
    b. Appropriate limitations are established on the areas to be entered and the activities to be undertaken to prevent occupational exposure
    c. The individual receives enhanced training providing information commensurate with the areas to be entered and activities to be undertaken while unescorted.

3. Members of the public, including tour groups and visiting non-DOE dignitaries, who enter the controlled area and are continuously escorted, should receive a radiological safety orientation. This orientation should include the following topics and be commensurate with the hazards present in the areas to be entered and the required controls:

    a. Risk of low-level occupational radiation exposure, including cancer and genetic effects
    b. Risk of prenatal radiation exposure
    c. Member of the public and management responsibilities for radiation safety
    d. Adherence to radiological posting and labeling
    e. Applicable emergency procedures
    f. Training for issuance of dosimeters, where applicable.

4. Information may be communicated by classroom lecture, videotape, or other appropriate methods. An examination is not required.

5. Sign-in logs may be used as radiation safety training and orientation records as required by Article 725.

PART 3 Radiological Worker Training

Table 3-1 specifies those individuals who should receive Radiological Worker Training.

631 General Provisions

1. Each individual shall demonstrate knowledge of the radiation safety training topics established in Article 613.1, commensurate with the hazards in the area and required controls, by successful completion of an examination and appropriate performance demonstrations prior to being permitted unescorted access to radiological areas and prior to performing unescorted assignments as a radiological worker [see 835.901(b)]. Radiological Worker Training should include the DOE's core course training materials (DOE-HDBK-1130-2008), as applicable, and should be expanded to include site-specific information.

2. Workers may challenge DOE's Radiological Worker I or II core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire standardized core Radiological Worker I or II Training should be completed. Challenges should not apply to the site-specific portions.

3. Radiological Worker I Training may be structured to be a prerequisite for Radiological Worker II training.

4. Radiological Worker II Training includes all of the requirements of Radiological Worker I Training and expands on the topic of hands-on work with radioactive materials. Radiological Worker II Training prepares the worker to deal with higher levels of radiation and radioactive contamination.

5. Individuals with current Radiological Worker I Training may be upgraded to allow unescorted access to other areas by completing only the additional training provided in Radiological Worker II Training.

6. In the alternate year when training is not performed, refresher training should be completed.

7. If an escort is used in lieu of training, then the escort shall have completed the level of training required for the areas to be entered and the work to be performed and shall ensure that the escorted individual complies with the radiation protection program [see 835.901(d)].

632 Radiological Worker I

1. Site-specific Radiological Worker I Training, including High/Very High Radiation Area Training (Article 632.3), should encompass at a minimum the following practical factors:

    a. Entering and exiting simulated radiological buffer areas and radiation areas (and high radiation areas when such training is included)
    b. Performance of frisking for personnel contamination, as applicable
    c. Verification of instrument response and source check
    d. Proper response to alarm situations.

2. Course length will vary dependent upon the amount of site-specific material.

3. Unescorted worker access to high and very high radiation areas may be permitted upon successful completion of Radiological Worker I Training and High/Very High Radiation Area Training. Additional training (RWII) is required to enter contamination, high contamination, or airborne radioactivity areas unescorted, and should be required for entry into soil contamination areas during activities that will disturb the soil.

633 Radiological Worker II

1. Site-specific Radiological Worker II Training should encompass at a minimum the following practical factors:

    a. Donning of protective clothing, if applicable
    b. Entering a simulated radiological buffer area, contamination area and high radiation area to perform a task, if applicable
    c. Proper response to simulated abnormal situations
    d. Proper response to simulated alarms or faulty radiological control equipment
    e. Removing protective clothing and equipment and subsequently exiting the simulated area, if applicable
    f. Performance of frisking for personnel contamination, if applicable
    g. Verification of instrument response and source check.

2. Course length will vary dependent upon the amount of site-specific material.

634 Specialized Radiological Worker Training

1. Specialized Radiological Worker Training should be completed for non-routine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker I or II Training and should be provided to personnel planning, preparing, and performing jobs that have the potential for significant radiological consequences. Such jobs may involve special containment devices, the use of mockups, and ALARA considerations. In some cases, dependent upon site-specific criteria, pre-job briefings provide an acceptable alternative to Specialized Radiological Worker Training. The site-specific radiological control manual should establish the appropriate criteria that require Specialized Radiological Worker Training.

2. Based on the information cited above and requirements of 10 CFR 835, institution of the Radiological Worker I and II and specialized radiological worker training programs is sufficient to satisfy the job-specific training requirement of 10 CFR 835.902. The Department recognizes that other training provided in the workplace, including mock-up training for specific jobs, trade or craft specific training, laboratory safety training, and pre-job briefings, may include specific instructions regarding radiological controls. While the Department continues to encourage comprehensive training of the work force, documentation of these types of training is not required to satisfy the requirements of 10 CFR 835.902. The extent to which documentation of additional training is required to satisfy other provisions of 10 CFR 835 should be prescribed in the documented radiation protection program developed by the operating entity and approved by the Department.

PART 4 Radiological Control Technician and RCT Supervisor Qualification

641 General Provisions

Training and qualification of radiological control technicians (RCTs) and their immediate supervisors should address routine operations and also focus on recognizing and handling situations in both normal and changing radiological conditions. Newly qualified technicians and those still in training should be given the opportunity to work with qualified, experienced technicians to foster development.

642 Radiological Control Technician

1. Because of the nature of their duties (e.g., monitoring the workplace, implementing administrative controls and entry controls), RCTs would generally be expected to have responsibility for implementing measures necessary for ensuring compliance with 10 CFR 835. Therefore, RCTs will generally be subject to the education, training, and skills requirements of 10 CFR 835.103. RCT training should include the standardized core course training materials, (DOE-HDBK-1122-2009) as applicable, which should be expanded to include site-specific information.

2. RCT candidates who have prerequisite knowledge, such as college credit, operational experience, or related qualifications, may satisfy individual sections of the standardized core course training requirements by passing comprehensive challenge examinations.

3. Entry-level prerequisites should be established to ensure that RCTs meet the standards for physical condition and education. At a minimum, these standards should include the following:

    a. High school education or equivalency
    b. Fundamentals of mathematics, physics, chemistry, and science
    c. Systems and fundamentals of process, operations, and maintenance
    d. Reading and comprehension level sufficient to follow procedures, write permits, prepare survey maps, write reports, and prepare shipping and transfer permits
    e. Ability to work in a support role, including communicating verbal instructions to others
    f. Physical requirements to handle personal protective equipment and other equipment and assist others in work locations, commensurate with assignment.

4. RCTs are encouraged to pursue registration by the National Registry of Radiation Protection Technologists (NRRPT).

5. Sites are encouraged to give credit toward completion of standardized core training requirements for NRRPT registration.

643 Qualification Standards for Radiological Control Technicians

Qualification Standards define the requirements for demonstrating completion of training. Signatures on the forms in Qualification Standards provide documentation of satisfactory proficiency.

1. The Qualification Standards from the standardized core course should be supplemented to include site-specific elements.

2. Qualification Standards for the RCT position should include on-the-job training to provide hands-on experience directly applicable to the job.

3. An RCT trainee should be under direct supervision of a qualified RCT. Direct supervision would allow a qualified RCT to intervene if necessary.

644 Oral Examination Boards

The oral examination board provides an opportunity to identify areas of strength and weakness related to performance of radiological control technician duties and supervisor functions. The oral examination board also provides the opportunity to identify additional training needs to enhance RCT and supervisor training programs.

1. The radiological control manager should consider using an oral examination board to determine the initial qualification and requalification of candidates for RCT and supervisor positions.

2. The radiological control manager should designate the board members and appoint a chairperson.

3. The board constituted to evaluate RCT qualification should be composed of at least three persons to include an RCT supervisor, radiological control staff, and line management operations department supervisors and staff personnel, as applicable. RCT instructors may participate as non-voting members.

4. The board should assess the candidate's response to normal and emergency situations. Questions should be of the type that is not normally covered in a written examination.

5. The board constituted to evaluate RCT supervisor qualification should not include peers or subordinates as voting members.

645 Continuing Training

1. Following initial qualification, the RCT should begin a 2-year cycle of continuing training required for requalification.

2. Every requalification should include completion of practical training and a comprehensive written examination. A final oral examination board is encouraged.

3. Continuing training in radiological protection knowledge and skills should provide continued improvement in the knowledge and skills of the RCT.

4. Continuing training should include site-specific and DOE-wide changes in requirements and updates of lessons learned from operating experience and industry events.

5. Continuing training should include written examinations as applicable, demonstrations of proficiency controlled by qualification standards, and oral examinations as needed to ensure understanding of the topic.

6. Infrequently performed tasks, such as those for emergency response, may require annual training. Other tasks may require training prior to initiation.

646 Radiological Control Technician Supervisors

1. Because of the nature of their duties, RCT supervisors would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103. Training and education standards for RCT supervisors should be consistent with DOE-STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*.

2. RCT supervisors should have supervisory and leadership capabilities to direct the work of technicians; effectively interact with crafts, line supervisors, professional staff, and other managers; and be able to respond and direct others in emergency and abnormal situations.

3. RCT supervisors' knowledge of facility radiological control hazards, programs, and procedures should be reassessed every 2 years. DOE encourages the use of comprehensive oral examination boards in accordance with Article 643.

4. Oral examination boards should focus on the ability to analyze situations and supervise subordinates. The RCT supervisor's depth of knowledge should exceed that expected of an RCT.

647 Subcontracted Radiological Control Technicians

1. Because their responsibilities closely parallel those of in-house RCTs, subcontracted RCTs would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have the same knowledge and qualifications required of facility technicians performing the same duties. To obviate the need for full training as an RCT, the training and qualification program should include the following:

    a. Review of resumes to identify technicians with experience in jobs similar to those for which they will be employed
    b. Written examination and oral evaluation to verify appropriate knowledge level
    c. Identification of the duties technicians will be authorized to perform
    d. Training in facility procedures and equipment associated with the authorized duties
    e. Training on site-specific information, as applicable
    f. Observation of on-the-job performances by the radiological control technician Supervisor.

2. Subcontracted technicians who work at the facility for extended time periods (more than 6 months) should receive continuing training commensurate with their assigned duties, as applicable to the contract agreement. Completion of an oral examination in accordance with Article 643 is encouraged.

PART 5 Other Radiological Training

651 Management Training

1. Training and education standards for line managers of radiological control programs (or elements of those programs) should be consistent with DOE-STD-1107-97.

2. Line managers (DOE and contractors) who manage, supervise, or provide oversight of radiological control programs would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should be trained in the principles of this Standard. DOE has developed a course appropriate for these individuals. This course is, Radiological Control Training for Supervisors (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix A - Radiological Control Training for Supervisors*).

3. Such training should be based on DOE's core course training materials supplemented by site-specific procedures and be completed by new personnel prior to formally assuming line supervision and management responsibilities. This training should include the following:

    a. Guidance on handling such personnel interactions
    b. Emphasis on being factual
    c. Fundamentals of communicating risks
    d. Importance of keeping management informed.

4. Incumbents should participate in continuing training. The continuing training should emphasize self-assessment and external evaluations including performance indicators, root causes, and lessons learned based on operational experience.

652 Technical Support Personnel

Appropriate technical support personnel (engineers, schedulers, procedure writers) may be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should be trained in the ALARA fundamentals and dose reduction techniques. They should also participate in selected portions of job-specific and specialized training, particularly in situations using mock-ups. Technical support personnel should receive training consistent with DOE-HDBK-1110-2008, *ALARA Training for Technical Support Personnel*.

653 Planners

Planners who develop detailed work plans involving or associated with radioactivity or radioactive materials should have Radiological Worker Training to the level required by the workers using the work plans. It is recommended that planners have Radiological Worker II training. Planners would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103. Planners should receive training consistent with DOE-HDBK-1110-2008, *ALARA Training for Technical Support Personnel*.

654 Radiological Control Personnel

1. Radiological Control senior staff (see Article 143) and management would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have:

    a. A combination of education and experience commensurate with their job responsibilities
    b. Continuing training based on an assessment of job responsibilities to maintain and enhance proficiency
    c. Continuing training to remain cognizant of changes to the facility, operating experience, procedures, regulations, and quality assurance requirements.

2. Radiological support personnel may include but are not limited to: dosimetry technicians; instrument technicians; medical personnel; records clerks; whole body counter technicians; and laboratory personnel.

3. Radiological support personnel would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have:

    a. Applicable training on standardized core course topics from Radiological Worker I and II and Radiological Control Technician Training and additional job-specific topics
    b. Training appropriate to the tasks to be performed
    c. Continuing training to provide continued improvement in knowledge and skills.

4. Training and education standards for radiological control senior staff and support personnel should be consistent with DOE STD-1107-2007.

5. DOE encourages certification and involvement with professional industry organizations.

655 Radiographers and Radiation Generating Device Operators

1. Radiographers would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have training in accordance with 10 CFR 34.31.

2. Radiation generating device operators would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have training appropriate for the radiation source involved and commensurate with the level described in 10 CFR 34.43

3. DOE has developed a course appropriate for operators of x-ray devices. This course is Radiological Safety Training for Radiation-Producing (X-Ray) Devices (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix C - Radiological Safety Training for Radiation-Producing (X-Ray) Devices*).

656 Emergency Response Personnel

Provisions should be in place to accommodate rapid site and radiological area access by on-site and off-site emergency workers such as firefighters, medical personnel, and security personnel.

1. Emergency response personnel, from both on-site and off-site, may be required to work in radiological areas.

2. Emergency response personnel should receive special radiological worker training commensurate with the situations they are likely to encounter. Any individual assigned to perform emergency actions that may result in a dose exceeding the occupational dose limits shall receive Radiological Worker or equivalent training [see 835.1302(c)].

3. Such training should be based on DOE's Radiological Worker core course and site-specific training materials.

4. If such workers are not trained, trained escorts should be assigned.

5. Training should make it clear that lifesaving has priority over radiological controls.

6. Records of this training should be maintained.

PART 6 Training For Special Applications

661 Plutonium Facilities

The content of DOE-HDBK-1145-2008, *Radiological Safety Training for Plutonium Facilities*, should be considered in addition to DOE's core training materials at plutonium facilities.

662 Uranium Facilities

The content of DOE-HDBK-1113-2008, *Radiological Safety Training for Uranium Facilities*, should be considered in addition to DOE's core training materials at uranium facilities.

663 Tritium Facilities

The content of the training appendix to DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*, should be considered in addition to DOE's core training material at tritium facilities.

664 Accelerator Facilities

The content of DOE-HDBK-1108-2002, *Radiological Safety Training for Accelerator Facilities*, should be considered in addition to DOE's core training material at accelerator facilities.

665 Radiological Contamination Control for Laboratory Research

DOE has developed a course appropriate for individuals who participate in laboratory research using radioactive materials. This course is, Radiological Contamination Control for Laboratory Research, (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix B - Radiological Contamination Control for Laboratory Research*).

CHAPTER 7 RADIOLOGICAL CONTROL RECORDS

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PART 1 General Provisions

711 Purpose

This chapter prescribes practices for preparing and retaining radiological control records. The work force and management are required to use records to document radiological safety afforded to individuals on-site. Records of radiological control programs may be required to support worker health studies and future disputes or claims. Therefore, these records should be high quality, readily retrievable, and managed for the prescribed retention period. Consideration should be given to cross-referencing related records to aid retrievability. Records shall be handled such that personal privacy is protected.

712 Records Management Program

1. A radiological records management program should be established. This program should ensure that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable), and disposition. The records management program shall be sufficient to ensure that records are maintained as necessary to document compliance with 10 CFR 835 [see 835.701(a)] and should include records of the following:

    a. Radiological Control Policy Statements
    b. Radiological Control Procedures
    c. Individual Monitoring Records
    d. Internal and External Dosimetry Policies and Procedures (including Bases Documents)
    e. Personnel Training (course records and individual records)
    f. ALARA Program Implementation
    g. Radiological Instrumentation Test, Maintenance, and Calibration
    h. Radiological Surveys
    i. Area Monitoring Dosimetry Results
    j. Radiological Work Permits
    k. Radiological Performance Indicators and Assessments
    l. Radiological Safety Analysis and Evaluation Reports
    m. Quality assurance measures
    n. Radiological Incident and Occurrence Reports (and Critique Reports, if applicable)
    o. Sealed radioactive source accountability and control
    p. Release of material to controlled areas
    q. Reports of loss of radioactive material.

2. Where radiological services (for example, dosimetry and laboratory analyses) are purchased, there should be a clear agreement regarding records responsibility during performance of the service. Records of results should reside in the custody of the originating contract organization.

3. Detailed information concerning an individual's exposure shall be made available to that individual, upon request. An individual's exposure information may be provided to others consistent with the Privacy Act of 1974 (PA), which contains requirements to protect the privacy of individual records [see 835.702(f) and 801(d)].

4. The records management program shall:
    a. Protect records containing entire or partial social security numbers as Personally Identifiable Information (PII).
    b. Only disclose information in accordance with the Privacy Act and the Health Insurance Portability and Accountability Act of 1996 (HIPAA) as appropriate.

713 Recordkeeping Standards

1. Radiological control records should be accurate and legible. The records should include the following:

    a. Identification of the facility, specific location, function, and process
    b. Signature or other identifying code of the preparer and date
    c. Legible entries in ink
    d. Corrections identified by a single line-out, initialed and dated
    e. Supervisory signature to ensure review and proper completion of forms.

2. A file of names, signatures, and initials for future identification of the individual who signed or initialed a record should be maintained, as needed, with the record or by the radiological control organization.

3. Radiological control records should not include:

    a. Opaque substances for corrections
    b. Shorthand or other non-standardized terms.

4. Similar procedural standards should be established for records of data that are recorded and stored electronically.

5. Unless otherwise specified, radiological control records shall use the special units of curie, roentgen, rad, and rem, including multiples of these units, or other conventional units such as dpm, dpm/100 cm^2 [see 835.4]. Use of the international system of units (becquerel, gray, and sievert) should be limited to calculational, scientific, or reference purposes. The SI units, ecquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards.

PART 2 Employee Records

721 Employment History

1.For each radiological worker whose occupational exposure is monitored in accordance with Article 511.1 or 521.1, efforts shall be made to obtain records of prior years' occupational doses. If formal records of previous occupational doses cannot be obtained, a written estimate signed by the individual may be accepted [see 835.702(e)]. Where practical, the association between the radiation dose and job function should be preserved for trending purposes and future worker health studies. The following information should be maintained:

a. Previous work history detailing radiological work assignments, to the extent practical, and yearly occupational doses at other DOE and non-DOE facilities.
b. Nuclear Regulatory Commission Form 4 or equivalent that documents previous occupational radiation doses.
c. Ongoing work history documenting job classification and radiation doses; the facility and occupational codes required by DOE O 231.1B, Environment Safety and Health Reporting, for reporting occupational dose to DOE should be used for this process.
d. DOE standardized forms to document previous and ongoing radiation doses.

722 Personnel Radiological Records

1. Individual monitoring records shall be maintained to demonstrate compliance with the regulatory limits [see 835.701(a)].

   a. Records of doses received by all individuals for whom individual monitoring was performed as required by Article 511.1 or 521.1, including records of zero dose, shall be maintained [see 835.702(a)].
   b. These records shall be sufficient to evaluate compliance with all applicable dose limits and monitoring and reporting requirements [see 835.702(c)(1) & (2)].

2. Radiation dose records shall contain information sufficient to identify each person, including social security, employee number, or other unique identifier [see 835.702(c)(2)].

3. Procedures, data, and supporting information needed to reconfirm an individual's dose at a later date shall be maintained [see 835.702(g)].

4. External dose records shall include applicable extremity, skin, lens of the eye, and whole body dose monitoring results [see 835.702(c)(3)]. These doses are usually measured with personnel dosimeters, but records may include:

   a. Evaluations resulting from anomalous dose results such as unexpected high or low doses
   b. Dose evaluations from lost or damaged dosimeters, or for unmonitored workers
   c. Evaluations of non-uniform radiation doses.

5. Internal dose records shall include committed effective dose [see 835.702(c)(4)(i)], committed equivalent doses to the affected organs and tissues [see 835.702(c)(4)(ii)], and identity of radionuclides [see 835.702(c)(4)(iii)]. The supporting information typically includes the following:

    a. Applicable whole body and lung counting results (including chest wall thickness measurements where applicable)
    b. Applicable urine, fecal and specimen analysis results, including estimated intake
    c. Dose assessment, as required.

6. Records of the summation of external equivalent dose to the whole body and committed equivalent dose to any organ assigned a dose shall be maintained for the individual receiving such dose [see 835.702(c)(5)(ii)].

7. The total effective dose received by each individual monitored in accordance with Article 511.1 or 521.1 shall be maintained for each year the individual is monitored [see 835.702(c)(5)(i)].

8. The equivalent dose to the embryo/fetus of a declared pregnant worker shall be maintained [see 835.702(c)(6)] and should be kept with the occupational dose records for that worker.

9. Individual dose records shall include the cumulative total effective dose [see 835.702(c)(5)(iii)].

10. Reasonable efforts shall be made to obtain records of prior years' doses for each radiological worker monitored in accordance with Article 521 or 522 [see 835.702(e)]. If an individual's previous employer is not responsive to initial efforts to obtain these records, at least two additional attempts should be made. Records of lifetime occupational dose should be maintained with the individual's occupational dose records. Some radiological workers, such as Defense Nuclear Facilities Safety Board and DOE Headquarters staff members, may have site access but not be expected to exceed 100 mrem in a year at the site. Maintenance of lifetime dose records for these individuals is not expected.

11. Records of authorization to exceed administrative control levels should be retained.

12. Emergency doses and planned special exposures [see 835.204 & 1302] shall be accounted for separately, but should be maintained with the individual's occupational dose records.

13. Records of non-uniform dose to the skin need not be retained in an individual's dose records if the dose is less than 2 percent of the limit for the skin in Table 2-1 [see 835.702(b)] (see Article 723 for requirements for records of radiological incidents and occurrences).

14. Records of internal dose (committed effective dose or committed equivalent dose) are not required if the dose is less than 0.01 rem (0.1 mSv). The bioassay or air monitoring result used to estimate the dose shall be maintained. The unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold.

723 Other Personnel Radiological Records

1. The complete records of radiological incidents and occurrences involving personnel dose should be retained in, or cross-referenced to, the individual's dose records. Records related to doses exceeding the Table 2-1 limits including authorized emergency doses and planned special exposures and other, non-authorized doses exceeding the limits, shall be maintained [see 835.1301(b)].

2. Records of employee radiological safety concerns that have been formally investigated and documented should be maintained.

3. Records of the formal written declaration of pregnancy, including the estimated conception date, and revocations of declarations of pregnancy shall be maintained [see 835.704(d)]. Records indicating that the pregnancy has concluded (therefore, the conditions of Article 215 do not apply) should also be maintained.

724 Medical Records

1. Pre-employment medical records, if available, and reports of periodic medical examinations should be maintained.

2. Physical examination reports and fit testing results for respirator use should be maintained for respirator users.

3. Medical evaluations and treatment performed in support of the radiological control program should be documented.

4. Medical treatments such as chelation therapy to reduce the committed effective dose and committed equivalent dose from unplanned internal exposures.

5. Disclosure of medical records shall be consistent with HIPAA.

725 Radiological Training and Qualification Records

1. Records of training and qualification in radiological control are maintained to demonstrate that an individual received appropriate information to perform the work assignment in a safe manner. Qualification standard records are retained for on-the-job and practical factor training as well as for formal classroom training.

2. Formal records or summary reports of training and qualification should be readily available to first-line supervision and management of involved personnel to aid in making work assignments.

3. Personnel training records shall be controlled and retained [see 835.704(a)]. At a minimum, these records should include the following:

    a. Course title
    b. Attendance records with instructor's name
    c. Employee's name and identification number
    d. Date of training
    e. Identification of the examination or evaluation form, including sufficient data to identify which test each individual completed
    f. Verification document or record confirming satisfaction of the training requirement
    g. Documentation related to exceptions for training requirements and extensions of qualification
    h. Quizzes, tests, responses and acknowledgments of training, with the date and signature of the individual trained
    i. Special instructions to females, their supervisors, and coworkers concerning prenatal radiation dose, acknowledged by the worker's signature.

4. Records shall be retained for the following types of radiation safety training [see 835.704(a)]:

    a. General employee radiological training
    b. Radiological worker training
    c. Periodic training, as appropriate
    d. Members of the public training for unescorted access.

5. Records should be retained for the following types of radiation safety training:

    a. Instructor training
    b. Training of other radiological control personnel
    c. Respiratory protection training
    d. Qualifications for special tests or operations
    e. Orientation of members of the public
    f. Training of emergency response personnel.

6. Records shall be maintained as necessary to demonstrate that individuals who are responsible for the development and implementation of measures necessary to ensure compliance with 10 CFR 835 have the appropriate education, training, and skills to execute these responsibilities [see 835.103 and 835.701(a)]. These records should include records of the training provided in accordance with Parts 4 and 5 of Chapter 6 of this Standard.

7. The following instructional materials should be maintained:

    a. Course name, with revision and approval date.
    b. Instructor's manuals, course content, or lesson plans containing topical outlines.
    c. Video and audio instructional materials, including the dates and lessons for which they were used.
    d. Official handouts or other materials retained with the master copy of the course.
    e. Job-specific training documents, such as instrument use, radiological procedures, radiological work permit special training requirements, pre-job briefings, and mock-up training.

PART 3 [Reserved]

PART 4 Radiological Control Procedures

741 Policies, Procedures, and Radiological Work Permits

Records of the radiological control program should consist of policy statements, procedures, work authorizations, and supporting data. The records should be maintained in a manner that will allow correlation with the corresponding support information. For example, procedures for performing radiation surveys should be identifiable with the survey results. Completed radiological work permits should be maintained.

742 ALARA Program Records

Records of actions taken to maintain occupational exposures ALARA shall be maintained [see 835.701(a)]. These records shall include facility design and control measures [see 835.704(b)] and should include:

a. ALARA plans and goals
b. The minutes of ALARA committees and other committees where radiological safety issues are formally discussed
c. Records of pre-job briefings and post-job evaluations
d. Records of temporary shield and portable ventilation installation and removal.

743 Quality Assurance Records

Records of quality assurance reviews and audits developed for radiological control functions shall be retained to ensure that sufficient records are specified, prepared, reviewed, approved, and maintained to accurately reflect completed work [see 835.704(c)]. DOE O 414.1D, *Quality Assurance* and 10 CFR 830.120 provide additional information regarding quality assurance records. Quality assurance records should include:

a. Assessment checklists
b. Assessment methods
c. Assessment results
d. Assignment of corrective actions
e. Completion and verification of corrective actions.

PART 5 Radiological Monitoring

751 Area Monitoring Records

1. Radiological control programs require the performance of radiation, airborne radioactivity, and contamination monitoring to determine existing conditions in a given location. Databases, forms or maps with sufficient detail to permit identification of original survey and sampling locations should be maintained. Radiological monitoring results should be recorded on appropriate standard forms or in appropriate electronic formats and should include the following common elements:

    a. Date, time, and purpose of the survey
    b. General and specific location of the survey
    c. Name and signature of the surveyor and analyst
    d. Pertinent information needed to interpret the survey results
    e. Reference to a specific radiological work permit if the survey is performed to support the permit.

2. Records shall be maintained to document:

    a. Results of monitoring and surveys for radiation and radioactive materials [see 835.703(a)]
    b. Results of monitoring and calculations used to determine individual occupational doses [see 835.703(b)]
    c. Results of surveys for release of materials from radiological areas [see 835.703(c)]
    d. Results of sealed radioactive source leak tests and inventories [see 835.704(f)]
    e. Results of surveys of radioactive material packages received from transportation [see 835.405 and 701(a)]
    f. Changes in monitoring equipment, techniques, and procedures [see 835.704(e)].

752 Radiation Monitoring

In addition to the elements provided in Article 751, records of radiation monitoring should include at a minimum, the following information:

    a. Instrument model and serial number
    b. Results of the measurements of area dose rates
    c. Locations of hot spots and other radiological hazards
    d. Facility conditions existing during the survey that may have affected radiological conditions, as applicable.

753 Airborne Radioactivity Monitoring

In addition to the elements provided in Article 751, records of airborne radioactivity monitoring should include, at a minimum, the following information:

    a. Model and serial number of the sampler or unique identifier of each sampler and laboratory counting instrument and appropriate supporting parameters including counting efficiency, counting time, and correction factors
    b. Locations of fixed air samplers
    c. Locations of portable air samplers used for a survey
    d. Measured air concentrations
    e. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium
    f. Identification (e.g., names and/or employee numbers) of individuals in the area for whom DAC-hour exposure should be calculated.

754 Contamination Monitoring

In addition to the elements provided in Article 751, records of contamination monitoring should include, at a minimum, the following information:

a. Model and serial number of counting equipment, when direct-reading surveys are conducted
b. Contamination levels (using appropriate units) and whether the contamination was fixed or removable
c. Appropriate supporting parameters such as counting efficiency, counting time, correction factors, type of radiation
d. Location of areas found to contain hot particles or high concentrations of localized contamination
e. Follow-up survey results for decontamination processes, preferably cross-referenced to the original survey.

755 Sealed Radioactive Source Leak Tests and Inventories

1. In addition to the elements provided in Article 751, records of sealed radioactive source leak tests should include, at a minimum, the following information:

   a. Model and serial number of counting equipment
   b. Contamination levels (using appropriate units) and type of radiation with appropriate supporting parameters such as counting efficiency, counting time correction factors
   c. Corrective actions for leaking sources.

2. Records of accountable sealed radioactive source inventories shall include, at a minimum, the following information [see 835.704(f) and 835.1202(a)]:

   a. The physical location of each accountable sealed radioactive source
   b. Verification of the presence and adequacy of associated postings and labels
   c. Verification of the adequacy of storage locations, containers, and devices.

PART 6 Instrumentation and Calibration Records

761 Calibration and Operational Checks

1. Calibration records for fixed, portable, and laboratory radiation measuring instruments and equipment and individual monitoring devices shall be maintained [see 835.703(d)]. These calibration records should include frequencies, method, dates, personnel, training, and traceability of calibration sources to NIST or other acceptable standards.

2. Calibration and maintenance records shall be maintained for instruments and equipment used for monitoring [see 835.703d]. Calibration and maintenance records should be maintained for the following equipment:

    a. Portable survey instruments
    b. Bioassay measurement equipment
    c. Laboratory, counting room, and fixed radiation measuring equipment
    d. Process and effluent monitors and sampling equipment
    e. Radiation area monitors
    f. Portal monitors and other personnel contamination monitors
    g. Pocket and electronic dosimeters
    h. Air sampling equipment
    i. Tool and waste monitoring equipment
    j. Protective clothing and equipment monitors.

3. Documentation of instrument operational checks for documented surveys shall be maintained [see 835.701(a) & 835.401(b)(4)]. Such records should be maintained for a period not less than the calibration period of the instrument.

4. Maintenance results for each instrument and device shall be created and retained [see 835.703(d)]. Maintenance histories for each instrument and device should be created and include the nature of any defects and corrective actions taken.

762 Special Calibration Records

Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication, or unusual occurrence should be retained. In addition, records of special instrument calibrations and modifications made in accordance with Article 562.6 shall be retained [see 835.703(d)].

PART 7 Records Management

771 Media

A combination of media may be used for a comprehensive records system. All records should be stored in a manner that ensures their integrity, retrievability, and security and, unless otherwise specified, shall be retained until final disposition is authorized by DOE [see 835.701(b)].

772 Microfilm

Records may be microfilmed provided the resulting film copy is capable of producing a clear, legible printed copy after storage for the specified period. The following controls should be administered:

1. Verification that a copy printed from microfilm is legible.

2. Confirmation that all information within a record has been copied to microfilm.

3. Periodic quality audits of the final microfilm version of a record.

773 Computerization of Records

1. Records may be transferred to electronic storage media provided certain precautions are taken to ensure that the information is maintained in a retrievable configuration.

2. Controls for the use and handling of electronic storage media should include the following:

    a. A master index of documents on the electronic storage medium
    b. A program to ensure back-up and retrievability of information
    c. Quality control during data entry and analysis
    d. An index identifying software applications used in conjunction with the data
    e. Software validation and verification
    f. Periodic quality audits of software
    g. Prevention of unauthorized manipulation of data
    h. Assurance that previously stored information is retrievable and useable after system modifications.
    i. Provisions for converting the data to new storage media and software before the current storage media and software become obsolete.

774 Retention

1. 10 CFR 835 establishes requirements for retaining records. Upon cessation of activities that could result in the occupational exposure of individuals, all required records related to individual exposure monitoring shall be transferred to DOE [see 835.702(h)].

2. Once a record has been created, reviewed, and signed by appropriate supervision, the record is considered complete and should not be modified. Subsequent errors identified in a completed record may be corrected by creating a supplemental record that includes traceability for the correction.

775 Physical Protection of Records

1. Methods for protecting documents should include vaults, file rooms with fixed fire suppression, fire rated cabinets, duplicate storage, or combinations of these.

2. Storage arrangements should address physical damage that could be caused by temperature extremes, moisture, infestation, electromagnetic fields, excessive light, stacking, theft, and vandalism.

3. Records should, as a minimum, be protected from:

    a. Exposure to fire, equivalent to an Underwriters Laboratories, Inc., 1.5-hour, or greater, fire resistance rating.
    b. Exposure to water damage caused by a 100-year flood.
    c. Exposure to windstorm velocities of 100-year recurrence.

PART 8 Radiological Reporting

781 Reports to Individuals

1. Individuals who are monitored in accordance with Article 511.1 or 521.1 shall be provided an annual report of their dose [see 835.801(c)]. Upon request, an individual shall be provided detailed information concerning his or her exposure [see 835.801(d)].

2. Upon request, terminating employees shall be provided a report, as soon as data are available but not later than 90 days following the last day of employment. A written estimate, based upon available information, shall be provided upon termination, if requested [see 835.801(b)].

3. Reports of individual doses shall include the site or facility name, the individual's name and social security number, employee number, or other unique identification number, and all dose information required by Articles 722.4 – 722.9 [see 835.801(a)]. Reporting of lifetime occupational dose is suggested.

4. Reports of individual exposure to radiation or radioactive material required under DOE O 232.2, *Occupational Reporting and Processing of Operations Information* or as a result of a planned special exposure, emergency exposure, or accident should be submitted to DOE in accordance with applicable occurrence reporting requirements. Copies of the individual dose information contained in these reports shall be provided to the affected individual at a time not later than transmittal of the report to the Department [see 835.801(e)].

5. Monitoring results, including zero dose, should be reported to each member of the public monitored in accordance with Article 511 or 521 within 30 days and no later than 90 days after the end of the visit. This report may serve as the annual report to these individuals. However, if an individual visits a site or facility more than once in a year, then an annual report should be sent which sums the doses from all of the visits.

6. Radiation exposure data pertaining to a special individual, as defined by DOE O 231.1B, *Environment, Safety and Health Reporting*, who visits a DOE or DOE contractor site or facility to conduct Department-related business, must be reported to the REMS repository simultaneous with dispatch of reports to individuals, within 30 days after the assessment of the radiation exposure.

782 Annual Radiation Dose Summary

DOE O 231.1B, *Environment, Safety and Health Reporting*, provides reporting requirements for the Annual Radiation Dose Summary. This report includes internal and external radiation dose results for monitored DOE and DOE contractor employees, and for monitored members of the public.

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10 CFR 71, *Packaging and Transportation of Radioactive Material*, U.S. Nuclear Regulatory Commission [423.12, 552.4]

10 CFR 708, *Doe Contractor Employee Protection Program*, U.S. Department of Energy [345]

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10 CFR 830, *Nuclear Safety Management*, U.S. Department of Energy [118.4, 743.1]

10 CFR 835, *Occupational Radiation Protection,* U.S. Department of Energy [multiple citations]

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DOE O 232.2 (8/29/11) *Occurrence Reporting and Processing of Operations Information*, [127, 781.4]

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DOE O 420.1C, (12/4/12) *Facility Safety*, [118.4, 128, 381]

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ADDITIONAL REFERENCES

In addition to the documents cited in this Standard, references to documents that may be pertinent to the Department's occupational radiological control program may be found in the reference section of DOE G 441.1-1C.

GLOSSARY

Terms from 10 CFR 835 [see 835.2] are not included in the glossary and are used in this Standard consistent with their regulatory definition.

abnormal situation: Unplanned event or condition that adversely affects, potentially affects, or indicates degradation in the safety, security, environmental, or health protection performance or operation of a facility.

activation: Process of producing a radioactive material by bombardment with neutrons, protons, or other nuclear particles.

administrative control level: A numerical occupational dose constraint established at a level below the occupational dose limits provided in Chapter 2 to administratively control and help reduce individual and collective dose.

ALARA Committee: Multi-disciplined forum that reviews and advises management on improving progress toward controlling radiation exposure and radiological releases.

assessment: Evaluation or appraisal of a process, program, or activity to estimate its acceptability.

becquerel (Bq): The International System (SI) derived unit for radioactivity. One becquerel is equal to one nuclear decay or transformation per second.

collective dose: The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation

company-issued clothing: Clothing provided by the company for non-radiological purposes, such as work coveralls and shoes.

containment device: Barrier, such as a glovebag, glovebox, or tent, for inhibiting the release of radioactive material from a specific location.

continuing training: Training scheduled over a specified time, such as over a two-year period, for the purpose of maintaining and improving technical knowledge and skills.

continuous air monitor (CAM): Instrument that continuously samples and measures the levels of airborne radioactive materials on a "real-time" basis and has alarm capabilities at preset levels. Also referred to as a real-time air monitor.

contractor senior site executive: The individual at a DOE contractor-operated facility or site who has final on-site corporate authority and is often called President, General Manager, Site Manager, or Director.

counseling: Advice, information exchange, and guidance provided to employees on radiologically related topics, such as dose perspectives; potential health effects from radiation exposure; skin contaminations; contaminated wounds; internally deposited radioactivity; pregnancy; and radiation exposure. This advice and guidance are normally provided by knowledgeable, senior professionals from the radiological control organization and other organizations, such as Medical, as appropriate.

critical mass: The smallest mass of fissionable material that will support a self-sustaining chain reaction under specified conditions.

critique: Meetings of personnel involved in or knowledgeable about an event (either a success or an abnormal event) to document a chronological listing of the facts.

decontamination: Process of removing radioactive contamination from personnel, equipment, or areas.

direct contamination reading: The apparent surface contamination level, expressed in disintegrations per minute per 100 cm^2, resulting when an appropriate contamination probe or detector is placed in close proximity (e.g., ~1/4 inch) to the soil surface. Appropriate efficiency and geometry correction factors should be applied to such a reading.

disintegration per minute (dpm): The rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

DOELAP: Department of Energy Laboratory Accreditation Program for personnel dosimetry and bioassay programs.

dose assessment: Process of determining radiation dose and uncertainty included in the dose estimate, through the use of exposure scenarios, bioassay results, monitoring data, source term information, and pathway analysis.

embryo/fetus: Developing human organism from conception until birth. Same as unborn child.

engineered controls: A special form of physical design feature in which components and systems, such as piping, containments, ventilation, filtration, or shielding, are used to reduce airborne radioactivity, radiation levels, and the spread of contamination.

facility: For the purpose of this Standard, a facility includes systems, buildings, utilities, and related activities whose use is directed to a common purpose at a single location. Examples include: accelerators, storage areas, test loops, nuclear reactors, radioactive waste disposal systems and burial grounds, testing laboratories, research laboratories, and accommodations for analytical examinations of components. Also includes: pipelines, ponds, impoundments, landfills and the like and motor vehicles, rolling stock, and aircraft.

filter integrity test: Test performed on High-Efficiency Particulate Air (HEPA) filters to identify any damage to the filter or leakage around the filter.

fixed contamination: Radioactive material that has been deposited onto a surface and cannot be readily removed by non-destructive means, such as casual contact, wiping, brushing, or laundering. Fixed contamination does not include radioactive material that is present in a matrix, such as soil or cement, or radioactive material that has been induced in a material through activation processes.

frisk or frisking: Process of surveying personnel for contamination. Frisking can be performed with hand-held survey instruments or automated monitoring devices.

gestation period: The time from conception to birth, approximately 9 months.

gray (Gy): SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

high-efficiency particulate air (HEPA) filter: Throwaway extended pleated medium dry-type filter with 1) a rigid casing enclosing the full depth of the pleats, 2) a minimum particle removal efficiency of 99.97 percent for thermally generated monodisperse di-octyl phthalate smoke particles with a diameter of 0.3 micrometer, and 3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

hot particle: Fuel, activated corrosion product, or other particles of small size that have a high specific activity as a result of nuclear fission or neutron activation. When in direct contact with the skin, hot particles are capable of producing a equivalent dose to the skin of 100 millirem or more in one hour to a localized area.

hot spot: Localized source of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 millirem (1 mSv) per hour on contact.

infrequent or first-time activities: Radiological work activities or operations that require special management attention and consideration of new or novel radiological controls. The designation of infrequent or first-time activities is specifically applicable to facilities that conduct routine and recurring process operations, and is not applicable to facilities that routinely conduct first-time activities, such as experimental or research facilities.

irradiator: Sealed radioactive material used to irradiate other materials and that has the potential to create a radiation level exceeding 500 rad (5 grays) in 1 hour at 1 meter. Although not addressed in this Standard, acceptable radiological controls for irradiator use are specified in Title 10, Code of Federal Regulations, Part 36.

lifetime dose: Total occupational dose over a worker's lifetime, including external and internal dose.

low-level waste: Waste that contains radioactive material and is not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in Section 11e(2) of the Atomic Energy Act, as amended. Test specimens of fissionable material irradiated only for research and development and not for production of power or plutonium may be classified as low-level waste provided the concentration of transuranic activity is less than 100 nCi/g.

personal protective equipment: Equipment such as respirators, face shields, safety glasses and protective clothing used to protect workers from excessive exposure to radioactive or hazardous materials.

personnel dosimeters: Devices designed to be worn by a single individual for the assessment of equivalent dose such as film badges, thermoluminescent dosimeters (TLDs), and pocket ionization chambers.

personnel monitoring: Systematic and periodic estimate of radiation dose received by individuals during working hours. Also, the monitoring of individuals, their excretions, skin, or any part of their clothing to determine the amount of radioactivity present.

planned special exposure: Preplanned, infrequent exposure to radiation, separate from and in addition to the annual dose limits.

prenatal radiation exposure: The exposure of an embryo/fetus to radiation.

primary dosimeter: A dosimeter worn on the body used to obtain the formal record of whole body radiation dose.

protective clothing: Clothing provided to personnel to minimize the potential for skin and personal and company-issued clothing contamination. Also referred to as "anti-contamination clothing," "anti-Cs," and "PCs."

qualification standard: The explicit performance requirements for minimum proficiency in technical, academic, and site-specific knowledge and practical skills used in determining satisfactory completion of training programs. The qualification standard is used to qualify radiological control technicians at DOE facilities.

rad: Unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joules per kilogram (0.01 gray).

radioactive material: Any material that spontaneously emits ionizing radiation (e.g., X- or gamma rays, alpha or beta particles, neutrons). The term "radioactive material" also includes materials onto which radioactive material is deposited or into which it is incorporated. For purposes of practicality, both 10 CFR 835 and this Standard establish certain threshold levels below which specified actions, such as posting, labeling, or individual monitoring, are not required. These threshold levels are usually expressed in terms of total activity or concentration, contamination levels, individual doses, or exposure rates.

radioactive waste: Solid, liquid, or gaseous material that contains radionuclides regulated under the Atomic Energy Act, as amended, and is of negligible economic value considering the cost of recovery.

radioactivity: A natural and spontaneous process by which the unstable atoms of an element emit or radiate excess energy and/or particles from their nuclei and, thus change (or decay) to atoms of a different element or to a lower energy state of the same element.

radiography: Examination of the structure of materials by non-destructive methods, using a radioactive source or a radiation generating device.

radiological buffer area (RBA): An intermediate area established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure.

radiological control hold point: Cautionary step in a technical work document requiring the radiological control organization to perform some action or verification. The radiological control hold point requirements should be satisfactorily completed before the work is continued.

radiological control technician: A radiological worker whose primary job assignment involves assessment of workplace radiological conditions, specification of protective measures, and provision of assistance and guidance to other individuals in implementation of radiological controls.

radiological label: Label on an item which indicates the presence of radiation or radioactive materials.

radiological posting: Sign, marking, or label that indicates the presence or potential presence of radiation or radioactive materials.

Radiological Source Registry and Tracking (RSRT) system: DOE's centralized repository for reporting information on sealed sources according to DOE O 231.1B.

radiological work: Any work that requires handling of radioactive material or access to radiological areas.

radiological work permit (RWP): Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The radiological work permit serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

refresher training: Training scheduled in the alternate year when full training is not completed for Radiological Worker I and Radiological Worker II personnel.

release to uncontrolled areas: Release of material from administrative control after confirming that the residual radioactive material meets the requirements in DOE O 458.1

rem: Unit of equivalent dose and effective dose.

removable contamination: Radioactive material that can be removed from surfaces by non-destructive means, such as casual contact, wiping, brushing, or washing.

senior site executive: That person at a DOE contractor-operated facility or site who has final on-site corporate authority and is often called the President, General Manager, Site Manager, or Director.

sievert (Sv): SI unit of any of the quantities expressed as equivalent dose. The equivalent dose in sieverts is equal to the absorbed dose in grays multiplied by the radiation weighting factor (1 Sv = 100 rem).

site: An area managed by DOE where access can be limited for any reason. The site boundary encompasses controlled areas.

soil contamination area: An area in which soil contamination is present at levels that are not releasable in accordance with DOE's environmental protection standards.

standard radiological warning trefoil: Symbol designed and proportioned as illustrated in ANSI N2.1.

step-off pad: Transition area between contaminated and non-contaminated areas that is used to allow exit of personnel and removal of equipment.

sticky pad: Step-off pad provided with a tacky surface to reduce the potential for inadvertently tracking contamination out of a contaminated area.

survey: An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

technical work document: A term used to generically identify formally approved documents that direct work, such as procedures, work packages, or job or research plans.

thermoluminescent dosimeter (TLD): Radiation monitoring device used to record the exposure of personnel or areas to certain types of radiation.

transferable contamination: The total contamination levels, expressed in terms of disintegrations per minute per 100 cm^2, on items such as shoes, shoe covers, vehicle tires, tools, or other equipment that have come into contact with contaminated soils.

transuranic waste: Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

whole body dose: The sum of the effective dose for external exposures and the committed effective dose for internal exposures.