

U.S. Department of Energy Orders Self-Study Program



DOE G 441.1-1C RADIATION PROTECTION PROGRAMS GUIDE

**NATIONAL NUCLEAR SECURITY ADMINISTRATION
LEARNING AND CAREER DEVELOPMENT DEPARTMENT**

DOE G 441.1-1C, RADIATION PROTECTION PROGRAMS GUIDE FAMILIAR LEVEL

OBJECTIVES

Given the familiar level of this module and the resources listed below, you will be able to

1. Match radiation protection-related terms to their definitions;
2. Discuss the elements that should be taken into consideration to determine the likelihood of an individual receiving a dose in excess of a regulatory monitoring threshold;
3. Give three examples of criteria that should trigger a formal as-low-as-is-reasonably-achievable (ALARA) review;
4. List five features of an acceptable internal dosimetry program;
5. List five features of an acceptable external dosimetry program;
6. Discuss the actions management must perform to implement their responsibilities related to radiation-generating devices;
7. List the essential elements of an acceptable program to evaluate and control radiation dose to an embryo/fetus;
8. State the method of air sampling used to determine if the criteria for posting airborne radioactivity areas have been exceeded;
9. Discuss the common characteristics of effective contamination control programs;
and
10. List two factors that are indicators that there is a need to post contamination areas and high contamination areas.

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

Note: If you think that you can complete the practice at the end of this level without working through the instructional material and/or the examples, complete the practice now. The course manager will check your work. You will need to complete the practice in this level successfully before taking the criterion test.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

RESOURCES

DOE G 441.1-1C, *Radiation Protection Programs Guide*, 5/19/08.
10 CFR 835, "Occupational Radiation Protection."

Note: The following references may be required to answer questions in the practice and criterion test for this module.

DOE-STD-1098-99, *Radiological Control*, March 2005.
DOE STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Positions at DOE Facilities*, November 2007.
DOE-STD-1121-2008, *Internal Dosimetry*. October 2008.
NUREG-1400, *Air Sampling in the Workplace*, 1993.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

INTRODUCTION

The familiar level of this module is designed to provide the basic information related to DOE G 441.1-1C, *Radiation Protection Programs Guide*, as required in DOE-STD-1174-2003, *Radiation Protection Functional Area Qualification Standard*, December 2003.

Completion of this module also meets certain requirements associated with the DOE Facility Representative Program and the DOE Intern Program. The information contained in this module addresses specific requirements and as such does not include the entire text of the source document. Before continuing, you should obtain a copy of the Order. Copies of the DOE Directives are available at <http://www.directives.doe.gov/> or through the course manager.

In March 2007, DOE published an updated implementation Guide that discussed acceptable methods for ensuring that the functional elements of radiological activities will be managed and administered according to 10 CFR 835, "Occupational Radiation Protection." The March 2007 Guide was part of DOE's efforts to eliminate redundant requirements and guidance and compiled the guidance previously provided in a set of 13 Implementation Guides.

On June 8, 2007, the DOE published an amendment to 10 CFR 835. DOE G 441.1-1C reflects the June 8, 2007, amendment to 10 CFR 835 and provides cross-references to other guides, DOE-STD-1098-99, *Radiological Control*, March 2005, DOE directives, and industry consensus standards that provide detailed guidance for implementing specific requirements in 10 CFR 835.

DOE G 441.1-1C provides guidance with respect to implementing the provisions of all the functional areas contained in 10 CFR 835, amplifies the regulatory requirements of 10 CFR 835, and provides explanations and examples of the basic requirements for implementing the requirements of 10 CFR 835.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

RADIATION PROTECTION PROGRAMS (RPP)

10 CFR 835 establishes specific requirements for the development, content, revision, and approval of the documented RPP for a DOE activity.

The cognizant DOE Headquarters Program Office approves the RPP for a specific DOE activity. The RPP ensures that the DOE activity will be conducted according to the provisions of 10 CFR 835. The RPP also satisfies the requirement for an implementation plan found in other DOE directives.

The approved RPP details how a DOE activity shall be in compliance with 10 CFR 835 and should identify the functional elements appropriate for that activity. Additional documentation should be developed and maintained to supplement the approved RPP to demonstrate that an RPP can be effectively managed and administered to achieve compliance with 10 CFR 835. This documentation typically includes a site radiological control manual developed to the guidance contained in the DOE-STD-1098-99, *Radiological Control* (RCS), as well as detailed implementing procedures, appropriate management policy statements, and technical basis documentation. While this documentation need not be part of the RPP, it should be clearly linked to the compliance commitments contained in the RPP.

ORGANIZATION AND ADMINISTRATION

The RPP shall include plans, schedules, and other measures for achieving compliance with 10 CFR 835. Plans should include establishing the organization and administration of the RPP to ensure that the program implements measures that ensure that regulatory compliance can be achieved and sustained. The authority and responsibility for radiation protection should originate at the highest levels of line management and should be emphasized throughout the organization. Ultimately, workers should be aware of their individual responsibilities for radiation protection.

Administrative Process

Administrative processes should include a hierarchy of documents that describe management policies, requirements, expectations, and objectives for the RPP. This documentation should typically include:

- a policy statement that includes management's commitment to conduct radiological operations in a manner that will ensure the health and safety of all its employees, contractors, and the general public;
- a site-specific radiological control manual or handbook that addresses all the functional elements of the RPP;
- procedures that provide detailed instructions for implementing various functional elements of the RPP; and
- technical basis documents that detail the decisions and approaches used to achieve regulatory compliance. The documents should include supporting analyses and justification sufficient to demonstrate that regulatory compliance can be achieved and maintained.

Radiological Control Organization

A radiological control organization should be established to support line managers and workers. To function effectively, the radiological control organization should be independent of the line organization that is responsible for production, operation, or research activities, and should have an equivalent reporting level.

Education, Training, and Skills

Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR 835 shall have the appropriate education, training, and skills to discharge these responsibilities.

Essential radiation protection positions are identified in DOE STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Positions at DOE Facilities*.

DOE developed and implemented courses to enhance the content of training provided to general employees, radiological workers, and radiological control technicians across the

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

DOE complex and brings these core training programs up to a standard consistent with the commercial industry.

Internal Audit and Self-Assessment

Internal audits and self-assessments are required for an effective RPP. Internal audits shall be conducted through a process that ensures that all functional elements of the program are reviewed no less frequently than every 36 months.

An audit plan should be developed that identifies the functional elements of the RPP and the schedule for review to ensure that over a 36-month period, all of the functional elements are reviewed. Table 1 identifies the applicable regulatory provisions, contractual requirements, and recommended guidance document(s) that are useful in achieving compliance with these provisions.

Change No: 1
 DOE G 441.1-1C
 Level: Familiar
 Date: 12/1/08

Table 1 RPP functional elements

Functional Element	Regulatory Provision	Contractual/Guidance Document
1. Organization and Administration	10 CFR 835, Subpart B	Chapter 3.0 of this Guide
2. ALARA Program	10 CFR 835.101(c), Subpart K	Chapter 4.0 of this Guide.
3. External Dosimetry Program	10 CFR 835.401 (a), 402(a), (b)	Chapter 6.0 of this Guide.
4. Internal Dosimetry Program	10 CFR 835.401(a), 402(c), (d)	Chapter 5.0 of this Guide.
5. Area Monitoring and Control		
a. Area Radiation Monitoring	10 CFR 835.401(a)	Chapter 6.0 of this Guide.
b. Airborne Radioactivity Monitoring	10 CFR 835.209, 401(a), 403	Chapter 10.0 of this Guide.
c. Contamination Monitoring and Control	10 CFR 835.401(a), Subpart L	Chapter 11.0 of this Guide.
d. Instrument Calibration and Maintenance	10 CFR 835.401(b)	Chapter 9.0 of this Guide.
6. Radiological Controls		
a. Radiological Work Planning	10 CFR 835.501(d), 1001(b), 1003	DOE-STD-1098-99, RADIOLOGICAL CONTROL
b. Entry and Exit Controls	10 CFR 835, Subpart F	Chapter 7.0 of this Guide.
c. Radiological Work Controls	10 CFR 835, Subpart F, 1003	Chapter 7.0 of this Guide.
d. Posting and Labeling	10 CFR 835, Subpart G	Chapter 12.0 of this Guide.
e. Release of Materials and Equipment	10 CFR 835.1101	Chapter 11.0 of this Guide.
f. Sealed Radioactive Source Accountability and Control	10 CFR 835, Subpart M	Chapter 15.0 of this Guide.
7. Emergency Exposure Situations	10 CFR 835.1301, 1302	DOE O 151.1-1C, <i>Comprehensive Emergency Management System</i> (DOE 2005c)
8. Nuclear Accident Dosimetry	10 CFR 835.1304	Chapter 6.0 of this Guide.
9. Records	10 CFR 835, Subpart H	Chapter 13.0 of this Guide.
10. Reports to Individuals	10 CFR 835, Subpart I	Chapter 13.0 of this Guide.
11. Radiation Safety Training	10 CFR 835, Subpart J	Chapter 14.0 of this Guide.
12. Limits for the Embryo/Fetus	10 CFR 835, Subpart C	Chapter 8.0 of this Guide.

ALARA

In promulgating 10 CFR 835, DOE considered alternatives to reduce the risk from radiation exposure to workers that included retaining the current occupational dose limits, reducing these limits, and emphasizing efforts to maintain occupational doses ALARA. DOE elected to emphasize the ALARA process to maintain occupational dose for DOE.

ALARA PROGRAMS

Formal Plans and Measures

The method of implementing an ALARA program is highly dependent on the complexity and magnitude of potential radiological hazards associated with the DOE activity. The elements of an effective ALARA program should be identified in a formal ALARA plan or procedure. The RPP shall clearly identify the ALARA plans and measures employed by the DOE activity. The degree of formality and the level of detail contained in these plans and measures and other pertinent documentation should be commensurate with the magnitude of the radiological hazard associated with the DOE activity. ALARA plans and measures should address the following elements at a level commensurate with the radiological hazards associated with the DOE activity:

- Policy and management commitment
- ALARA training
- Plans and procedures
- Internal assessments/audits
- ALARA design review
- Radiological work/experiment administration and planning
- Records

Policy and Management Commitment

Management commitment to ALARA is a critical element in ensuring a successful program. This commitment should include a written policy statement from a high level of corporate management. This commitment should hold all levels of management and individual workers responsible for adhering to the company's ALARA policy. If appropriate, union leadership endorsement of the ALARA policy should be considered. Senior site and line management should demonstrate their support of the ALARA program

through direct communication, instruction, inspection of the workplace, and actions, including:

- making decisions that place ALARA considerations before cost or schedule considerations,
- praising workers who identify ALARA solutions,
- supporting the ALARA committee, and
- publicizing ALARA success stories.

All site personnel should be made aware of management's commitment to ALARA, and radiological workers should be instructed on their responsibility to comply. Management's ALARA commitment statement should be updated and reaffirmed periodically.

ALARA Training

Specialized ALARA training should be developed for personnel who plan, prepare, schedule, estimate, or engineer jobs that have the potential for significant radiological consequences. The purpose of training these personnel in ALARA concepts and techniques is to empower them to include ALARA considerations in the early phases of job planning and engineering. This training should provide the basics of ALARA concepts and the use of ALARA-related equipment, such as containment devices, shielding, ventilation, and special tools. Topics such as radioactive waste (radwaste) minimization, application of decontamination efforts, and basic contingency planning for mitigation of accidental spills and releases may also be appropriate.

Plans and Procedures

10 CFR 835.101(c) requires that the content of each RPP be commensurate with the nature of the activities performed and include formal plans and measures for applying the ALARA process to occupational exposures. The RPP and supporting procedures should describe the organization, responsibilities, and method of operation of the ALARA program. These documents should be reviewed and updated according to an established schedule.

Internal Assessments/Audits

10 CFR 835.102 requires that internal audits of the RPP be conducted such that all functional elements are reviewed no less frequently than every 36 months and shall include program content and implementation. The ALARA program is one of these functional elements. The occupational ALARA program should be evaluated by an individual(s) or members of the ALARA committee with no direct responsibility for implementing the program.

ALARA Design Review

ALARA design reviews should include the following actions:

- Review the general configuration of the facility and/or equipment. Facility design and selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning.
- Verify that radiological design criteria are consistent with applicable federal/state regulations, standards, guides, and DOE directives.
- Verify that the confinement and ventilation systems provide the required level of protection from airborne contamination.
- Evaluate and confirm the adequacy of specific control devices for reducing occupational doses.
- Verify that the design will be able to maintain personnel entry control for each radiological area, commensurate with existing or potential radiological hazards in the area.
- Verify that each entrance or each access point to high and very high radiation areas will have the required control features.
- Assess the adequacy of planned radiological monitoring and nuclear criticality safety instrumentation and determine if the proposed instrumentation is appropriate for the expected types, levels, and energies of the radiation(s) to be encountered, and if it has sufficient redundancy and capability for operation under normal operating conditions and during emergencies.

The ALARA design review should have six discrete phases:

- assess dose;
- review projected radiological conditions against the trigger points or numerical criteria established to initiate a review;
- identify applicable radiological design criteria;

- review similar facilities, designs, and processes to assist in the selection of optimum ALARA design features and less costly alternatives using approved numerical criteria;
- incorporate and document features in the design package to reduce the exposure of personnel, the spread of radioactive contamination, the release of radioactive effluent, and the creation of radioactive waste; and
- post-construction review the effectiveness of ALARA engineering features to provide feedback to the design engineers and to help refine the design process.

Optimization Methodology

Optimization methods are required to ensure that occupational exposure is maintained ALARA in developing and justifying facility designs or modifications and physical controls. Optimization methodology provides the technical and managerial basis for setting numerical criteria for ALARA decisions in facility design, work process development, and the design or purchase of special tools and equipment. Selection of an appropriate cost-benefit factor for reducing occupational dose involves a judgment of the relative value of dose, normally in terms of dollars per rem avoided. Additionally, guidance on optimization methodology will provide the basis for selecting trigger points or collective dose values. Numerical criteria for ALARA decision-making should include radioactive waste volume, radioactive effluent, contamination levels, and airborne radioactivity levels.

At sites with significant collective dose, formally documented optimization methodologies should be developed for ALARA reviews, and decisions on implementation of ALARA efforts should be developed. This may be on a site- or facility-specific basis. Application of optimization methodologies should lead to consistent, rational, repeatable decisions as to which ALARA efforts are justifiable. The level of effort involved in documenting ALARA decisions should be commensurate with the potential dose savings to be realized. A detailed evaluation is not required if the cost of the evaluation exceeds the potential value of the benefits.

Radiological Work Administration and Planning

10 CFR 835.1003 requires that the combination of design and administrative controls shall ensure that the occupational dose to general employees will not exceed the limits

established in 10 CFR 835.202 and that the ALARA process is used for personnel exposures to ionizing radiation. Additionally, 10 CFR 835.501(d) requires radiological work permits (RWPs) to control entry into and perform work in radiological areas.

Job Reviews

A formal ALARA job review should be performed for work or experiments with the potential to exceed the established numerical radiological criteria. The following are examples of criteria that should trigger a formal ALARA review.

- The estimated individual or collective dose is greater than pre-established criteria.
- The predicted concentrations of airborne radioactivity could exceed pre-established criteria.
- There is potential for significant radiological exposures.
- The removable contamination in work areas could exceed pre-established criteria.
- Individuals will enter areas where exposure rates could exceed pre-established criteria.

The ALARA job review should encompass three discrete phases:

- pre-job planning and dose assessment
- specification and implementation of ALARA controls and dose tracking
- post-job review

Criteria should be established to trigger a formal post-job review. Examples include:

- an actual collective dose equivalent of 5 person-rem or greater,
- actual doses outside the range of 25% of pre-job estimates,
- use of the stop radiological work authority,
- issuance of a radiological occurrence/deficiency report, or
- identification of significant lessons learned.

The post-job review should compare the actual person-hours and person-rem with the estimates, evaluate the effectiveness and cost of the ALARA controls, document the lessons learned, and make recommendations on ways to control dose and contamination for similar activities. The ALARA review should be documented and records should be readily retrievable.

In the special case of an ALARA review for a planned special exposure, additional

requirements are described under 10 CFR 835.204.

Consideration of Non-radiological Hazards

The work planning process should integrate the consideration of other industrial, physical, and chemical hazards that an individual may encounter. Efforts to maintain worker doses ALARA should ensure that the risk of personnel injury from other hazards is not disproportionately increased. The ALARA process should consider the impact of other occupational hazards when optimizing worker radiation dose. For example:

- excessive protective clothing to control personnel contamination events may lead to heat stress situations.
- respiratory protective devices used to reduce intakes of radionuclides may impair visual acuity and communications capabilities between workers.
- protective clothing to protect workers from chemical hazards may slow work down leading to increased worker dose.

An integrated approach during the work planning process will ensure that all occupational hazards are appropriately considered and the ALARA process is followed.

INTERNAL DOSIMETRY PROGRAM

In the 2007 amendment to 10 CFR 835, DOE changed most of the dosimetric terms used in 10 CFR 835 to reflect the recommendations for assessing dose and associated terminology from ICRP Publication 60, *1990 Recommendations of the ICRP on Radiological Protection*, and ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*. DOE made this change mainly because these recommendations are based on updated scientific models and more accurately reflect the occupational doses to workers than the models currently used by DOE.

During the rulemaking process DOE received a comment that, under certain circumstances, when an individual conducts multiple activities involving both activities under 10 CFR 835.1(b)(1) and excluded activities it is ambiguous as to how the rule would be applied when using different dose coefficients and weighting factors to calculate the total effective dose for the worker from both activities. DOE agreed that guidance was needed for this provision. In the preamble for the final rule DOE stated that for the purpose

of compliance with 10 CFR 835.1(b)(1) and (c), DOE considers the terms in table 2 to be equivalent.

Table 2. Dosimetric equivalent terms

Dosimetric Term as Defined by Excluded Activity Cognizant Regulator	DOE Amended Dosimetric Term
Committed effective dose equivalent	Committed effective dose
Committed dose equivalent	Committed equivalent dose
Cumulative total effective dose equivalent	Cumulative total effective dose
Deep dose equivalent	Equivalent dose to the whole body
Dose equivalent	Equivalent dose
Effective dose equivalent	Effective dose
Lens of the eye dose equivalent	Equivalent dose to the lens of the eye
Quality factor	Radiation weighting factor
Shallow dose equivalent	Equivalent dose to the skin or Equivalent dose to any extremity
Weighting factor	Tissue weighting factor
Total effective dose equivalent	Total effective dose

10 CFR 835 requires that internal dosimetry programs be conducted for radiological workers, declared pregnant workers, occupationally exposed minors, and members of the public entering controlled areas who are likely to receive intakes that exceed specified levels for committed effective dose equivalent in a year. An internal dosimetry program generally consists of three elements:

- an air monitoring program, using a combination of real-time, fixed, and portable devices, as appropriate;
- an individual monitoring program, using direct and/or indirect radiobioassay, and personal breathing zone (BZ) air monitoring, as appropriate; and
- a dose evaluation program that evaluates the data collected by the air and individual monitoring programs to determine the magnitude of individual doses.

IMPLEMENTATION GUIDANCE

This section of DOE G 441.1-1C provides guidance for establishing and conducting internal dosimetry programs for individuals who have the potential for intakes of radioactive materials. It includes guidance for design and implementation of the radiobioassay program, and for evaluating, recording, reporting, and managing internal doses.

An acceptable internal dosimetry program includes the following features:

- an adequate staff with appropriate technical training;
- documentation that provides scientific information and other rationale to explain essential elements of the internal dosimetry program;
- written policies and procedures covering essential steps in the activities used to determine worker internal dose;
- criteria and methods for implementing an appropriate air monitoring program;
- defined criteria for identifying workers who need to participate in the individual monitoring program;
- appropriate radiobioassay measurement methods and frequencies;
- methods for control, accountability, and safe handling of samples;
- appropriate dosimetry models and default parameters for evaluating internal dose;
- timely analysis of radiobioassay samples and measurements, transmission of results, dose evaluation, and recommendations to operations management;
- adequate detection capability and quality of radiobioassay measurements;
- defined criteria and actions for identifying individuals with suspected intakes, based on workplace and radiobioassay measurements;
- appropriate action-level guidelines;
- defined program to report internal doses to workers, management, and DOE;
- historical records of radiobioassay measurement results and dose evaluations;

- historical records of the program, and changes in the program over time;
- a quality assurance program covering essential steps in the activities that determine worker internal dose.

PROGRAM MANAGEMENT AND ADMINISTRATION

General Requirements

The internal dosimetry program shall comply with the dose limits established in 10 CFR 835. Additionally, radiobioassay programs implemented to demonstrate compliance with 10 CFR 835 shall be accredited or excepted from accreditation according to the DOE Laboratory Accreditation Program (DOELAP) for radiobioassay; or shall be determined to have performance substantially equivalent to that of programs accredited under DOELAP for radiobioassay.

Organization, Staffing, and Facilities

The internal dosimetry program should be administered by the radiological control organization under the leadership of the radiological control manager. The internal dosimetry program should have a designated leader with demonstrated expertise in internal dose evaluation. When elements of the internal dosimetry program are performed by one or more subcontractors, the radiological control organization should establish an arrangement of contractual standards and assessments that ensure that subcontractors meet all applicable requirements in 10 CFR 835, the documented RPP, DOELAP standards, and the internal dosimetry technical basis document.

Staffing

The radiological control organization management should ensure that the internal dosimetry program is adequately staffed to carry out its functions. The analysis of workplace and radiobioassay measurement data and the evaluation of internal dose involve complex evaluation and professional judgment. Personnel with responsibility for internal dose evaluation should have the necessary expertise and skill, based on appropriate education and training in conjunction with practical experience, to perform their assigned duties. It is important that internal dosimetry specialists be capable of recognizing

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

conditions warranting follow-up radiobioassay and dose evaluation. Personnel should be familiar with the relevant internal dosimetry literature and the recommendations of national and international scientific organizations with regard to internal dose evaluation. Management of the radiological control organization should establish minimum requirements for those staff who evaluate internal doses. These requirements should include both experience and education requirements.

Facilities and Resources

Facilities and tools used by internal dosimetry personnel should be adequate for performing calculations required for the evaluation of dose from radionuclides in the body. A library of handbooks, reference materials, scientific publications, and other resources pertaining to internal dosimetry should be readily available.

Technical Basis Document

Internal dosimetry technical basis documentation should be developed and should include technical methods, supporting evidence, and reference information used to provide the technical foundation for the internal dosimetry program.

Internal Dosimetry Procedure Manual

10 CFR 835 requires that written procedures be developed and implemented to ensure compliance with the regulation. These procedures should be consistent with 10 CFR 835, the DOELAP standard, and technical basis documentation.

Quality Assurance

Quality assurance in support of internal dosimetry programs should be conducted in accordance with DOE-STD-1121-2008, *Internal Dosimetry*.

The internal dosimetry program should be included as a functional element subject to the internal audit requirements of 10 CFR 835.102.

AIR MONITORING AND CONTAMINATION CONTROL PROGRAMS

The objectives of an air monitoring program are to

- verify the integrity of radioactive material containment,
- detect the release of radioactive materials from some routine operations,
- detect inadvertent releases of those materials in the workplace,
- evaluate and provide the basis for modification to containment systems,
- provide a basis for the design of radiobioassay programs, and
- verify that selected groups do not need to participate in a radiobioassay program.

In most cases, the air monitoring program is used to supplement and validate the individual monitoring program. However, when there is no practical radiobioassay method or when there is a technology shortfall, the air monitoring program may be the basis for the determination of internal doses. These two cases are discussed below.

Air Monitoring When There is No Practical Radiobioassay Method

In situations where no radiobioassay method is available for the radionuclides in question, and no radiobioassay program, either routine or special, can show compliance with 10 CFR 835, personal (BZ) air monitoring may be used for demonstrating compliance with 10 CFR 835. BZ air monitoring is part of the Individual Monitoring Program which is detailed below. However, other fixed or portable monitoring instruments that provide either real-time or retrospective may be required when BZ monitoring data is not available or to supplement or validate the BZ data if it is available. Radionuclides with short half-lives, including the short-lived decay products of ^{222}Rn and ^{220}Rn are examples of radionuclides where intakes cannot be determined through radiobioassay and must be determined from personal air monitoring.

Recourse for Technology Shortfall

Derived investigation levels (DILs) for reasonable and practical routine radiobioassay programs may be significantly less than the achievable minimal detectable amounts (MDA) for certain radionuclides, such as plutonium. Since a technology shortfall for routine radiobioassay exists, the facility should consider the following actions:

- enhance contamination and air monitoring and the use of indicators to trigger early special radiobioassay monitoring;
- enhance personal contamination monitoring to trigger special radiobioassay monitoring;

- use the best practicable radiobioassay monitoring methods;
- implement enhanced design, operation, controls, and personnel protection equipment and procedures to minimize intakes;
- implement supplementary air monitoring; and
- document and justify the planned supplementary approach in the facility's internal dosimetry technical basis documentation.

When air monitoring data are used, each worker's stay times (in hours) and the average concentration (in derived air concentrations (DAC) to which the worker is exposed should be multiplied to yield exposures to airborne radioactive materials in units of DAC-hours. Forty DAC-hours corresponds to 0.1 rem (0.001 Sv) committed effective dose for radionuclides with a stochastic annual limit on intake.

INDIVIDUAL MONITORING PROGRAM

Individual monitoring programs should

- provide for investigation of suspected intakes,
- provide data for evaluating internal dose, and
- provide results that demonstrate compliance with the radiation dose limits given in 10 CFR 835.

Establishing the Need for Individual Monitoring

Radiological workers who could likely receive intakes resulting in 0.1 rem or more committed effective dose equivalent in a year shall participate in an internal dose evaluation program. Declared pregnant workers, occupationally exposed minors, and members of the public are also required, under specific conditions, to participate in internal dosimetry programs.

Minimum Detectable Amount

The internal dosimetry program staff should determine the MDA for each radiobioassay and BZ air monitoring method for each radionuclide present. The MDAs should be documented in procedures and their statistical basis given in the internal dosimetry technical basis documentation.

As various aspects involved with individual monitoring methods affect MDAs, procedures should contain descriptions of the method(s) of individual monitoring measurements, analytical methodologies, and measurement parameters used in each component of the individual monitoring program.

Several other factors affect the method of radiobioassay used and its associated MDA. They include

- the possible need for improved detection capability to assess individual dose during the special radiobioassay following an intake requiring internal dose evaluation, due to diminishing amounts of material in compartments as time goes on;
- the need for improved precision and accuracy if residual retention and excretion from prior intakes interferes with the detection of additional intakes in subsequent years;
- timeliness of results needed to manage individuals and keep subsequent intakes low enough to avoid exceeding dose limits;
- convenience to the affected individuals;
- costs, including lost production time while individuals are participating in the radiobioassay program; and
- the impact of the method of radiobioassay on the frequency of radiobioassay measurements.

Where practicable, the method of individual monitoring, analytical methodology, and measurement parameters should result in an MDA less than the corresponding DILs for all radionuclides to which an individual might be exposed.

Detection and Confirmation of Intakes

Decisions regarding the detection and confirmation of suspected occupational intakes of radioactive material should be based on answers to the following questions:

- Can it be concluded reliably that the analyte is present in the measured sample ($>$ Decision Level [L_c])?
- Is the measurement result unexpected? In other words, is the result beyond the range of values that would be expected due to environmental background sources or due to previously recognized intakes?
- Is the intake, and resulting dose implied by the measurement significant enough to warrant follow-up measurements or investigation?

If the answer to all these questions is “yes”, then follow-up measurements or investigation is warranted. Internal dosimetry programs should establish appropriate and technically-based decision criteria to assist in answering these questions. Such decision criteria should be included in the technical basis document for the site or facility.

The proper decision criteria for the first question is the L_c which is a purely statistical concept based on an acceptable probability of “false positive” conclusions. The L_c for radiobioassay and air sample measurements should be set by considering the acceptable rate of false positives, the cost and consequences of false positives, and the dosimetric consequences of false negatives. The analytical laboratory L_c should be based on a reagent blank. Radiobioassay results above the L_c may be expected in the absence of a new intake due to normal statistical fluctuations, non-occupational or environmental sources, or prior confirmed intakes. In the case of environmental sources of interference an “occupational decision level” should be established, above which the measurement result is concluded to be statistically significant and above the range of values that would normally be expected from environmental sources of the radionuclide. In the case of prior confirmed intakes, an individual-specific “occupational decision level” should be established that takes into account the expected contribution from the prior intakes. Finally, for each route of intake, measurement type, and radioactive material of interest time-dependent DILs should be established. Such DILs are based solely on dosimetric considerations, and typically correspond to an implied intake, and corresponding dose of 1 investigation level, i.e., 0.1 rem. DOE G 441.1-1C has adopted the value of 0.1 rem (0.001 Sv) committed effective dose as the value which, for regulatory purposes, is regarded as sufficiently important to justify further investigation. However, a site or facility may wish to establish lower follow-up levels for ALARA purposes.

If the measurement result is statistically significant, unexpected, and dosimetrically

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

significant, then follow-up measurements and/or an investigation should be done to attempt to confirm or rule out the intake. An intake should be considered to be confirmed if the three criteria are satisfied and the measurement result is associated with a known incident, or appropriate follow-up measurements meet the three criteria above, or follow-up investigation indicates that an intake has occurred. Refer to DOE-STD-1121-2008, for additional information on the detection and confirmation of intakes.

INTERNAL DOSE EVALUATION

10 CFR 835 requires internal dose evaluation programs for assessing intakes of radionuclides and for maintaining adequate worker exposure records.

Required Dose Calculations

Internal doses should be evaluated for all confirmed intakes. For intakes confirmed with radiobioassay results below the DIL, no further investigation or follow-up radiobioassay is indicated. For intakes confirmed with radiobioassay results above the DIL or exposures greater than 40 DAC hours, follow-up radiobioassay and an investigation should be performed.

While the investigation should be tailored to the specific individual and exposure circumstances, the trigger levels and preliminary actions to be taken for exposures to the different radionuclides encountered at the facility should be documented in the internal dosimetry technical basis documentation and procedures.

Evaluation of Internal Dose from Radiobioassay and Air Monitoring Data

Methods for evaluating the various doses from intakes should be specified in the internal dosimetry technical basis documentation.

Periodic Reevaluation of Internal Dose

In the case of certain well-retained radionuclides, long-term follow-up and reevaluation of doses may be required. The internal contribution to lifetime occupational dose should continue to be reevaluated as further radiobioassay results and improved methods for

evaluating internal dose become available.

Evaluations for general employees with prior confirmed intakes should be revised when information demonstrates a change in the currently evaluated committed effective dose of 0.5 rem (0.005 Sv) or a factor of 1.5 of the previously assigned dose for that intake, whichever is higher. In cases where intakes are detected or confirmed in a year subsequent to the year of the intake, the committed effective dose should be attributed to the known or assumed year of the intake, and all records and reports for that year should be amended as appropriate. An acceptable approach would be for DOE sites to update their dosimetry program to reflect the amended 10 CFR 835 tissue and radiation weighting factors, and to assess doses using the updated factors at some predetermined time.

DOE does not encourage routine recalculation of internal doses in response to changes in internal dosimetry methodologies such as biokinetic models, tissue weighting factors, or improved bioassay techniques after a final dose estimate has been completed and recorded. Internal doses calculated using technically sound and defensible methods available at the time of the dose estimate are an acceptable way to meet the Department's expectations for internal dose monitoring and compliance with occupational exposure dose limits promulgated in 10 CFR 835.

DOE recognizes there may be unique situations in which a DOE site may consider or be directed to reevaluate an internal dose estimate. Examples of such situations are a response to litigation, determination that an internal dose has been incorrectly estimated, or availability of new bioassay data. In such cases the decision to recalculate a final internal dose estimate should be made on a case-by-case basis and consider:

- The magnitude of the expected change,
- Programmatic costs,
- Impact on compliance with dose limits,
- Documentation of the recalculated result in official records, and
- Communication of the recalculated dose to current and former workers.

To ensure compliance with record-keeping provisions of 10 CFR 835 subpart H, the technical basis and results of determinations to recalculate a completed internal dose assessment should be documented in official site records.

EXTERNAL DOSIMETRY PROGRAM

Due to the types of material handled or processed, low-level, chronic occupational exposures to external ionizing radiation are difficult to avoid, necessitating an external dosimetry program at most DOE and DOE-contractor facilities that use, handle, or store radioactive materials. An external dosimetry program generally consists of three elements:

- an area monitoring program, using an array of fixed and portable devices,
- an individual monitoring program, using personnel dosimeters, and
- a dose evaluation program that evaluates the data collected by the area and individual monitoring programs to determine the magnitude of individual doses.

The ICRP Publication 60 dosimetric quantities adopted in 10 CFR 835 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. Operational quantities and their relation to the protection quantities listed in 10 CFR 835 are provided in section 6.0.1 fo DOE G 441.1-1C.

IMPLEMENTATION GUIDANCE

Chapter 6 of DOE G 441.1-1C provides guidance for establishing and conducting an external dosimetry program for individuals who are likely to be exposed to external sources of ionizing radiation. Conduct of an external dosimetry program involves determining area and individual monitoring methods and frequencies, distributing and controlling monitoring devices, and evaluating external doses. The chapter also addresses program organization, administration, staffing, and training.

An external dosimetry program should include the following features:

- adequate staff provided with appropriate technical training;
- a technical basis document that explains each program element;
- procedures that address each step in the activities that determine external dose;
- criteria and methods for implementing the area monitoring program;

- criteria and methods for identifying individuals who require individual monitoring;
- appropriate personnel dosimeter measurement methods and frequencies;
- methods for control, accountability, and safe handling of dosimeters;
- appropriate dosimetric models and default parameters for evaluating external dose;
- timely analysis of personnel dosimeter measurements and transmission of results, dose evaluation, and recommendations to monitored individuals, management, and DOE, as appropriate;
- historical records of the external dosimetry program, procedures, and results; and
- a quality assurance (QA) program that covers all steps in the activities that determine individual external dose.

GENERAL REQUIREMENTS

The external dosimetry program shall be

- accredited by DOELAP, or
- excepted from DOELAP accreditation according to DOELAP standards, or
- determined to have performance substantially equivalent to that of programs accredited under the DOELAP for personnel dosimetry.

Technical Basis Document

A technical basis document should be developed for the external dosimetry program to provide the regulatory, scientific, and technical foundation of the program. The technical basis document should include:

- the methods used for evaluating external doses from workplace and individual monitoring data and the technical basis for those methods;
- justification of categories selected for participation in and exception from DOELAP personnel dosimeter performance testing;
- QA procedures for dosimeters that are outside of the DOELAP testing protocol, as appropriate;
- the physical characteristics of external radiation to be monitored, methods for calculating external doses, methods for documenting calculations, dose evaluation quality assurance, and procedures for recording and reporting external dose results;
- the methodology used in determining the dose of record when multiple dosimeters are used and when dosimeters are relocated;

- individual monitoring methods, their lower limits of detectability, and monitoring intervals, along with a rationale or justification for the methods and intervals chosen;
- calibration models, parameters, assumptions, and default values used in dosimetric modeling and evaluation; and
- statistical methods for evaluating dosimeter data, using appropriate controls, identifying above-background values, and analyzing trends.

The technical basis document should be reviewed periodically and updated as necessary to ensure that it remains appropriate for current conditions. The technical basis document should be handled as a controlled document and retained as an RPP record.

Procedures

10 CFR 835 requires that written procedures be developed and implemented as necessary to ensure compliance, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards. All functions of the external dosimetry program should be specified in written procedures that provide for appropriate quality control and QA measures. The procedures should be consistent with 10 CFR 835, the DOELAP technical standards, and the technical basis document. In summary, the procedures should provide the following information:

- methods and requirements for measuring, evaluating, and recording external dose;
- methods for consistent collection of workplace and personnel monitoring data, its evaluation, documentation of results, and records maintenance;
- components and reporting structure of the external dosimetry program;
- responsibilities of line management and members of the dose evaluation group; and
- elements of the area monitoring program that are germane to external dose determination.

AREA MONITORING PROGRAM

The area monitoring program supplements the individual monitoring program by providing a prospective assessment of radiological conditions and back-up data for individual dose evaluations.

Monitoring Instruments and Devices

External radiation monitoring instruments and devices include both fixed and portable instruments that provide real-time indication of radiation levels and passive monitoring devices that provide a retrospective indication of radiological conditions.

Although fixed instruments provide the advantage of continuous operation with little or no attention, their application is limited by their lack of mobility. Fixed instruments should be used to monitor areas and installations

- having a known and relatively predictable operation where little variation in the radiological hazards is expected;
- where monitoring of an access point is desirable to warn individuals of hazards in the area;
- where it is desirable to continuously monitor an area to detect changes in radiological conditions;
- where continuous monitoring and alarm functions are necessary to prevent unplanned exposures; and
- as necessary to provide input into interlocks, control devices, and alarm systems that depend on or that control the operation being monitored.

Portable instruments are most appropriate for use in performing prospective monitoring for the purposes of work planning, radiological condition verification, facility integrity verification, and operational assessments. The quality and utility of the data provided by portable instruments depend on the knowledge and skills of the user. Because of these important applications and significant vulnerabilities, portable instruments should be used only by trained individuals (such as specifically-trained radiological workers and radiological control technicians). Passive monitoring devices should be placed in areas surrounding radiological areas to verify that doses in these areas do not exceed the individual monitoring threshold. Passive monitoring devices should be placed where they will be exposed to radiation fields similar to those affecting individuals frequenting the area, but should be protected from loss or vandalism. The use of passive monitoring devices to characterize radiation fields as a part of pre-job planning should also be considered.

Performance of Area Radiation Monitoring

10 CFR 835 defines radiation and high radiation areas in terms of the radiation levels at a distance of 30 centimeters from the source or from any surface penetrated by the radiation. 10 CFR 835 defines very high radiation areas in terms of the radiation levels at a distance of 100 centimeters. Therefore, area radiation monitoring should be performed at these distances to ensure compliance with 10 CFR 835.

Allowance for Physical Characteristics

The physical characteristics of the radiation field present should be considered in the design of the monitoring program and in the evaluation of external dose equivalent. These characteristics include radiation quality, energy, fluency rate, and direction of incidence. If certain characteristics are not known, the assumed values used as the basis for the area monitoring program design should be documented in the technical basis document.

Recourse for Technology Shortfall

The technology may not be available to perform area monitoring for some types of radiation at levels indicative of the monitoring requirements. If the performance objectives cannot be achieved for this reason, the facility should

- use the best practicable monitoring methods; and
- implement enhanced design, operational controls, personnel protection equipment, and procedures to control external exposures.

INDIVIDUAL MONITORING PROGRAM

This section of DOE G 441.1-1C discusses program features for individual monitoring, compensatory actions for lost, damaged, or contaminated dosimeters, nuclear accident dosimetry, and dosimetry for planned special exposures.

Establishing the Need for Individual Monitoring

It is usually not necessary for all individuals at a facility to wear dosimeters unless there is a documented technical basis. Unnecessary issuance of dosimeters should be avoided. If an individual does not enter areas where there is a likelihood of external exposure resulting in

a dose near or in excess of the regulatory monitoring thresholds, issuance of a dosimeter to that individual is discouraged.

10 CFR 835 establishes individual monitoring requirements based on the likelihood of an individual receiving a dose in excess of a regulatory monitoring threshold. Judging the likelihood of potential exposures should include consideration of the following:

- areas to which the individual will have access;
- the individual's previous occupational dose during the current year;
- activities taking place in the areas to be entered;
- restrictions on areas entered or time in these areas;
- design basis radiological conditions in the areas to be entered;
- documentation of actual radiological conditions in the areas to be entered, obtained through prior individual and area monitoring;
- potential for changes that may affect the radiological conditions.

Routine Monitoring of Individual External Doses

Individual monitoring shall be performed for those individuals likely to receive external doses exceeding the monitoring thresholds provided in 10 CFR 835 and for individuals entering high radiation or very high radiation areas. The frequency of collecting and processing personnel dosimeters depends on the measurement method and associated lower limit of detectability. The collection frequency should be chosen so that it is unlikely that an individual will receive a dose equivalent equal to or greater than the values listed in 10 CFR 835.402(a) from external radiation without detection and quantification.

Whole Body Monitoring

10 CFR 835.402(a) requires monitoring for individuals likely to exceed the specified whole body dose threshold as a result of exposure to external radiation sources. For radiological workers this is an effective dose of 0.1 rem (0.001 Sv) or more in a year. 10 CFR 835.2(b) specifies that for external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm (1000 mg/cm²) in tissue. It also specifies that equivalent dose to the whole body may be used as effective dose for external exposures.

For individuals who require individual monitoring, external dose should be determined using such devices as thermoluminescent dosimeters, track-etch dosimeters, or radiation-sensitive film. The dosimeter should be worn to provide a measurement of the maximum dose received at any location on the whole body. When the whole body is exposed fairly uniformly, the location should be on the front of the torso between the neck and waist. For nonuniform irradiation, multiple dosimeters should be used or the primary dosimeter should be relocated to the area receiving the highest dose.

Lens of the Eye Monitoring

The lens of the eye dose equivalent shall be evaluated at a tissue depth of 0.3 cm.

For uniform exposures, a measurement taken in the torso region is sufficient. For nonuniform exposures that would result in an individual receiving a significantly higher dose to the lens of the eye than to the whole body, such as access to or near reactor beams, X-ray machines, sources of beta radiation, and shield penetrations, the dose equivalent should be measured near the eye, such as with a dosimeter worn on the side of the head or forehead.

Skin and Extremity Monitoring

Exposure to the extremities and skin from external radiation shall be evaluated using the shallow dose equivalent as evaluated at a tissue depth of 0.007 cm. Monitoring for skin exposure is usually performed in conjunction with that for the effective dose equivalent using a single whole body dosimeter. This method is adequate for uniform or nearly uniform fields.

Neutron dose to the extremities may be determined by one of three methods:

- direct measurement by neutron sensitive dosimeters,
- barring sufficient neutron energy information, or for ease in implementation, a factor of two (i.e., a doubling) may be applied to neutron doses calculated using the existing neutron quality factors;
- application of a gamma dose to neutron dose correction factor determined through the measurement of the gamma and neutron dose rates incident to the affected extremities, or

- application of a whole body dose to extremity dose correction factor determined through measurements of the neutron dose rates incident to the whole body and the affected extremities.

Justification for the choice of dosimeter and placement of dosimeter and results of field gradient measurements should be provided in the technical basis document.

Embryo Monitoring

Following the pregnancy declaration, a declared pregnant worker should continue to wear her dosimeter in the normal manner if she will be entering areas or performing work for which individual monitoring is required. If she is in an area where the dose is likely to approach 50 millirem in a month, a supplemental dosimeter should be worn to obtain a monthly estimate of the dose. If she is exposed to localized sources of radiation, the supplemental dosimeter should be worn on or near the abdomen.

Nonuniform Radiation Fields

When individuals will be exposed to radiation in a manner that will result in significantly nonuniform doses to various areas of the whole body, multiple dosimeters should be issued or the primary dosimeter should be relocated to the area of the whole body likely to receive the highest dose. Multiple dosimeters should be used to assess whole-body dose when radiation fields vary by >50% over the whole body and the anticipated dose to the maximally exposed area is >100 millirem (1 mSv) or 1 rem during the dosimeter issue period. The technical basis document should provide details regarding the basis for dosimeter location(s) under nonuniform exposure conditions. Preliminary judgments on the need for multiple dosimeters and placement of multiple dosimeters should be made from direct exposure rate surveys with portable monitoring instruments or monitoring with dosimeters placed on phantoms. Multiple dosimeters may be used at any time to provide more detailed information for estimates of whole body dose.

Lost, Damaged, or Contaminated Dosimeters

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.

Reentry of the individual into radiological areas should not be made until a review has been conducted, the individual has been issued a new dosimeter, and management has approved reentry. The review may be as simple as a documented survey showing the dosimeter not to be contaminated, in which case the worker may go back to work immediately. Otherwise, a review should include a dose evaluation to replace the results of the lost, damaged, or contaminated personnel dosimeter and should determine if work can continue during an investigation.

Nuclear Accident Dosimetry

Nuclear accident dosimetry shall be provided to individuals in installations with sufficient quantities of fissile material to potentially constitute a critical mass, such that the excessive exposure of individuals to radiation from a nuclear accident is possible. Nuclear accident dosimetry shall include:

- a method to conduct initial screening of individuals involved in a nuclear accident,
- methods and equipment for analysis of biological materials,
- a system of fixed nuclear accident dosimeter units, and
- personal nuclear accident dosimeters.

Planned Special Exposures

Planned special exposures are included in an individual's occupational dose record, but shall not be considered when determining compliance with the occupational dose. To maintain separate records of doses resulting from planned special exposures and routine occupational exposures, dosimeters adequate to measure the potential doses and appropriate for the work to be performed should be provided.

EXTERNAL DOSE EVALUATION

Radiation protection requirements are expressed in terms of limiting values of equivalent dose to individuals. The limiting values for equivalent dose in 10 CFR 835 are specified as total effective dose to the whole body and equivalent dose for other organs and tissues.

Required Dose Calculations

Records shall be maintained to document the doses received by all individuals monitored according to 10 CFR 835.402 and to document doses received as a result of planned special exposures, doses exceeding the monitoring thresholds of 835.402, and authorized emergency exposures. The following quantities shall be recorded for external dose received during the year:

- effective dose from external sources of radiation
- equivalent dose to the lens of the eye
- equivalent dose to the skin
- equivalent dose to the extremities

For airborne radionuclides that pose an external exposure hazard, the DAC values in appendix C of 10 CFR 835 shall be used to control exposure. The technical basis document should note which radionuclides could be present and whether the individual dosimeter responds correctly to the quality of the radiation or whether immersion exposures should be calculated separately and added to dosimeter results. When it is necessary to apply airborne radioactivity monitoring results to individual external dose assessment, such applications should include consideration of the concentration of the contaminant in the workplace and the duration of the exposure

Special Considerations

Personnel dosimeter measurements are the preferred source of data for evaluating the external dose of individuals likely to exceed the monitoring thresholds. Area monitoring data and other personnel monitoring data should be used to evaluate external dose if personnel dosimeter measurements are not feasible or are not available. When personnel dosimeter measurements are not available, a dose evaluation should be performed for that period. The dose evaluation should be based on personnel dosimeter results from other individuals in the same area, on previously recorded doses, or on area monitoring results of

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

the ambient radiation levels. These estimated or assigned doses shall be clearly recorded and maintained. When area monitoring results are used to estimate individual dose, the results of surveys, measurements, and calculations used to determine individual occupational exposure from external sources should be recorded.

When an individual is provided multiple dosimeters, the dose measured by the highest responding dosimeter on the whole body should be assigned as the whole body dose of record. When multiple dosimeters are employed more than once during the year, dosimeter results may be summed by location and the highest total assigned as the whole body dose of record.

If tissue weighting factors are used to calculate effective dose from external radiation fields, the weighting factors in 10 CFR 835 shall be used. If necessary, a compartmentalization methodology may be applied to the multiple dosimeter results.

For nonuniform exposures of the skin, the assessment of the exposed area should be recorded with the equivalent dose to the skin. Nonuniform exposures of the skin of the extremities from X-rays, beta radiation, and radioactive materials on the skin, including hot particles, should be assigned to the extremity, not the skin. If the nonuniform equivalent dose to the skin does not exceed 1 rem (0.01 Sv), then recording the dose is not required.

When an individual has been monitored for extremity exposure at some time during the calendar year, but is not monitored for the entire year, the equivalent dose from the whole body dosimeter should be used as the extremity dose of record for periods when extremity dosimeters are not worn.

If it is necessary to determine an equivalent dose to the lens of the eye in the absence of reliable monitoring data, the equivalent dose should be used as an approximation of the lens of the eye dose, or appropriate dose conversion factors should be used to convert the dosimeter reading to the lens of the eye dose.

Note: You do not have to do example 1 on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do example 1 or go to the next section of this document.
--

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

4. State the three elements of an external dosimetry program.

Note: When you are finished, compare your answers to those contained in the example 1 self-check. When you are satisfied with your answers, go to the next section of this document.

EXAMPLE 1 SELF-CHECK

1. List the four documents that are typically included as administrative processes in a radiation protection program.
 - Policy statement
 - Site-specific radiological control manual
 - Procedures
 - Technical basis document
2. List the six discrete phases of an ALARA design review.
 - Dose assessment
 - Review projected radiological conditions against the trigger points
 - Identify the applicable radiological design criteria
 - Review similar facilities, designs, and processes
 - Incorporate and document features in the design package to reduce personnel exposure, the spread of radioactive contamination, the release of radioactive effluent, and the creation of radioactive waste
 - Review the effectiveness of ALARA engineering features
3. State the objectives of an air monitoring program.

The objectives of an air monitoring program are to

 - verify the integrity of radioactive material containment,
 - detect the release of radioactive materials from some routine operations,
 - detect inadvertent releases of those materials in the workplace,
 - provide the basis for modification to containment systems,
 - provide a basis for the design of radiobioassay programs, and
 - verify that selected groups do not need to participate in a radiobioassay program.

4. State the three elements of an external dosimetry program.

The three elements are

- an area monitoring program
- an individual monitoring program
- a dose evaluation program

RADIATION-GENERATING DEVICES (RGDs)

The RGDs addressed in DOE G 441.1-1C may be classified as either devices that must be electrically energized to produce ionizing radiation or sealed radioactive sources that emit radiation continuously. RGDs are used at DOE sites with a great variety of configurations and operating characteristics and in a wide spectrum of applications.

Specific examples of RGDs addressed in DOE G 441.1-1C include sealed photon- or neutron-emitting radioactive sources; X-ray producing radiography equipment; research and analytical X-ray or electron beam machines; sealed radioactive sources used as irradiators; particle accelerators; neutron generators; Van de Graff generators; electromagnetic pulse generators; electron microscopes; electron arc welders; microwave cavities that produce X-rays incidentally; and cabinet X-ray machines used for security applications.

ADMINISTRATIVE ORGANIZATION AND CONTROLS

RGD control should be maintained by individuals responsible for RGD operations. Overview for radiological safety should be provided by the independent radiological control organization.

Contractor Management

To implement their responsibilities, management should perform the following tasks:

- Appoint an RGD custodian for each RGD.
- Exercise supervision to ensure safe RGD operation.
- Review RGD procedures and operational and maintenance logs.
- Schedule periodic inspections and monitoring.
- Approve operating and emergency procedures.
- Schedule and otherwise provide for training to ensure that RGD custodians and RGD operators are trained and re-certified.
- Terminate the operation of any unsafe RGD installation.

RGD Custodian

The appointed RGD custodian should provide direct control over RGD installations and operations. Specific responsibilities of the RGD custodian should include the following actions:

- Control the keys to RGD installations, RGDs, and/or RGD storage facilities and authorize the operation of the RGD installation.
- Ensure that RGD operators follow applicable operating procedures.
- Ensure that RGD operators follow the applicable radiological work permit (RWP) or other written authorization.
- Ensure that required dosimeters are properly worn.
- Ensure that inspections of RGD interlocks, warning lights, and other safety features are performed and documented.
- Ensure that all required monitoring is performed and documented.
- Ensure that all RGD operators are trained.
- Review and approve materials used for training RGD operators, in cooperation with the radiological control staff.
- Ensure that accountability records of assigned RGDs are maintained.
- Notify the radiological control staff of changes in shielding configuration, use, storage, disposal, or loss of an RGD.
- Ensure proper disposition of unneeded RGDs.
- Ensure that sealed radioactive source integrity tests are performed.
- Maintain schematics, safety device wiring diagrams, manufacturer-provided instruction manuals, and operations and maintenance records.

RGD Operator

RGD operators are those individuals authorized by the RGD custodian to use the RGD.

The RGD operator should perform the following actions:

- Ensure proper control of the RGD installation and/or area.
- Ensure that inspections and monitoring are performed and documented.
- Ensure that required dosimeters are worn properly by all individuals in the vicinity of RGD operations.
- Follow the applicable RWP, or alternative authorization, and ensure that other individuals also adhere to the requirements of those documents.

- Establish control of all adjacent areas where individuals could receive a dose approaching administrative limits and ensure that those areas are unoccupied during RGD operations.
- Maintain access control over the actual RGD exposure area.
- Follow all applicable operating procedures.
- Terminate unsafe RGD operations.

Qualified Expert

Management should appoint a qualified expert(s). To ensure technical qualification, the radiological control manager should approve the qualified expert. The qualified expert should have the knowledge and training necessary to measure ionizing radiations, analyze the significance and evaluate the potential health effects of monitoring results, and advise on matters related to radiological control as it pertains to installations covered by this guide. The qualified expert should have in-depth knowledge of characteristics associated with RGDs, RGD installations, and applicable rules, manuals, Orders, and standards. The qualified expert should periodically review the following areas and provide recommendations to the radiological control manager:

- the design or modification of RGD installations,
- the results of preoperational inspections and radiological monitoring,
- the engineered safety features and administrative controls,
- the need for and adequacy of the personnel monitoring program for the installation, and
- the training materials used for the RGD custodians and operators.

Radiological Control Manager

A radiological control manager should be designated to ensure independent overview of radiological operations, including RGDs. The radiological control manager's function is similar to that of the radiological protection supervisor or radiation protection officer, as described in the specific standards referenced in the guide and publications of the National Council on Radiation Protection and Measurements.

Radiological Control Organization

The radiological control organization should provide support to managers and radiological workers. Radiological control staff should perform the following tasks to implement their functions:

- Evaluate adherence to the RPP by conducting preoperational and periodic inspections and radiation monitoring of RGD installations.
- Provide radiological support to line managers and RGD operations.
- Ensure that all inspections and monitoring are performed and documented.
- Perform radiation monitoring of open installations to verify proper posting and control of boundaries during operations and removal of hazards after operations.
- Monitor all RGD installations for potential or actual unsafe operations or conditions and conformity to the site-specific RPP.
- Review the operational and maintenance logs maintained by the RGD custodians and operators to ensure that controls are commensurate with existing or potential radiological hazards.

ENGINEERED SAFETY CONTROLS

10 CFR 835.1001 requires that measures be taken to maintain radiation exposures in controlled areas ALARA. The primary method used shall be physical design features. Administrative controls shall be incorporated only as supplemental methods and for specific activities where physical design features are impractical. 10 CFR 835.1003 further requires that during routine operations, the combination of design features and administrative controls shall provide that the anticipated occupational dose to general employees does not exceed regulatory limits and that the ALARA process is used for personnel exposures to ionizing radiation.

Shielding

Permanent shielding should be designed and installed consistent with the guidance provided in American National Standards Institute (ANSI) N43.3

The effect of temporary shielding should be evaluated before installation. The installation, use, and removal of temporary shielding should be controlled by procedures and in accordance with RCS article 314.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

Access Control and Safety Devices

10 CFR 835,501 establishes requirements for maintaining control over entries into radiological areas. 10 CFR 835.502 establishes supplemental requirements for entry controls for high and very high radiation areas.

The purpose of access control devices is to prevent unauthorized or inadvertent entry into a radiological area and/or to warn of a hazard.

If locked entryways are used, the keys used for one RGD installation or storage facility should not provide access to another RGD installation or storage facility.

Additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas. Such measures should include locking or securing service doors and panels with tamper resistant fasteners or the use of multiple and redundant access controls.

Interlocks

Doors and access panels in exempt shielded, shielded, and unattended installations should be equipped with one or more fail-safe safety interlocks to prevent irradiation of an individual.

If an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor shall prevent either normal access into the area or operation of the RGD.

Device Controls

One or more physical control devices should be used to secure the RGD to prevent unauthorized access and use. The control system governing the production of radiation should be equipped with a lock and key to prevent unauthorized use. The key controlling the production of radiation in one RGD should not control the production in another.

Control devices used to limit RGD time, position, current, voltage, beam intensity, or control panel lights or system indicators should be fail-safe.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

Run-Safe and Emergency Shutdown Devices

Administrative procedures should be implemented to ensure that the RGD installation and the RGD safety interlock control devices are such that

- radiation cannot be produced until the interlock system logic has been completely satisfied,
- production of radiation cannot be resumed by merely reestablishing the interlock circuit at the location where an interlock was tripped, and
- the safety circuit cannot be re-energized or reestablished automatically.

For each area designated as a high radiation area or very high radiation area, 10 CFR 835.502 provides an option that permits a control device to automatically generate audible or visible alarm signals to alert individuals and the cognizant RGD operator of a potential entry into the area before it occurs. To meet ANSI N43.3 guidance, warning devices should be provided as an addition to any other access control features. These warning devices are typically warning lights.

All RGD warning lights should be red or magenta for consistency. A sufficient number of lights should be installed so that at least one light is easily visible from all reasonably occupied areas that may have dangerous radiation levels and from reasonable avenues of approach to such areas.

EVALUATION AND CONTROL OF RADIATION DOSE TO THE EMBRYO OR FETUS

DECLARATION OF PREGNANCY/WITHDRAWAL OF DECLARATION

Due to the higher sensitivity of the embryo or fetus to ionizing radiation, 10 CFR 835 establishes provisions for individuals to voluntarily declare their pregnancy and to accept restrictions on the dose equivalent to the embryo or fetus. It remains the sole and fundamental responsibility of the worker to decide whether to formally declare her pregnancy and consequently become subject to the above dose limits and restrictions. It is the employer's responsibility to ensure that the worker is fully informed and provided with counseling to assist in her decision making. Deciding whether or not to accept the risk from radiation dose to the embryo or fetus is entirely the responsibility of the pregnant worker.

A pregnancy may be declared by the pregnant worker or the worker who is planning a pregnancy, and shall be formally declared in writing. The declaration shall include the estimated date of conception, and should be declared as early in the pregnancy as possible. A declared pregnant worker that is planning a pregnancy should notify her supervisor as soon as possible following verification of conception. The statement should be signed by the employee and delivered to her supervisor or to a designated contact in health physics, laboratory safety, occupational health, or medical services.

10 CFR 835 also allows an individual who has declared her pregnancy to withdraw her declaration and to return to the general employee occupational dose limit. The employer is considered to be notified of the withdrawal of the declaration of pregnancy at the time that the individual submits a signed and dated statement to her supervisor or to the designated contact, indicating that she is withdrawing her formal declaration of pregnancy. No additional explanation or justification should be requested by the employer. The worker shall be allowed to withdraw her declaration of pregnancy at any time, thus terminating any work restrictions. Once such notification has been made, it is the employer's responsibility to remove any imposed work or area restrictions.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

WORK RESTRICTIONS FOLLOWING DECLARATIONS OF PREGNANCY

Following the submittal of a declaration of pregnancy, the radiation equivalent dose received by the embryo or fetus before the declaration should be calculated as soon as practicable. Once this equivalent dose has been calculated, the dose equivalent allowed for the remaining gestation period should be determined. An evaluation of the equivalent dose that the embryo or fetus is likely to receive while the declared pregnant worker is performing her current job duties should be performed to determine if work restrictions are necessary. The evaluation should take into consideration the 0.5 rem equivalent dose limit, the equivalent dose remaining for the gestation period, and the requirement not to vary substantially above a uniform exposure rate that would satisfy the 0.5 rem limit during the gestation period. If the nature of the declared pregnant worker's duties make it likely that either the 0.5 rem limit will be exceeded or that substantial variation will occur, then work restrictions shall be established. If it is determined that the equivalent dose to the embryo or fetus has already exceeded 0.5 rem, the declared pregnant worker shall not be assigned to tasks where additional occupational exposure is likely during the remainder of the gestation unless she voluntarily revokes her pregnancy declaration.

A uniform exposure rate in rem/week may be calculated by subtracting the equivalent dose received by the embryo or fetus before the declaration of the pregnancy from the 0.5 rem limit and then dividing this difference by the approximate number of weeks remaining in the gestation period. 10 CFR 835 allows flexibility for a facility-specific determination of what constitutes a substantial variation. The value selected will vary depending on site-specific factors such as nature of work performed, radiological conditions in the areas to be entered, and the sensitivity and accuracy of the individual monitoring methods used. DOE recommends a value equal to the calculated uniform equivalent dose rate per week +100%.

PORTABLE MONITORING INSTRUMENT CALIBRATION

PURPOSE

DOE G 441.1-1C, provides guidance for a portable monitoring instrument calibration program that addresses selection, calibration, tests for operability, maintenance, calibration equipment, calibration quality, laboratory documentation, facilities, and staff.

This section of the module provides direction for selecting, calibrating, testing, and maintaining portable radiation monitoring instruments and equipment.

The essential elements of an acceptable portable instrument calibration program include the following:

- a system that ensures that calibration will be performed periodically on each instrument;
- an internal audit program shall be conducted no less frequently than every 36 months;
- a records program that documents results of maintenance and calibration performed on instruments and equipment used for area monitoring and contamination control;
- procedures that address the calibration of reference sources, support instruments, and field instrument;
- a method to determine when instruments have been returned out-of-calibration and a method to notify users of out-of-calibration instruments;
- an adequate technical staff with appropriate training in instrument calibration; and
- a dedicated facility that permits calibrations without outside physical interference.

INSTRUMENT SELECTION

Instruments shall be selected that are appropriate to measure the type(s), levels, and energies of radiation(s) encountered and for the existing environmental conditions. To ensure these requirements are met, the initial instrument selection process should include knowledge of facility radiation types, energies, anticipated or known ranges, and results of available instrument performance and testing data. The selection process should include type testing and acceptance testing.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

INSTRUMENT CALIBRATION

ANSI N323A, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*, sets forth criteria for proper portable monitoring instrument calibration. An instrument calibration shall be performed on each instrument periodically at an established frequency. The calibration frequency should be determined and the calibration should be performed. If routine checks indicate that the response of an instrument remains stable over a long period of time, then the calibration frequency may be extended. Conversely, if routine checks indicate that an instrument fails to provide a stable response over the prescribed calibration interval, then the calibration interval should be shortened. The reliability of an instrument and appropriate calibration frequency should be determined by collecting and analyzing data.

OPERABILITY TESTS

Functional tests should be performed before an instrument is used in the field. Functional tests should be detailed in the instrument-use procedures and should include, as a minimum, general condition, battery condition, verification of current, background readings, and other tests as applicable to the instrument. Functional tests should also include a source response before initial operation. During use in the field, instruments should be tested with a check source to ensure that the readings remain within prescribed limits. The performance of functional tests during use in the field should be documented appropriately.

Performance tests should be performed periodically and after maintenance to ensure that the instruments continue to meet performance requirements for field measurements. These tests may be conducted as part of the calibration procedure.

MAINTENANCE

Maintenance shall be performed periodically on an established frequency. Maintenance activities should be directed toward ensuring that the instruments continue to meet the required accuracy for field measurements.

All preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the instrument

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

manufacturer. If the manufacturer does not provide routine maintenance procedures, the maintenance organization should write one.

CALIBRATION EQUIPMENT AND CALIBRATION QUALITY

The calibration laboratory should possess and maintain appropriate radiation and non-radiation standards to achieve reliable operation. Instruments should be calibrated with appropriate standards that are traceable to the National Institute of Standards and Technology or its international equivalents.

LABORATORY DOCUMENTATION

The calibration laboratory should maintain the laboratory protocol, the laboratory records, and the calibration records. Historical records should be maintained to detail any changes or revisions in procedures or protocols. The laboratory protocol describes the laboratory operations. This documentation should also include the detailed calibration procedures for each instrument routinely calibrated. The laboratory records, on the other hand, are those records that document the activities of the laboratory. Finally, the calibration records are those records that document the maintenance, calibration, and testing of each instrument and source used.

LABORATORY AND STAFF

The location, design, and use of the calibration laboratory should ensure that conditions within the laboratory would not affect calibration quality. Additionally, the laboratory shall be designed to keep worker exposures in compliance with 10 CFR 835. The laboratory should also have an appropriate selection of calibration equipment and should be operated with a properly organized and trained staff.

ASSESSMENTS

Internal audits of the radiation protection program shall be conducted such that, over a 3-year period, all functional elements are assessed, including program content and implementation.

AIR MONITORING

The purposes for conducting an air monitoring program can be characterized as the need to assess individual exposures to airborne radioactive material, determine the need for and prescribe appropriate personnel protection from airborne radioactive material, and provide early warning of unexpected increases in airborne radioactivity levels. The type of air monitoring to be performed depends on what the monitoring results are needed for. Under 10 CFR 835, air monitoring results are required to measure the concentrations of airborne radioactive material, determine posting requirements, determine the effectiveness of the engineered controls and barriers used to contain and confine radioactive material, determine appropriate protective equipment and measures, and provide warnings of significantly elevated levels of airborne radioactive materials. Additionally, air monitoring results may be used to estimate individual intake.

IMPLEMENTATION GUIDANCE

This section describes acceptable methods for establishing and operating an air monitoring program adequate to demonstrate compliance with 10 CFR 835. The discussion is divided into the following topics:

- determining the need for air monitoring,
- placement of air sampling and real-time air monitoring equipment,
- selection and operation of air sampling equipment,
- selection and operation of real-time air monitoring equipment,
- sample analysis and data review,
- quality control and quality assurance, and
- administrative controls.

Additional information about air monitoring is provided in NUREG-1400, *Air Sampling in the Workplace*, 1993. NUREG-1400 contains the following technical information:

- evaluation of the need for air sampling, including air sampling based on potential intakes and concentrations, and air sampling systems;
- location of air samplers, including purpose of airflow studies, determination of airflow patterns, and selecting sample location;
- demonstration that air sampling is representative of inhaled air;
- adjustments to derived air concentrations;

- measurement of the volume of air sampled; and
- evaluation of sampling results, including detecting changes in air concentrations over time, efficiency of collection media, and detection sensitivity.

NUREG-1400 should be consulted to obtain pertinent technical information concerning regulatory guidance provided in the guide.

Determining the Need for Air Monitoring

The decision to perform air monitoring should be based on consideration of actual and potential radiological conditions. Actual conditions are typically confirmed by air sampling results with detectable levels of activity. Potential conditions are identified through the use of professional judgment and experience regarding the likelihood that a radiological condition will exist. When evaluating potential conditions, normal situations and unusual situations that can occur should be considered.

Placement of Air Sampling and Real-Time Air Monitoring Equipment

Once the need for air monitoring has been established, the monitor/sampler location(s) can be determined. Location is important because inappropriately placed equipment may not provide representative results. Concentrations of airborne radioactivity in an area can vary from one location to another. Air sampling equipment is most effective when located close to individuals to provide an indication of airborne radioactivity levels to which they are exposed. Real-time air monitoring equipment should be located to provide an early warning to individuals of a significant increase in levels of airborne radioactive material. When selecting locations for air sampling and real-time air monitoring equipment, consideration should be given to the locations of possible release points and workers, the purpose of the sample, and room air flow patterns. The cost of real-time monitors and the time required to collect and analyze sample media limit the number used in a facility. The technical basis for air sampling and real-time air monitoring equipment placement should be documented. The following considerations should be included in technical basis documentation:

- locations of release points and individuals
- purpose of sample
- room air flow patterns

AIR SAMPLING EQUIPMENT

Types of air sampling equipment include fixed-location air samplers, portable air samplers, and personal air samplers. Selection of air sampling equipment should be based on the type of sample being collected. Detailed technical information regarding air-sampling systems is provided in NUREG-1400.

Breathing Zone Air Monitoring

Breathing zone air monitoring should be used when air monitoring results are used to assign internal doses and when determining the effectiveness of respiratory protection equipment. Breathing zone air monitoring involves collecting an air sample from the individual's breathing environment, making allowances to eliminate interferences the samplers themselves may have on the individual's activities. Breathing zone air samples can be collected using fixed-location air samplers, portable air samplers, or personal air samplers.

Source-Specific Air Sampling

Source-specific air sampling is the collection of an air sample near an actual, or likely, release point in a work area. Fixed-location and portable air samplers can be used to verify containment or confinement integrity, to document airborne radioactive material levels, and to provide information to determine when the use of respiratory protective devices is necessary.

Grab Sampling

Grab sampling should be used for temporary or non-routine situations and as a backup for other types of air sampling in the event of equipment failure. Grab sampling can be used to determine if areas should be posted as airborne radioactivity areas and if respiratory protective devices should be used for protection against airborne radioactive material. Portable air sampling equipment should be used for operations requiring grab sampling.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

REAL-TIME AIR MONITORING EQUIPMENT

Instrument Selection

Instruments used for real-time air monitoring shall be appropriate for the type(s), levels, and energies of radiation(s) encountered in the workplace and for existing environmental conditions. The selection of real-time air monitors should be based on the characteristics of the airborne radioactive material, the anticipated range of airborne radioactive material concentrations, and the possible variations of the concentrations over time. Commonly used monitors at DOE facilities are particulate-radioactive material continuous air monitors (CAM), impactor air monitors, and gaseous radioactive material monitors. Monitors that use background-reduction methods may also be used. CAMs should not be used when high levels of contamination or other factors would prevent them from providing reliable results. If a real-time air monitor is likely to become highly contaminated or if unreasonably high flow rates are needed, the technician should use a portable survey instrument to obtain periodic direct readings of fixed air sample media or periodic grab samples with rapid analysis.

SAMPLE ANALYSIS AND DATA REVIEW

Provisions for detecting changes in radiological conditions, detecting the gradual buildup of radioactive material, verifying the effectiveness of engineering and process controls in containing radioactive material, and identifying and controlling potential sources of individual exposure to radioactive material require that certain evaluations of air monitoring results be performed. Additional technical information regarding evaluation of sampling results is provided in NUREG-1400 (section 6).

QUALITY CONTROL AND QUALITY ASSURANCE

Records of the results of air monitoring shall be documented and maintained. To meet this requirement, quality control should be applied to all phases of the air monitoring program including sample identification, handling, storage, air sampling and real-time air monitoring equipment, counting room equipment, and record-keeping.

ADMINISTRATIVE CONTROLS

A document should be developed that provides the technical basis for selecting, placing, and operating air sampling and real-time air monitoring equipment. This document should include information such as:

- performance and acceptance testing of new equipment;
- filter media characteristics;
- sample transport line losses (if applicable);
- flow rate and duration of sample collection;
- identification of relevant supplies and equipment by manufacturer, make, and model;
- performance of air flow studies;
- rationale for the use and placement of air samplers and real-time air monitors;
- rationale for demonstrating that air samples are representative of air breathed by workers;
- list of, and a facility map showing, actual locations of air sampling and real-time air monitoring equipment;
- calculation of the decision level, minimum detectable activity, and minimum detectable concentration for sampling/counting configurations;
- procedures for sample analysis;

Written procedures should be available for

- collecting air samples,
- performing operability checks of air sampling and real-time air monitoring equipment,
- calibrating flow rate meters,
- calibrating any radiation detectors that are part of the air monitoring equipment,
- conducting air flow studies to aid in the placement of air sampling and real-time air monitoring equipment, and
- interpreting the air monitoring results.

RADIOACTIVE CONTAMINATION CONTROL

Work with unsealed quantities of radioactive material creates the potential for generating radioactive contamination. 10 CFR 835 requires a contamination control program to provide warning of the presence of surface contamination and to prevent the inadvertent transfer of contamination at levels exceeding specified values outside of radiological areas under normal operating conditions.

An acceptable contamination control program incorporates two types of control: engineered control and administrative control. Contamination monitoring verifies the effectiveness of the contamination control program.

Activities that have the potential to generate surface contamination should be evaluated to ensure appropriate controls are established. To the extent practicable, contamination controls should be consistent to facilitate effective implementation by affected individuals. This section describes methods for establishing and operating an acceptable contamination control program. The discussion is divided into the following topics:

- contamination control program management
- physical design features
- administrative control
- contamination monitoring

CONTAMINATION CONTROL PROGRAM MANAGEMENT

Common characteristics of effective contamination control programs include:

- strong, written upper management commitment to control contamination in the workplace;
- consistent line management implementation of required controls through established procedures, training, and frequent supervision;
- detailed work planning, including effective hazards analysis, pre-job briefings, and post-job debriefings; and
- consistent program support by affected individuals.

Management commitment should be established in a written policy that may be included in the ALARA policy statement or other policy-level document. The policy should be implemented by written procedures, technical work documents, and radiological work

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

permits commensurate with the hazards and required controls and sufficient to ensure consistent program implementation given the education, training, and skills of the affected individuals.

ENGINEERED CONTROLS

Appropriate controls that prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions shall be maintained and verified. 10 CFR 835.1001 requires that measures be taken to maintain radiation exposure ALARA through physical design features and administrative controls. The primary methods used shall be engineered controls. Administrative controls shall be employed only as supplemental methods.

Engineered controls that should be considered to enhance control of workplace contamination include:

- containment of process materials to the maximum practicable extent,
- components and materials that minimize leakage across seals,
- catch basins and drains to control contamination from potential leakage points,
- multiple barriers to control the spread of contamination,
- adequate working space around serviceable components to facilitate maintenance and repairs,
- filters on ventilation from areas of lower to areas of higher contamination levels,
- adequate space for donning and removal of protective clothing and individual frisking in low-background areas, and
- offices and break areas that are away from radiological areas to reduce exposure.

In addition, facility design, including materials selected, shall include features that facilitate operations, maintenance, decontamination, and decommissioning. These activities should be facilitated by limiting the size of any contaminated areas and the magnitude of the contamination levels within those areas. To the maximum possible extent, materials used should be readily decontaminated using water or steam. Smooth, corrosion resistant surfaces and rounded edges also facilitate decontamination.

When permanent engineered controls are not sufficient to prevent the spread of contamination in the workplace, temporary engineered controls such as containment devices and portable or auxiliary ventilation, should be installed. These circumstances arise frequently during maintenance, modifications, and decontamination and decommissioning.

ADMINISTRATIVE CONTROL

When the use of engineered controls is impractical, administrative controls shall be implemented to maintain exposures ALARA. To control the spread of contamination and limit individual exposures, a graded, multiple-tier system should be used in and around contaminated areas. The effectiveness of the controls should be verified through the conduct of contamination monitoring. Acceptable administrative controls include the following:

- work authorizations
- access, entry, and egress controls
- posting and labeling
- control of radiological work
- personal and material decontamination
- skin and clothing contamination

CONTAMINATION MONITORING

Comprehensive surveillance for contamination is the best available assurance of compliance with the requirements of 10 CFR 835. Frequent routine and special contamination monitoring should be performed in and around contaminated areas to verify the levels and locations of contamination and to alert personnel to changes in levels. An effective contamination monitoring program includes the capability to

- calibrate instruments and perform appropriate operational tests,
- monitor for contamination,
- determine the lower detection limits for field and laboratory instruments, and
- conduct the appropriate quality control checks to ensure reliable instrument performance.

An effective contamination monitoring program also includes the following components:

- contamination control values
- monitoring features

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

- material and equipment controls

Note: You do not have to do example 2 on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do example 2 or go to the next section of this document.

EXAMPLE 2

1. List four types of radiation generating devices.
2. List four of the essential elements of an acceptable portable instrument calibration program.
3. Discuss the basis used to determine if air monitoring is needed.

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

Note: When you are finished, compare your answers to those contained in the example 2 self-check. When you are satisfied with your answers, go on to the next section of this document.

EXAMPLE 2 SELF-CHECK

1. List four types of radiation generating devices.

Any four of the following constitute a correct answer.

Sealed photon- or neutron-emitting radioactive sources; X-ray producing radiography equipment; research and analytical X-ray or electron beam machines; sealed radioactive sources used as irradiators; particle accelerators; neutron generators; Van de Graff generators; electromagnetic pulse generators; electron microscopes; electron arc welders; microwave cavities that produce X-rays incidentally; and cabinet X-ray machines used for security applications.

2. List four of the essential elements of an acceptable portable instrument calibration program.

Any four of the following constitute a correct answer.

The essential elements of an acceptable portable instrument calibration program include the following:

- a system that ensures that calibration will be performed periodically on each instrument;
- a records program that documents results of maintenance and calibration performed on instruments and equipment used for area monitoring and contamination control;
- procedures that address the calibration of reference sources, support instruments, and field instrument;
- a method to determine when instruments have been returned out-of-calibration and a method to notify users of out-of-calibration instruments;
- an adequate technical staff with appropriate training in instrument calibration; and
- a dedicated facility that permits calibrations without outside physical interference.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

3. Discuss the basis used to determine if air monitoring is needed.

The decision to perform air monitoring should be based on consideration of actual and potential radiological conditions. Actual conditions are typically confirmed by air sampling results with detectable levels of activity. Potential conditions are identified through the use of professional judgment and experience regarding the likelihood that a radiological condition will exist. When evaluating potential conditions, normal situations and unusual situations that can occur should be considered.

POSTING AND LABELING FOR RADIOLOGICAL CONTROL

The purpose of a radiological hazard posting and labeling program is to identify and effectively communicate radiological hazards to individuals, allowing them to take the appropriate protective actions.

10 CFR 835 requires that certain areas and items be posted or labeled to control personnel exposure to radioactive material and ionizing radiation and to prevent the spread of contamination.

GENERAL

10 CFR 835 establishes specific requirements for posting of controlled areas, radioactive material areas (RMAs), and radiological areas. Controlled areas are established to warn individuals that they are entering areas that, because of the presence of radiological areas and/or RMAs, are controlled for radiation protection purposes. RMAs and radiological areas are established within the controlled area to provide warning of specific hazards that may require individual protective action for safe entry and egress.

10 CFR 835 also establishes specific requirements for labeling of items or containers of radioactive material exceeding specified threshold activity levels. Radioactive material labels are used to provide warning to individuals of the presence of radioactive material, particularly in areas in which the radiological hazard does not warrant area posting.

10 CFR 835 requires that written procedures be developed and implemented as necessary to ensure compliance, commensurate with the radiological hazards and consistent with the education, training, and skills of the exposed individuals.

Design

To the extent practicable, controlled area postings should use the yellow and magenta radiological hazard warning color scheme, but the flexibility provided in 10 CFR 835.602(b) extends to the shape, color scheme, and content of the controlled area postings.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

Postings for radiological areas and radioactive material areas and labels on radioactive items and containers of radioactive material shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background. Magenta is the preferred color for the trefoil and any lettering on the posting. Unless circumstances do not permit, the standard radiation warning trefoil should be oriented with one blade downward and centered on the vertical axis. The standard radiation-warning trefoil should be displayed as prominently as is practicable.

Content

In addition to the standard radiation warning trefoil, postings and labels required by 10 CFR 835 shall include the appropriate heading (“Caution,” “Danger,” or “Grave Danger”) and wording describing the radiological hazard.

Required signs may include radiological protection instructions. Supplemental wording describing additional warnings or directions should be included on the postings or labels, as appropriate. Recommended supplemental wording on potential and actual radiological conditions and specific controls is discussed in chapters 2 and 4 of the RCS.

Visibility

Signs required by 10 CFR 835 shall be clearly and conspicuously posted. Each item or container of radioactive material that requires labeling shall bear a clearly visible label.

When posting is required, appropriate signs should be placed intermittently along the boundary. The effect of visibility on opening doors or other changes in configuration should be considered when posting radiological hazard warning signs. At least one sign should be on each side of an area’s boundary, and a sign should be visible from any normal avenue of approach. A distance of 40 feet between signs along the area’s boundary is acceptable.

Accessibility

Radiological areas and RMAs are defined based upon area accessibility. An area is considered accessible to individuals when it contains entrance or access points of sufficient size to permit human entry.

Areas with entrance or access points consisting of locked doors or other controls and interlocks should be considered accessible to individuals. Areas with entrance or access points consisting of doors or portals, such as man hole covers, that are bolted or otherwise more permanently sealed may be considered inaccessible unless such doors or portals are opened on a routine basis. Areas in which the radiological hazard is located underground, such that significant soil excavation, drilling, natural forces, or other forms of intrusion would be required to gain access, may be considered inaccessible. In general, areas with entrance or access points that require the use of tools or lifting or excavation equipment to gain access may be considered inaccessible to individuals.

Boundaries and Barriers

Controlled areas, RMAs, and radiological areas should be identified by the use of a boundary identifier or a physical barrier and sufficient signs. The combination of signs and boundary identifiers should be sufficient to warn approaching individuals that they are entering an area controlled for radiation protection purposes. Boundary identifiers may consist of ropes, chains, color-coded adhesive tape, or other materials sufficient to delineate the boundary of the area. Because color-coded adhesive tape applied to floors may not be highly visible and provides no impediment to entry, its use as a boundary identifier should be limited to counter-top applications or to use in conjunction with other boundary identifiers.

CONTROLLED AREAS

Controlled areas are established and posted to warn individuals that they are entering areas in which radiological areas and RMAs exist. All radiological areas and RMAs lie within the boundaries of controlled areas.

Each entrance or access point to a controlled area shall be posted if that area contains radioactive materials or radiation fields that require posting. The sign should contain

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

wording equivalent to “Controlled Area;” however, the actual wording, color scheme, and sign may be selected by the contractor to avoid conflict with local security requirements. If the boundaries of the controlled area are contiguous with those of radiological areas or RMAs, the area should be posted with the controlled area and radiological area/RMA postings. A controlled area may incorporate one or more radiological areas and/or RMAs. Controlled area borders should not be contiguous with the site boundary.

POSTING FOR CONTROL OF EXPOSURE TO EXTERNAL RADIATION

10 CFR 835 establishes requirements for three areas that shall be posted to provide warning of external radiation fields: radiation areas, high radiation areas, and very high radiation areas. The need to post these areas is contingent upon two factors: area accessibility, and the radiation field intensity and duration, such that an individual’s dose may exceed the specified threshold in one hour.

The posting thresholds established in 10 CFR 835 are based on the radiation field intensity measured at a specified distance from the radiation source or from any surface penetrated by the radiation. That distance is 30 cm for radiation and high radiation areas and 100 cm for very high radiation areas. To ensure continuing compliance with the posting requirements, a degree of conservatism should be established in the local posting requirements. The desired degree of conservatism may be established by posting affected areas at an exposure rate lower than that specified, or measuring the exposure rate at a distance less than that specified, or both. The degree of conservatism established in the posting regimen for external radiation hazards should be adequate to address issues of monitoring equipment variability and likely variations in area radiological conditions.

POSTING FOR CONTROL OF CONTAMINATION

10 CFR 835 establishes requirements for three areas that shall be posted to provide warning of the presence of radioactive contamination: contamination area, high contamination area postings for removable surface contamination, and airborne radioactivity area postings for airborne contamination. The need to post contamination areas and high contamination areas is contingent on the area accessibility and the presence of removable surface contamination at levels exceeding the specified removable surface contamination values.

RADIOACTIVE MATERIAL POSTING

10 CFR 835 requires that certain areas where radioactive material is used, handled, or stored be posted as radioactive material areas. The need to post RMAs is contingent on two factors: area accessibility and the presence of items or containers of radioactive material in the area in quantities exceeding the applicable values.

A difficulty that may arise in identifying RMAs is in determining the location of the RMA boundaries. While the boundaries of the radiological areas are readily identified through the conduct of area monitoring, the boundaries of a radioactive material are more nebulous. It may be apparent that the quantity of radioactive material in a specified room or enclosure does not exceed that level defining an RMA, but the sum of the quantities of radioactive material in a series of adjoining rooms or enclosures may exceed the threshold level. Such a condition will necessarily lead to questions regarding whether an RMA exists and, if so, the logical RMA boundaries.

There are two acceptable approaches for defining boundaries of RMAs. Under the first acceptable approach, the quantity of radioactive material in individually identifiable rooms or enclosures may be considered. If there are multiple radioactive items or containers, then the activity of each radionuclide present in all of the items and containers should be summed, divided by the appropriate value and added to the similarly determined ratios for all other radionuclides present to determine the activity to threshold value ratio for the designated room or area. The postings, if necessary, should be erected at the individual room or enclosure entry or access point(s) or, if there is a common access point to the rooms or enclosures, then the posting may be erected at that point. Under the second acceptable approach, the quantity of radioactive material present in a group of rooms or enclosures may be considered (using the sum-of-the-fractions rule as discussed above) and the postings, if necessary, should be erected at the common entry or access points. The decision regarding the appropriate location for the posting(s) will be based largely on considerations of convenience.

EXCEPTIONS FROM POSTING REQUIREMENTS

Accessible areas may be excepted from the radiological area and radioactive material area posting requirements for periods of less than 8 continuous hours when the area is placed under the observation and control of individuals who are knowledgeable of and empowered to implement required access and exposure control measures. The observing individual(s) should be stationed to provide line of sight surveillance of the area boundaries and verbal warnings. For situations that require only simple access control measures, such as entry prevention, a minimally trained individual would suffice. For situations that require more complicated access and exposure control measures, a radiological control technician should be used. A sufficient number of individuals should be used to provide for adequate access and exposure control.

The following accessible areas are excepted from the radioactive material area posting requirements:

- radiological areas posted according to 10 CFR 835.603(a) – (f);
- areas where each item or container of radioactive material is clearly and adequately labeled such that individuals entering the area are made aware of the hazard; and
- areas in which the radioactive material of concern consists solely of structures or installed components which have been activated.

RADIOACTIVE MATERIAL LABELING

Each item or container of radioactive material shall be labeled. The label shall contain the standard radiation warning trefoil and the words “CAUTION, RADIOACTIVE MATERIAL” or “DANGER, RADIOACTIVE MATERIAL.” The label shall also provide sufficient information to permit individuals handling or using the containers or working in the vicinity of the containers to take precautions to avoid or minimize exposures.

The following information should be included on the labels, as appropriate:

- radiological hazard,
- an estimate of the quantity of radioactivity,
- radioisotope(s) and activity,
- dates monitored,
- any special handling instructions necessary to permit individuals to implement appropriate protective measures,

- the name of the individual performing the monitoring, and
- a description of the material, as appropriate.

Exceptions from Labeling Requirements

Containers and items are excepted from the radioactive material labeling requirements under any one of the following circumstances:

- The items or containers are used, handled, or stored in areas posted and controlled, and sufficient information is provided to permit individuals to take appropriate protective actions.
- The quantity of radioactive material is less than one-tenth of the values specified in 10 CFR 835.
- The items or containers are packaged and labeled according to Department of Transportation regulations or corresponding DOE Orders.
- The items or containers are inaccessible or accessible only to individuals authorized to handle or use them, or to work in the vicinity.
- The items or containers are installed in manufacturing or process equipment, such as reactor components, piping, and tanks.
- The radioactive material consists solely of nuclear weapons or their components.

OCCUPATIONAL RADIATION PROTECTION RECORD-KEEPING

This section of DOE G 441.1-1C includes instructions for implementing a program that will meet DOE requirements for generating, administering, and retaining occupational radiation protection records and reports. Complete and accurate radiation protection records are necessary to

- provide information used to protect individuals from radiation exposure,
- evaluate the effectiveness of the radiation protection program,
- demonstrate compliance with regulations and requirements, and
- defend the radiation protection program against unwarranted litigation.

This section of DOE G 441.1-1C describes acceptable methods for conducting a functional and effective program for generating and administering occupational radiation protection program records and reports. An acceptable radiation protection records program should

- be implemented by individuals who are knowledgeable of the record-keeping requirements;
- have documented policies and procedures for record and report generation and administration;
- demonstrate accuracy, completeness, timely record and report generation, and retrieval capability; and
- maintain documents that are traceable, verifiable, and retrievable, to substantiate historical events.

RECORDS TO BE GENERATED AND MAINTAINED

Required records include individual monitoring and dose, workplace monitoring and control, and administrative records. The following is a list of the types of records that must be maintained. Additional information about records is in DOE G441.1-1C, chapter 13.

- Individual monitoring and dose records
- Internal doses
- External doses
- Summation of internal and external doses
- Lifetime occupational dose
- Non-uniform exposure to the skin
- Planned special exposures

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

- Dose resulting from emergency or accidental exposures
- Records of embryo/fetus dose and declared pregnant workers
- Individual monitoring program records
- Equipment capabilities
- Radiation safety analysis and evaluation records
- Work authorizations
- Area and material/equipment monitoring records
- Airborne radioactivity monitoring records
- Records of releases of materials and equipment from radiological areas
- Radiation safety training
- ALARA records
- Facility design
- Entry and access control records
- Sealed radioactive sources
- Radiation protection program, policies and procedures
- Audits and programmatic reviews
- Posting and labeling
- Calibration, functional tests, and maintenance records
- Reports
- Reports to individuals
- Records requested by monitored individuals
- Termination dose reports
- Reports to DOE
- Reports of planned special exposures
- Privacy act considerations
- Informing individuals
- Identifying individuals
- Requesting correction or amendment of a record
- Responding to requests
- Accounting for disclosures

RADIATION SAFETY TRAINING

GENERAL INFORMATION

Radiation safety training shall be provided to all individuals before being permitted unescorted access to controlled areas or before being occupationally exposed to ionizing radiation during access to controlled areas, whether escorted or not.

A radiation safety training program sufficient to meet the requirements of 10 CFR 835.901 should include:

- course materials from DOE that are applicable to the radiological hazards and controls associated with the specific DOE activity;
- site- and activity-specific content and instruction;
- performance demonstrations and examinations as appropriate to demonstrate understanding of key concepts and practices; and
- an evaluation of other applicable DOE requirements.

10 CFR 835.901(a) and (b) establish requirements for distinct levels of radiation safety training. If an individual will be permitted unescorted access to controlled areas or receive occupational exposure to ionizing radiation during escorted or unescorted access to controlled areas, a determination must be made regarding the appropriate level of knowledge and the type of training to be provided. This determination should be based on

- the nature of the radiological hazards in area(s) to which the individual will be granted access and the nature of the work to be performed;
- the type and complexity of protective actions that the individual might be expected to undertake in the areas to be entered;
- a determination with regard to whether or not the individual will be under constant escort or supervision; and
- the individual's previous education, training, and experience in working with radioactive materials and in the vicinity of radiological hazards.

TRAINING COURSE CONTENT

General employee radiological training(GERT) provides the appropriate level of training for individuals who:

- enter controlled areas unescorted; or
- receive occupational exposure during controlled area entry (whether escorted or not).

These are the individuals addressed in 10 CFR 835.901(a). GERT does not provide the appropriate level of training for individuals who enter radiological areas unescorted or for those individuals who perform unescorted duties as a radiological worker.

Radiation Worker Training (RWT)-I provides the appropriate level of training for individuals who:

- enter non-contaminated radiation areas (but not high or very high radiation areas) or areas in which they are likely to receive doses exceeding 0.1 rem (0.001 Sv) in a year (e.g., certain radioactive material areas and areas surrounding radiological areas);
- work with sealed or fixed radioactive material that does not produce high radiation fields (i.e., fields exceeding 0.1 rem (0.001 Sv) in an hour); or
- work with radiation producing devices that do not produce high radiation fields (i.e., fields exceeding 0.1 rem (0.001 Sv) in an hour).

RWT-I is not appropriate for individuals who enter contaminated areas or high radiation areas unescorted. However, RWT-I may be augmented by the specific high/very high radiation area entry training module to prepare RWT-I trained individuals for safe entry into high or very high radiation areas.

RWT-II has been developed to provide the appropriate level of training for individuals who, in addition to the above criteria:

- are expected to enter high radiation areas;
- are expected to enter contaminated areas; or
- are otherwise expected to work with unsealed quantities of radioactive materials.

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.

- Basic radiological fundamentals and radiation protection concepts;
- Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;
- Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented to control exposures to radiation and radioactive materials, including routine and emergency actions;
- Individual rights and responsibilities related to implementation of the radiation protection program;
- Individual responsibilities for implementing ALARA measures; and
- Individual exposure reports that may be requested.

FACILITY-SPECIFIC MATERIALS

To implement an effective radiation safety training program, the core courses should be augmented with facility-specific information. The following information should be considered in developing facility-specific training materials:

- procedures for entering and exiting the authorized areas, including use of work authorizations;
- controls on radiation exposures, including administrative control levels and fetal exposure control;
- measures for use of protective equipment, including protective clothing and respiratory protective devices;
- alarms, warning signals, and response actions;
- ALARA measures implemented at the facility;
- requirements for interfacing with the radiation protection organization;
- skills required by the worker to execute his radiation safety responsibilities;
- worker responsibilities for self and coworker protection, including exercise of stop work authority; and
- measures for requesting personal dose records and reports.

COMPLETION OF RADIATION SAFETY TRAINING

Successful completion of radiological worker training (RWT) shall be demonstrated by completion of an examination. Examinations should be written, but other measures may be implemented to accommodate those with special needs.

Computer-based examinations, using automated examination composition and scoring, may be used as appropriate. The minimum passing score for examinations, including challenge examinations, should be established at or above 80 percent. Chapter 6 of the RCS and the core course program management guides provide detailed guidance for conducting examinations.

In addition to an examination, students in RWT classes shall be required to complete performance demonstrations commensurate with their duties. Performance demonstrations typically involve such activities as safely entering and exiting simulated radiological areas, donning and removing protective clothing, and performing whole body frisking. Chapter 6 of the RCS and the RWT core course material provide detailed guidance for conducting performance demonstrations.

In addition to the initial training provided before an individual is granted access to the specified areas, radiation safety training shall be conducted at least once every 24 months and whenever significant changes are implemented that might affect the individual. This periodic training should not simply repeat the initial training, but should review key principles, provide more detailed knowledge of the subject matter required in 10 CFR 835.901(c), and stress new program requirements and seldom-used knowledge and skills.

USE OF ESCORTS IN LIEU OF TRAINING

Constant escort of an individual may affect the extent of required training. The use of constant escort may obviate the need for certain types of training by making the escort responsible for the protection and actions of the affected individual. This approach should only be used when

- the individual will enter the area for a short period of time,
- provision of an escort will provide for an adequate level of safety, and

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

- provision of an escort will not result in significant adverse dose effects. This determination should be based on consideration of the resources that must be expended to escort the individual versus those necessary to provide the appropriate training.

TRAINING EFFECTIVENESS EVALUATIONS

Training effectiveness evaluations are quality assurance measures used to determine if qualified workers have retained all the required knowledge and skills and are applying them properly. Feedback is an important form of evaluation that encourages improvements and upgrades to the training programs. Comments from supervisors, instructors, and trainees should be used to enhance course effectiveness.

SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND CONTROL

This section of DOE G 441.1-1C provides guidance for establishing and operating a sealed radioactive source accountability and control program. Essential components of a sealed radioactive source accountability and control program should include:

- organization and responsibilities
- receipt
- labeling and storage
- inventory
- source leak testing
- handling and disposal

The responsibilities of the radiological control organization (RCO) for a sealed radioactive source accountability and control program should include:

- establishing the program,
- maintaining records related to the accountability and control of sealed radioactive sources,
- providing each source custodian with an inventory list of accountable sealed radioactive sources, and
- assisting the source custodian in training source users.

Sealed radioactive source custodians and source users are generally expected to work directly with radioactive materials and therefore would meet the 10 CFR 835.2(a) definition of the term “radiological worker.”

The source custodian should notify and obtain approval of the RCO before

- changing the use of a sealed radioactive source,
- transferring a sealed radioactive source to a new permanent storage location or to a new source custodian,
- modifying a device containing a sealed radioactive source,
- disposing or transferring a sealed radioactive source, and
- procuring additional sealed radioactive sources.

RECEIPT

Before receiving sealed radioactive sources, the RCO should assign the sources to the proper source custodians. When the sealed radioactive sources are received, the RCO should be notified. The packaging shall be inspected for damage and contamination and radiation monitoring should be performed. Except for gaseous sealed radioactive sources and tritium, a source leak test shall be performed upon receipt of all sealed radioactive sources. The RCO should perform the receipt monitoring and source leak test. The source custodian should be notified of the arrival of the sealed radioactive sources to ensure that proper accountability and controls are initiated. The sources should be placed into storage or into the device in which they will be used. The source custodian's and site's records should be updated to include the new sealed radioactive sources.

LABELING AND STORAGE

All sealed radioactive sources having an activity exceeding 10% of the applicable 10 CFR 835 appendix E values shall be labeled. Labels should be applied to all sealed radioactive sources, regardless of the activity of the source, to minimize the likelihood of loss or unauthorized usage. In recognition of the differing labels permanently applied to certain sealed radioactive sources by their manufacturers, labels applied to sealed radioactive sources may be excepted from the color specifications. However, standard colors and designs should be used to the extent practicable to foster instant recognition by affected individuals.

Labels should be applied directly to the sealed radioactive source, or the labels should be applied to the storage containers and devices containing sealed radioactive sources. The label should identify the radionuclide, source activity, date of assay, model and serial number of the source and container or device, and a method for identifying the source custodian.

Additionally, labels should include the contact radiation levels, removable contamination levels, dates monitored, and the name of the individual performing the monitoring. The label should be sufficiently durable to remain legible for the useful life of the device or storage container and should be located in a readily visible place. Ideally, all the labeling information should be on a label affixed to the source.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

If the source is too small to label, then either its source container or its radioactive material storage location should be labeled. A method of tracing a source to its label should be implemented if the label is affixed to the source container or radioactive material storage location. Commercially manufactured sources should have a serial number on the source itself that should be traceable to the serial number on the label. For sources without serial numbers, the contractor should permanently mark the source with a unique identification and should use the same identification mark on the label.

If the radiation intensity around the sealed radioactive source container will change significantly upon opening the container or changing the position of the source in the container, that information should be provided on a label so that it is easily observable by the operator.

The storage location should also be marked to easily identify the location during inventory. Storage locations, containers, and devices should be appropriate for the specific sources, and should only be used to contain radioactive materials. Storage rooms or cabinets that contain sealed radioactive sources should

- be isolated from occupied areas or located in radiological areas,
- be of a design that would minimize damage from fire, and
- be free of flammable or combustible substances.

Storage rooms or cabinets containing sealed radioactive sources should be locked, monitored routinely, and posted.

Radiation and contamination monitoring of the sealed radioactive source storage area or facility should be performed before its initial use and periodically thereafter. Monitoring shall be performed whenever changes in status are made that may significantly affect radiological conditions.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

INVENTORY

Except for certain circumstances discussed below, all accountable sealed radioactive sources shall be inventoried at intervals not to exceed six months. These inventories shall accomplish the following:

- Establish the physical location of each source.
- Verify the presence and adequacy of associated postings and labels.
- Establish the adequacy of storage locations, containers, and devices.

LEAK TESTING

Except for those sources consisting solely of gaseous radioactive material or tritium, sealed radioactive sources shall undergo a source leak test upon receipt, when damage is suspected, and at least every six months. A leak test should be performed before a sealed radioactive source is used the first time and when any measurable contamination is detected on handling or storage equipment.

Note: You do not have to do example 3 on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do example 3 or go directly to the practice.
--

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

EXAMPLE 3

1. List four reasons for maintaining radiological control records.
2. List four elements that should be included in a radiological training program.
3. Discuss the responsibilities of the RCO for a sealed radioactive source accountability and control program.

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

Note: When you are finished, compare your answers to those contained in the example 3 self-check. When you are satisfied with your answers, go on to the practice.

EXAMPLE 3 SELF-CHECK

1. List four reasons for maintaining radiological control records.

Complete and accurate radiation protection records are necessary to

- provide information used to protect individuals from radiation exposure,
- evaluate the effectiveness of the radiation protection program,
- demonstrate compliance with regulations and requirements, and
- defend the radiation protection program against unwarranted litigation.

2. List four elements that should be included in a radiological training program.

- Course materials from DOE that are applicable to the radiological hazards and controls associated with the specific DOE activity,
- Site- and activity-specific content and instruction,
- Performance demonstrations and examinations as appropriate to demonstrate understanding of key concepts and practices, and
- An evaluation of other applicable DOE requirements.

3. Discuss the responsibilities of the RCO for a sealed radioactive source accountability and control program.

The responsibilities are to

- establish the program,
- maintain records related to the accountability and control of sealed radioactive sources,
- provide each source custodian with an inventory list of accountable sealed radioactive sources, and
- assist the source custodian in training source users.

PRACTICE

This practice is required if your proficiency is to be verified at the familiar level. The practice will prepare you for the criterion test. You will need to refer to the guides, 10 CFR 835, and other references to answer the questions in the practice correctly. The practice and criterion test will also challenge additional analytical skills that you have acquired in other formal and on-the-job training.

1. Match the following terms from the radiological control guides with their definitions by entering the letter of the term next to its corresponding definition. The terms may be used more than once or not at all.

Terms

- A. Type II error
- B. Frisk
- C. Geotropism
- D. Minimum detectable amount
- E. Radiography
- F. Uniform exposure
- G. None of the above

Definitions:

- ___ 1. A change in an instrument's reading as its orientation changes, due to gravitational effects.
- ___ 2. Any gamma- or neutron-emitting sealed radioactive material that has the potential to create a radiation level exceeding 500 rads in 1 hour at 1 meter and is operated within the requirements.
- ___ 3. Examination of the structure of materials by nondestructive methods using a radiation-generating device.
- ___ 4. Hypothetical radiation field in which the fluency and its angular and energy distributions are the same throughout the volume of interest.
- ___ 5. The smallest amount of material which, after being taken into the body by inhalation or absorption through the skin, exists in the whole body, a compartment, an organ, or a tissue at a specified time.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

- ___ 6. Any radiobioassay measurement made on a predetermined, periodic schedule to determine if a worker has had any intake of radioactive material.
 - ___ 7. Process of monitoring an individual or a surface for contamination by directly scanning the surface with a suitable radiation detector.
 - ___ 8. Incorrectly concluding from a result that there is analyte present.
 - ___ 9. Incorrectly concluding from a result that there is no analyte present.
 - ___ 10. The smallest amount of an analyte in a sample that will be detected with a probability, β , of non-detection while accepting a probability, α , of erroneously deciding that a positive quantity of analyte is present in an appropriate blank sample.
2. Discuss the elements that should be taken into consideration to determine the likelihood of an individual receiving a dose in excess of a regulatory monitoring threshold.
3. Give three examples of criteria that should trigger a formal ALARA review.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

4. List five features of an acceptable internal dosimetry program.

5. List five features of an acceptable external dosimetry program.

6. Discuss the actions that management must perform to implement their responsibilities related to radiation-generating devices.

Change No: 1 DOE G 441.1-1C Level: Familiar Date: 12/1/08
--

7. List the essential elements of an acceptable program to evaluate and control radiation dose to an embryo/fetus.
8. State the method of air sampling used to determine if the criteria for posting airborne radioactivity areas have been exceeded.
9. Discuss the common characteristics of effective contamination control programs.

Change No: 1
DOE G 441.1-1C
Level: Familiar
Date: 12/1/08

10. List two factors that are indicators that there is a need to post contamination areas and high contamination areas.

Note: The course manager will check your practice and verify your success at the familiar level. When you have successfully completed this practice, go to the general level module.

Change No: 1 DOE G 441.1-1C Level: General Date: 12/1/08

DOE G 441.1-1C, RADIATION PROTECTION PROGRAMS GUIDE GENERAL LEVEL

OBJECTIVES

Given the familiar level of this module and a scenario, which includes a situation, the actions taken to remedy the situation, and the requirements related to the situation, you will be able to do the following:

1. Review the contractor's actions and decide if they are correct and complete.
2. Decide if the correct requirements were cited in each situation.
3. List the key elements you would look for in the contractor's action plan to correct the situation described in the scenario.
4. State which sections or elements of DOE G441.1-1C apply to the situation described in the scenario.

Note: If you think that you can complete the practice at the end of this level without working through the instructional material and/or the examples, complete the practice now. The course manager will check your work. You will need to complete the practice in this level successfully before taking the criterion test.

Change No: 1 DOE G 441.1-1C Level: General Date: 12/1/08

RESOURCES

DOE G 441.1-1C, *Radiation Protection Programs Guide*, 5/19/08.
10 CFR 835, "Occupational Radiation Protection."

Note: The following references may be required to answer questions in the practice and criterion test for this module.

DOE-STD-1098-99, *Radiological Control*, March 2005.

DOE STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Positions at DOE Facilities*, November 2007.

DOE-STD-1121-2008, *Internal Dosimetry*. October 2008.

NUREG-1400, *Air Sampling in the Workplace*, 1993.

Change No: 1 DOE G 441.1-1C Level: General Date: 12/1/08

INTRODUCTION

The familiar level of this module introduced DOE G 441.1-1C. Several methods for establishing programs that comply with 10 CFR 835, Occupational Radiation Protection, were discussed. In the general level of this module, students are presented with a scenario that depicts a work situation related to the guides. The example scenario includes a situation, the actions taken to remedy the situation, and the requirements related to the situation. Students will be asked to review the contractor's actions and decide if they are correct. Students will also be asked to decide if the correct requirements were cited in each situation. Please refer to the directives, guides, and the other resources as necessary to make your analysis and answer the questions.

Note: You do not have to do the example on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do the example or go on to the practice.
--

EXAMPLE

Review the following scenarios and the guide sections that were deemed applicable to the scenarios, and determine if the correct section was identified in each scenario. If not, provide the correct section.

SCENARIO 1

On 10/20/2008 operations was in the process of posting the interim storage area for waste boxes as a radiological buffer area for contamination control. The area had been posted as a radioactive material area. Radiological control technicians (RCTs) noticed some weather-related degradation of the plastic sealing the box, and were performing investigative surveys. Surveys of the base used to transport the box identified total alpha contamination at 6000 disintegrations per minute (dpm) per 100 square centimeters (100cm²) and 340 dpm/100cm² removable alpha, no beta/gamma on the front of the base in a seam adjacent to an area painted for fixed contamination. RCTs isolated the area and the area was posted as a "Contamination Area." The workers who discovered the contamination were surveyed with no contamination found. The surrounding area was surveyed with no additional contamination found.

The section identified in this scenario was G 441.1-1C, section 12.5.

SCENARIO 2

Medical radioisotopes were procured from a local supplier and delivered. A 10 mCi capsule of I-131 contained within a glass vial was received inside a tungsten shield container. The receipt survey of the vial indicated no detectable transferable contamination. In closing out the receipt process and in preparation for return of the tungsten shield container to the medical radioisotope supplier, Radiological control operations surveyed the inside of the shield container and found 1600 dpm transferable beta/gamma and 600,000 dpm total beta/gamma.

The section identified in this scenario was G 441.1-1C, section 15.3

Change No: 1
DOE G 441.1-1C
Level: General
Date: 12/1/08

Write your answers below and then compare your answers to the ones contained in the example self-check.

Change No: 1
DOE G 441.1-1C
Level: General
Date: 12/1/08

EXAMPLE SELF-CHECK

The sections identified were correct.

PRACTICE

This practice is required if your proficiency is to be verified at the general level. If you are to be qualified at the general level, the practice will prepare you for the criterion test. You will need to refer to the guides to answer the questions in the practice correctly. The practice and criterion test will also challenge additional analytical skills that you have acquired in other formal and on-the-job training.

Review the scenario below and answer the questions that follow the scenario.

SCENARIO

Contamination was discovered on an equipment operator's shoes when he was exiting the site. The contamination levels on the shoes were approximately 10,400 disintegrations per minute per 100 square centimeters (dpm/100 cm²) on the right shoe and 7,800 dpm/100 cm² on the left shoe.

This was the employee's first day on the job. His primary duty was driving a truck. He had performed no activity during the day in which such contamination would have been expected. An interview with the employee indicated that he had borrowed the shoes from a relative who had worked as a truck driver in a nearby mill. This is the suspected source of the contamination.

The root cause of this occurrence was that training provided to radiation workers did not adequately address the potential for contamination from local off-site sources. The training primarily emphasizes the prevention of on-site contamination.

The contaminated shoes were confiscated. The site pre-entry briefing provided by the subcontractor was revised to alert new employees of the potential contamination from local off-site sources and to initiate a radiological survey if such contamination may exist.

1. Review the contractor's actions and decide if they are correct and complete.
2. Did the level of contamination exceed the total contamination limits identified in 10 CFR 835, Occupational Radiation Protection, appendix D?

Change No: 1 DOE G 441.1-1C Level: General Date: 12/1/08

3. List the key elements you would look for in the contractor's action plan to correct the situation described in the scenario.
4. State which sections or elements of DOE G 441.1-1C apply to the situation described in the scenario.

Write your answers here.

Note: The course manager will check your practice and verify your success at the general level. When you have successfully completed this practice, the course manager will give you the criterion test.
